Special attention is called to the blank letter of recommendation for membership in the Society, and the application blank for membership bound in the back of this volume. It is hoped that members will put these blanks to good use as occasion offers.

Edgar Marburg,
Secretary-Treasurer.
AMERICAN SOCIETY
FOR
TESTING MATERIALS
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS

A.S.T.M. STANDARDS

ISSUED BIENNIAFLY

1916

EDITED BY THE SECRETARY-TREASURER
UNDER THE REGULATIONS GOVERNING PUBLICATIONS

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American Society for Testing Materials
Affiliated with the
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

GENERAL INFORMATION.

AMERICAN SOCIETY FOR TESTING MATERIALS.

Purpose.—The purpose of the Society is the promotion of knowledge of the materials of engineering, and the standardization of specifications and methods of testing.

Membership.—Membership may be held by individuals, firms, corporations, technical or scientific societies, companies, teaching faculties, and libraries. There are three classes of membership: Honorary Members, Members and Junior Members. A Junior Member must be less than thirty years of age and his status is changed to that of Member when he attains that age. A Junior Member is entitled to the full privileges of membership at a reduction in dues, except that he may not hold office.

Applications for membership filed on behalf of others than individuals should have indicated on the same the name and official title of the personal representative to whom the publications are to be sent, and by whom the voting privilege will be exercised.

Meetings.—The Society holds a general meeting annually. Additional meetings may be held at the discretion of the Executive Committee, or upon the written request of twenty-five (25) members.

Standing Committees.—The work of the Society is done largely through its standing committees, who present reports and recommendations at the annual meeting. One of the most important functions of the Society is the adoption of (1) "Standards," which include specifications, tests, methods,
and definitions; and (2) “Recommended Practice.” The procedure involved is set forth in the Regulations Governing Standing Committees. In general, proposed new Standards or proposed changes in existing Standards are published for one or two years in the Proceedings as Tentative Standards before taking action towards their formal adoption. A list of the Standards of the Society is given on pages 712–728, and of the Tentative Standards on pages 729–733.

On committees dealing with subjects having a commercial bearing, either an equal numeric balance is maintained between the representatives of producing and non-producing interests, or the latter are allowed to predominate with the acquiescence of the former. Unattached experts are classed as representatives of non-producing interests.

The personnel of the standing committees is given on pages 624–665.

Publications.—The publications of the Society consist of the Proceedings of about 1000 pages, published annually in two parts, of which Part I contains the committee reports and tentative standards, and Part II the technical papers presented at the annual meeting; (2) the volume of A.S.T.M. Standards of about 750 pages, published biennially in the even years and containing the standards adopted by the Society; (3) a Membership List of about 225 pages, published annually, and containing also the list of standing committees and general information concerning the International Association and the American Society; and (4) circulars to members, of which some eight or ten are issued at irregular intervals during the year.

Every member receives the above publications by virtue of his membership. The Proceedings and the volume of A.S.T.M. Standards are supplied in cloth binding without added charge. Members may receive the Proceedings bound in half-leather at an additional charge of 50 cents a volume.

The Standards of the Society, which are all subject to revision biennially in the even years, may be obtained in separate form at prices depending upon the number of copies required. (See page 736.)
The Society has also issued the following special publications, to which more detailed reference will be found on pages 736-737: (1) an Index of Volumes I to XII of the Proceedings; (2) the Reports from 1903 to 1914 of Committee D-1 on Preservative Coatings for Structural Materials; and (3) a Memorial Volume commemorative of Charles B. Dudley, late President of the Society.

The price list of all the publications of the Society is given on pages 734-737.

**Dues.**—The dues per annum are $15 for Members and $7.50 for Junior Members, the fiscal year commencing on January 1. There is no initiation fee. Life membership may be purchased by individuals by the payment of a sum calculated according to age under the Table of Expectancy based upon the American Experience Table of Mortality. Membership in perpetuity may be purchased by corporations, firms, etc., by the payment of $300.

A person elected after six months of the fiscal year have expired is required to pay only one-half of the annual dues, which entitles him to a copy of the current volume of A.S.T.M. Standards but does not entitle him to a copy of the Proceedings for that year. He may, however, exercise his privilege of paying a full year's dues and receive the Proceedings.

**International Association for Testing Materials.**

**Membership.**—Members of the American Society are eligible for membership in the International Association without other formality than the filing of an application for membership and the payment of dues. The dues are $4 per annum, the fiscal year commencing on January 1. Life membership may be purchased for the sum of $75.

**Congresses.**—The International Association holds Congresses triennially. Thus far six such Congresses have been held. The Sixth Congress was held in New York City in September, 1912. The Seventh Congress, which was to have been held in Petrograd, August 12-17, 1915, has been indefinitely postponed pending the termination of the European war.
Publications. (a) Proceedings.—Since 1908 the International Association for Testing Materials has published its Proceedings in the form of pamphlets, issued at irregular intervals. The pamphlets published between Congress years contain the minutes of Council meetings, official communications, membership lists, the personnel of technical committees, etc., while those issued during Congress years contain committee reports and the advance papers to be presented at the Congress. Every member of the Association receives, by virtue of his membership, all publications issued by the Association subsequent to the date of his membership.

(b) Congress Reports.—The Proceedings of the First Congress, held in Zurich in 1895; the Second Congress, held in Stockholm in 1897; and the Third Congress, held in Budapest in 1901, were published (in part) in French and German in the periodical Les Matériaux de Construction (Baumaterialienkunde), edited by H. Giessler, Stuttgart, 1896–1902. This publication has been discontinued.

The English edition of the Proceedings of the Fifth Congress, held in Copenhagen in 1909, is out of print.

The Proceedings of the Fourth and Sixth Congresses are obtainable at the following prices:

Report of the Fourth Congress, held in Brussels in 1906:

(1) A cloth-bound volume containing the official papers and proceedings ................ $3.50
(2) A cloth-bound volume containing the non-official papers .......................... 1.50

Report of the Sixth Congress, held in New York in 1912, in the form of two volumes of about 1100 pages each:

(1) In paper binding (2 vols.) .................................................. $7.00
(2) In cloth binding (2 vols.) ............................................... 8.00

The publications in English of the International Association are obtainable only from the McGraw-Hill Book Company, 239 West Thirty-ninth Street, New York.

The publications of the Association are also printed in German and French. Any inquiries concerning the publications in these languages should be addressed to the International Association for Testing Materials, 50 Nordbahnstrasse, Vienna, Austria.
A.S.T.M. STANDARDS

CONSISTING OF

STANDARD SPECIFICATIONS, STANDARD TESTS,
STANDARD METHODS, STANDARD DEFINITIONS, RECOMMENDED
PRACTICE
STANDARD SPECIFICATIONS
FOR
CARBON-STEEL RAILS.


The specifications for this material are issued under the fixed designation A1; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1901; REVISED, 1907, 1908, 1909, 1914.

INSPECTION.

1. Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the rails have been made and loaded in accordance with the terms of the specifications.

2. All tests and inspections shall be made at the place of manufacture, prior to shipment and shall be so conducted not to interfere unnecessarily with the operations of the mill.

MATERIAL.

3. The material shall be steel made by the Bessemer open-hearth process, as provided by the contract.

CHEMICAL REQUIREMENTS.

4. The chemical composition of each heat of the steel from which the rails are rolled, determined as prescribed in Section 4 of the standards, shall be such as to fulfill the following requirements:

- Carbon: 0.14-0.18%
- Silicon: 1.00-1.60%
- Manganese: 0.50-0.80%

Bessemer Steel.

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<th>Elements Considered</th>
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<td>50 - 69, incl.</td>
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<tr>
<td>Carbon, per cent.</td>
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<tr>
<td>Manganese, per cent.</td>
<td>0.80 - 1.10</td>
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<td>Phosphorus, max., per cent.</td>
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<td>Silicon, max., per cent.</td>
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Open-Hearth Steel.

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<th>Weights, lb. per yd.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 - 69, incl.</td>
</tr>
<tr>
<td>Carbon, per cent.</td>
<td>0.50 - 0.63</td>
</tr>
<tr>
<td>Manganese, per cent.</td>
<td>0.60 - 0.90</td>
</tr>
<tr>
<td>Phosphorus, max., per cent.</td>
<td>0.04</td>
</tr>
<tr>
<td>Silicon, max., per cent.</td>
<td>0.20</td>
</tr>
</tbody>
</table>

5. It is desired that the percentage of carbon in an entire order of rails shall average as high as the mean percentage between the upper and lower limits specified.

6. In order to ascertain whether the chemical composition is in accordance with the requirements, analyses shall be furnished as follows:

(a) For the Bessemer process, the manufacturer shall furnish to the inspector, daily, carbon determinations for each heat before the rails are shipped, and two chemical analyses every 24 hours representing the average of the elements, carbon, manganese, silicon, phosphorus, and sulfur contained in the steel, one for each day and night turn respectively. These analyses shall be made on drillings taken from the ladle test ingot not less than 3/8 in. beneath the surface.

(b) For the open-hearth process the manufacturer shall furnish the inspector with a chemical analysis of the elements, carbon, manganese, silicon, phosphorus, and sulfur for each heat.

(c) On request of the inspector, the manufacturer shall furnish a portion of the test ingot for check analysis.

PHYSICAL REQUIREMENTS.

7. Tests shall be made to determine:

(a) Ductility or toughness as opposed to brittleness;

(b) Soundness.
8. The physical qualities shall be determined by the drop test.

9. The drop-testing machine shall be the standard of the American Railway Engineering Association.

   (a) The tup shall weigh 2000 lb., and have a striking face with a radius of 5 in.

   (b) The anvil block shall weigh 20,000 lb., and be supported on springs.

   (c) The supports for the test pieces shall be a part of, or firmly secured to, the anvil. These supports shall be spaced 3 ft. between centers for rails 100 lb. per yd. or less in weight and 4 ft. for rails over 100 lb. per yd. in weight. The bearing surfaces of the supports shall have a radius of 5 in.

10. Drop tests shall be made on pieces of rail not less than 4 ft. and not more than 6 ft. long. These test pieces shall be cut from the top end of the top rail of the ingot, and marked on the base or head with gage marks 1 in. apart for 3 in. each side of the center of the test piece, for measuring the ductility of the metal.

11. The temperature of the test pieces shall be between 60 and 100° F.

12. The test piece shall ordinarily be placed head upwards on the supports, and be subjected to impact of the tup falling free from the following heights:

<table>
<thead>
<tr>
<th>Weight of Rail, lb. per yd.</th>
<th>Height of Drop, ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 - 60 inclusive</td>
<td>15</td>
</tr>
<tr>
<td>61 - 79</td>
<td>16</td>
</tr>
<tr>
<td>80 - 90</td>
<td>17</td>
</tr>
<tr>
<td>91 - 100</td>
<td>18</td>
</tr>
<tr>
<td>101 - 120</td>
<td>21</td>
</tr>
</tbody>
</table>

13. (a) Under impacts, the rail under one or more blows shall show at least 6 per cent elongation for one inch or 5 per cent each for two consecutive inches of the 6-in. scale, marked as described in Section 10.

   (b) A sufficient number of blows shall be given to determine the complete elongation of the test piece of at least every fifth heat of Bessemer steel, and of one out of every three test pieces of a heat of open-hearth steel.
14. It is desired that the permanent set after one blow under the drop test shall not exceed that in the following table, and a record shall be made of the information:

<table>
<thead>
<tr>
<th>Section</th>
<th>Weight, lb. per yd</th>
<th>Moment of Inertia</th>
<th>Permanent Set, in. (measured by middle ordinate in a length of 3 ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.R.A. - B</td>
<td>100</td>
<td>41.30</td>
<td>Bessemer Process: 2.05</td>
</tr>
<tr>
<td>A.R.A. - B</td>
<td>90</td>
<td>32.30</td>
<td>Bessemer Process: 2.20</td>
</tr>
<tr>
<td>A.R.A. - B</td>
<td>80</td>
<td>25.00</td>
<td>Bessemer Process: 3.15</td>
</tr>
</tbody>
</table>

15. Test pieces which do not break under the first or subsequent blows shall be nicked and broken, to determine whether the interior metal is sound. The words "interior defect" in the following sections shall be interpreted to mean seams, laminations, cavities, or interposed foreign matter made visible by the destruction test, saws or drills.

16. One piece shall be tested from each heat of Bessemer steel.

(a) If a test piece does not break at the first blow and shows the required elongation (Section 13), all the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(b) If, however, the test piece shows interior defect, the other test requirements having been met, all the top rails of the heat shall be accepted as special rails and further test shall be made on the second rails, as described in Paragraph (d) of this section.

(c) If the test piece breaks at the first blow or does not show the required elongation (Section 13), all the top rails of the heat shall be rejected.

(d) A second test shall then be made of the test piece selected by the inspector from the top end of any second rail.
or the bottom end of any top rail of the same heat, preferably the same ingot. If the test piece does not break at the first blow and shows the required elongation (Section 13), all the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(e) If, however, the test piece shows interior defect, other test requirements having been met, all the second rails of the heat shall be accepted as special rails and further test shall be made on the third rails, as described in Paragraph (d) of this section.

(f) If the test piece breaks at the first blow or does not show the required elongation (Section 13), all the second rails of the heat shall be rejected.

(g) A third test shall then be made of the test piece selected by the inspector from the top end of any third rail or the bottom end of any second rail of the same heat, preferably the same ingot. If the test piece does not break at the first blow and shows the required elongation (Section 13), all the remainder of the rails of the heat shall be accepted, provided that the test piece when broken does not show interior defect.

(h) If, however, the test piece shows interior defect, other test requirements having been met, all the remainder of the rails of the heat shall be accepted as special rails.

(i) If the test piece breaks at the first blow or does not show the required elongation (Section 13), all the remainder of the rails of the heat shall be rejected.

17. Test pieces shall be selected from the second, middle and last full ingot of each open-hearth heat.

(a) If two of these test pieces do not break at the first blow and both show the required elongation (Section 13), all of the rails of the heat shall be accepted, provided that none of the three test pieces when broken shows interior defect.

(b) If, however, any one of the three test pieces shows interior defect, the other test requirements having been met, all the top rails of the heat shall be accepted as special rails and further test shall be made on the second rails, as described in Paragraph (d) of this section.

(c) If two of the test pieces break at the first blow or
(d) A second test shall then be made from three test pieces selected by the inspector from the top end of any second rails or the bottom end of any top rails of the same heat, preferably the same ingots. If two of the test pieces do not break at the first blow and both show the required elongation (Section 13), all the remainder of the rails of the heat shall be accepted, provided that none of the three test pieces when broken shows interior defect.

(e) If, however, any one of the three test pieces shows interior defect, the other test requirements having been met, all the top rails of the heat shall be accepted as special rails and further test shall be made on the third rails, as described in Paragraph (g) of this section.

(f) If two of the test pieces break at the first blow or do not show the required elongation (Section 13), all the second rails of the heat shall be rejected.

(g) A third test shall then be made from three test pieces selected by the inspector from the top end of any third rails or the bottom end of any second rails of the same heat, preferably the same ingots. If two of the test pieces do not break at the first blow and both show the required elongation (Section 13), all the remainder of the rails of the heat shall be accepted, provided that none of the three test pieces when broken shows interior defect.

(h) If, however, any one of the three test pieces shows interior defect, the other test requirements having been met, all the remainder of the rails of the heat shall be accepted as special rails.

(i) If two of the test pieces break at the first blow or do not show the required elongation (Section 13), all the remainder of the rails of the heat shall be rejected.

18. No. 1 classification rails shall be free from injurious No. 1 Rails defects and flaws of all kinds.

19. (a) Rails which by reason of surface imperfections, No. 2 Rails or for causes mentioned in Section 30 hereof, are not classed as No. 1 rails will be accepted as No. 2 rails; but No. 2 rails which contain imperfections in such number or of such character as will, in the judgment of the inspector, render them unfit for recognized No. 2 uses, will not be accepted for shipment.
(b) No. 2 rails to the extent of 5 per cent of the whole order will be received. All rails accepted as No. 2 rails shall have the ends painted white, and shall have two prick-punch marks on the side of the web near the heat number near the end of the rail, so placed as not to be covered by the splice bars.

20. Rails accepted as special rails in accordance with Sections 16 and 17, shall have the ends painted blue and shall have three prick-punch marks on the side of the web near the heat number, so placed as not to be covered by the splice bars.

DETAILS OF MANUFACTURE.

21. The entire process of manufacture shall be in accordance with the best current state of the art.

22. Bled ingots shall not be used.

23. There shall be sheared from the end of the bloom formed from the top of the ingot, sufficient metal to secure sound rails.

24. The standard length of the rails shall be 33 ft., at temperature of 60° F. Ten per cent of the entire order will be accepted in shorter lengths varying by 1 ft. from 32 to 34 ft. A variation of \( \frac{1}{4} \) in. from the specified lengths will be allowed, except that for 15 per cent of the order a variation of \( \frac{3}{8} \) in. from the specified lengths will be permitted. No. 1 rails less than 33 ft. long shall have the ends painted green.

25. The number of passes and speed of the train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws, for a rail 33 ft. in length, and 100-lb. section, of \( 6\frac{3}{4} \) in., and \( \frac{1}{8} \) in. less for each 10-lb. decrease in section or \( \frac{1}{8} \) in. more for each 10-lb. increase in section.

26. The bars shall not be held for the purpose of reducing their temperature, nor shall any artificial means of cooling them be used after they leave the finishing pass. Rails, when on the cooling beds, shall be protected from snow and water.

27. The section of rails shall conform as accurately as possible to the templet furnished by the railroad company. A variation in height of \( \frac{1}{64} \) in. less or \( \frac{1}{32} \) in. greater than the
but no variation shall be allowed in the dimensions affecting the fit of the splice bars.

28. The weight of the rails specified in the order shall be maintained as nearly as possible, after complying with Section 27. A variation of 0.5 per cent from the calculated weight of section, as applied to an entire order, will be allowed.

29. Rails accepted will be paid for according to actual weights.

30. (a) The hot-straightening shall be carefully done, so that gagging under the cold presses will be reduced to a minimum. Any rails coming to the straightening presses showing sharp kinks or greater camber than that indicated by the middle ordinate of 4 in. in 33 ft. for A. R. A. type of sections, or 5 in. for A. S. C. E. type of sections, will be at once classed as No. 2 rails. The distance between the supports of rails in the straightening presses shall not be less than 42 in. The supports shall have flat surfaces and be out of wind.

(b) Rails heard to snap or check while being straightened shall be at once rejected.

31. Circular holes for joint bolts shall be drilled to conform to the drawing and dimensions furnished by the railroad company. A variation of \( \frac{1}{2} \) in. larger than the specified size of holes will be allowed.

32. (a) All rails shall be smooth on the heads, straight in line and surface, and without any twists, waves or kinks. They shall be sawed square at the ends, a variation of not more than \( \frac{1}{2} \) in. being allowed, and burrs shall be carefully removed.

(b) Rails improperly drilled or straightened, or from which the burrs have not been removed, shall be rejected, but may be accepted after being properly finished.

(c) When any finished rail shows interior defect at either end, or in any drilled hole, the entire rail shall be rejected.

33. (a) The name of the manufacturer, the weight and type of rail, and the month and year of manufacture, shall be rolled in raised letters and figures on the side of the web. The number of the heat and a letter indicating the portion of the ingot from which the rail was made, shall be plainly stamped on the web of each rail, where it will not be covered by the splice bars. The top rails shall be lettered "A," and the
succeeding ones "B," "C," "D," etc., consecutively; but in case of a top discard of 20 or more per cent, the letter "A" will be omitted. All markings of rails shall be done so effectively that the marks may be read as long as the rails are in service.

(b) Open-hearth rails shall be branded or stamped "O. H." in addition to the other marks.

34. All classes of rails shall be kept separate from each other.
STANDARD SPECIFICATIONS
FOR
OPEN-HEARTH STEEL GIRDER AND HIGH TEE RAILS.

Serial Designation: A 2-12.

The specifications for this material are issued under the fixed designation A 2; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process. The entire process of manufacture and testing shall accord with the best current practice.

2. Bled ingots, and ingots or blooms which show the effects of injurious treatment, shall not be used.

3. A sufficient discard from the top of each ingot shall be made at any stage of the manufacture to obtain sound rails. When finished rails show piping, they may be cut to shorter lengths until all evidence of this is removed.

II. CHEMICAL PROPERTIES AND TESTS.

4. The steel shall conform to either of the following requirements as to chemical composition, as specified in the order:

<table>
<thead>
<tr>
<th></th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, per cent</td>
<td>0.60 – 0.75</td>
<td>0.70 – 0.85</td>
</tr>
<tr>
<td>Manganese, per cent</td>
<td>0.60 – 0.90</td>
<td>0.60 – 0.90</td>
</tr>
<tr>
<td>Silicon, per cent</td>
<td>not over 0.20</td>
<td>not over 0.20</td>
</tr>
<tr>
<td>Phosphorus, per cent</td>
<td>&quot; &quot; 0.04</td>
<td>&quot; &quot; 0.04</td>
</tr>
</tbody>
</table>

(27)
5. To determine whether the material conforms to the requirements specified in Section 4, an analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt. Drillings for analysis shall be taken not less than \(\frac{3}{4}\) in. beneath the surface of the test ingot. A copy of this analysis shall be given to the purchaser or his representative.

6. A check analysis may be made from time to time by the purchaser from a test ingot or drillings therefrom furnished by the manufacturer.

III. PHYSICAL PROPERTIES AND TESTS.

7. (a) The test specimen shall be tested on a drop-test machine of the type recommended by the American Railway Engineering Association. The specimen shall be placed head upwards on the supports of the machine, and shall not break when tested with one blow in accordance with the following conditions:

<table>
<thead>
<tr>
<th>Weight and Height of Rail</th>
<th>Temperature of Specimen, deg. Fahr.</th>
<th>Distance between Supports, ft.</th>
<th>Weight of Tup, lb.</th>
<th>Height of Drop, ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rails weighing over 100 lb. per yd. and over 7 in. in depth</td>
<td>60 - 120</td>
<td>3</td>
<td>2000</td>
<td>Class A 15, Class B 12</td>
</tr>
<tr>
<td>All other sections</td>
<td>60 - 120</td>
<td>3</td>
<td>2000</td>
<td>13</td>
</tr>
</tbody>
</table>

(b) The atmospheric temperature at the time of testing shall be recorded in the test report.

(c) The testing shall proceed concurrently with the operation of the works.

8. (a) Three rails, each from the top of one of three ingots from each melt, shall be selected by the inspector, and a test specimen shall be taken from each of two of these.

(b) Drop test specimens shall not be less than 4 nor more than 6 ft. in length.

9. Two drop tests shall be made from each melt.

10. If the result of the drop test on only one of the two specimens representing the rails in a melt, does not conform to the requirements specified in Section 7, a retest on a specimen
from the third rail selected shall be made and this shall govern the acceptance or rejection of the rails from that melt.

IV. STANDARD SECTIONS, LENGTHS, AND WEIGHTS.

11. (a) The cold templet of the manufacturer shall conform to the specified section as shown in detail on the drawing of the purchaser, and shall at all times be maintained perfect.

(b) The section of the rail shall conform as accurately as possible to the templet, and within the following tolerances:

1. The height shall not vary more than $\frac{1}{64}$ in. under nor more than $\frac{3}{32}$ in. over that specified.

2. The over-all width of head and tram shall not vary more than $\frac{1}{8}$ in. from that specified. Any variation which would affect the gage line more than $\frac{3}{32}$ in. will not be allowed.

3. The width of base shall not vary more than $\frac{1}{8}$ in. under that specified for widths less than $6\frac{1}{2}$ in.; $\frac{3}{16}$ in. under for a width of $6\frac{1}{2}$ in.; and $\frac{1}{4}$ in. under for a width of 7 in.

4. Any variation which would affect the fit of the splice bars will not be allowed.

5. The base of the rail shall be at right angles to the web; and the convexity shall not exceed $\frac{3}{32}$ in.

(c) When necessary on account of the type of track construction, and notice to that effect has been given to the manufacturer, special care shall be taken to maintain the proper position of the gage line with respect to the outer edge of the base.

12. (a) Unless otherwise specified, the lengths of rails at a temperature of $60^\circ$ F. shall be 60 and 62 ft. for those sections in which the weight per yard will permit.

(b) The lengths shall not vary more than $\frac{1}{4}$ in. from those specified.

(c) Shorter lengths, varying by even feet down to 40 ft., will be accepted to the extent of 10 per cent by weight of the entire order.

13. (a) The weight of the rails per yard as specified in the order shall be maintained as nearly as possible after conforming to the requirements specified in Section 11.
Specifications for Girder and High Tee Rails.

(b) The total weight of an order shall not vary more than 0.5 per cent from that specified.
(c) Payments shall be based on actual weights.

V. WORKMANSHIP AND FINISH.

14. (a) Rails on the hot beds shall be protected from water or snow, and shall be carefully manipulated to minimize cold straightening.

(b) The distance between the rail supports in the cold-straightening presses shall not be less than 42 in., except as may be necessary near the ends of the rails. The gag shall have rounded corners to avoid injury to the rails.

15. (a) Circular holes for joint bolts, bonds, and tie rods shall be drilled to conform to the drawings and dimensions furnished by the purchaser.

(b) In Class A rails the tie-rod holes may be punched.

16. The ends shall be milled square laterally and vertically, but the base may be undercut \( \frac{3}{8} \) in.

17. (a) Rails shall be smooth on the head, straight in line and surface without any twists, waves, or kinks, particular attention being given to having the ends without kinks or drop.

(b) All burrs or flow caused by drilling or sawing shall be carefully removed.

(c) Rails shall be free from gag marks and other injurious defects of cold-straightening.

VI. CLASSIFICATION OF RAILS.

18. Rails which are free from injurious defects and flaws of all kinds shall be classed as No. 1 Rails.

19. (a) Rails which are rough on the head or which by reason of surface or other imperfections are not classed as No. 1 rails, shall be classed as No. 2 rails; provided they do not, in the judgment of the inspector, contain imperfections in such number and of such character as to render them unfit for No. 2 rail uses, and provided they conform to the requirements specified in Section 11.

(b) Rails which have flaws in the head exceeding \( \frac{1}{4} \) in. in depth, or in the base exceeding \( \frac{1}{8} \) in. in depth, shall not be classed as No. 2 rails.
(c) No. 2 rails will be accepted to the extent of 10 per cent by weight of the entire order.

VII. MARKING AND LOADING.

20. (a) The name or brand of the manufacturer, the year and month of manufacture, the letters “O. H.,” the weight of the rail, and the section number, shall be legibly rolled in raised letters and figures on the web. The melt number shall be legibly stamped on each rail where it will not be covered subsequently by the joint plates.

(b) Both ends of all short-length No. 1 rails shall be painted green.

Both ends of all No. 2 rails shall be painted white and shall have two heavy center-punch marks on the web at each end at such a distance from the end that they will not be covered subsequently by the joint plates.

21. (a) Rails shall be loaded in the presence of the inspector, and shall be handled in such a manner as not to bruise the flanges or cause other injuries.

(b) Rails of each class shall be placed together in loading.

(c) Rails shall be paired as to length before shipment.

VIII. INSPECTION.

22. The inspector representing the purchaser shall have tree entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.
STANDARD SPECIFICATIONS
FOR
LOW-CARBON-STEEL SPLICE BARS.

Serial Designation: A3 - 14.

The specifications for this material are issued under the fixed designation A3; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1901; REVISED, 1909, 1912, 1913, 1914.

I. MANUFACTURE.

1. The steel may be made by the Bessemer, open-hearth, or any other process approved by the purchaser.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Composition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td></td>
</tr>
<tr>
<td>Bessemer</td>
<td>≤ 0.10 per cent</td>
</tr>
<tr>
<td>Open-hearth</td>
<td>≤ 0.05</td>
</tr>
</tbody>
</table>

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

(32)
4. An analysis may be made by the purchaser from a finished splice bar representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

5. The splice bars shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>55 000 – 65 000</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent</td>
<td>25</td>
</tr>
</tbody>
</table>

6. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

7. Tension and bend test specimens shall be taken from the finished rolled bars. Tension test specimens shall be of 8-in. gage length. Bend tests may be made of an unpunched splice bar, flattened if necessary.

8. (a) One tension and one bend test shall be made from each melt.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH.

9. (a) The splice bars shall be smoothly rolled, true to template, and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and notching shall conform to the dimensions specified by the purchaser. A variation of \( \frac{1}{32} \) in. from the specified size and location of holes, and of \( \frac{1}{8} \) in. from the specified length of splice bar, will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The maximum camber in either plane shall not exceed \( \frac{1}{16} \) in. in 24 in., except as specified in Paragraph (b).
Specifications for Low-Carbon Splice Bars.

(b) For splice bars for girder and high tee rails, any variation from a straight line in a vertical plane shall be such as will make the bars high in the center, and the maximum camber in this plane shall not exceed $\frac{3}{64}$ in. in 24 in. Any variation from a straight line in a horizontal plane shall be such as will make the bars convex toward the web of the rail, and the maximum camber in this plane shall not exceed $\frac{1}{16}$ in. in 24 in.

Finish.

10. The finished splice bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking.

11. The name or brand of the manufacturer and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished splice bar.

VI. INSPECTION AND REJECTION.

Inspection.

12. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the splice bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the splice bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

13. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(b) Splice bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

14. Samples tested in accordance with Section 4, which represent rejected splice bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
MEDIUM-CARBON-STEEL SPLICE BARS.


The specifications for this material are issued under the fixed designation A 4; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913; REVISED, 1914.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

2. (a) The splice bars may be punched, slotted, and, in the case of special designs, shaped either hot or cold.

   (b) Bars that are punched, slotted or shaped cold shall be subsequently annealed.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Chemical Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon................not under 0.30 per cent</td>
</tr>
<tr>
<td>Phosphorus............not over 0.04 &quot;</td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least \( \frac{1}{8} \) in. beneath the surface of a test
ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a finished splice bar representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

6. The splice bars shall conform to the following minimum requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in</td>
<td>68 000</td>
</tr>
<tr>
<td>Elongation in 2 in., per cent</td>
<td>1 600 000</td>
</tr>
</tbody>
</table>

   but in no case under 20 per cent.

7. The bend test specimen specified in Section 8 shall bend cold through 180 deg. around a pin the diameter of which is equal to twice the thickness of the specimen, without cracking on the outside of the bent portion.

8. Tension and bend test specimens shall be taken from the finished bars. Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load
shall be axial. Bend test specimens may be $\frac{1}{2}$ in. square in section, or rectangular in section with two parallel faces as rolled.

9. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 7: A piece of the finished bar shall bend cold through 90 deg. around a pin the diameter of which is equal to twice the greatest thickness of the section, without cracking on the outside of the bent portion.

10. (a) One tension and one bend test shall be made from each melt.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH.

11. (a) The splice bars shall be smoothly rolled, true to template, and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and notching shall conform to the dimensions specified by the purchaser. A variation of $\frac{1}{32}$ in. from the specified size of holes, of $\frac{1}{16}$ in. from the specified location of holes, and of $\frac{1}{8}$ in. from the specified length of splice bar, will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The maximum camber in either plane shall not exceed $\frac{1}{16}$ in. in 24 in., except as specified in Paragraph (b).

(b) For splice bars for girder and high tee rails, any variation from a straight line in a vertical plane shall be such as will make the bars high in the center, and the maximum camber in this plane shall not exceed $\frac{3}{4}$ in. in 24 in. Any variation from a straight line in a horizontal plane shall be such as will make the bars convex toward the web of the rail, and the maximum camber in this plane shall not exceed $\frac{1}{16}$ in. in 24 in.
Specifications for Medium-Carbon Splice Bars.

Finish. 12. The finished splice bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 13. The name or brand of the manufacturer and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished splice bar.

VI. INSPECTION AND REJECTION

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the splice bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the splice bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Splice bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 5, which represent rejected splice bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
HIGH-CARBON-STEEL SPLICE BARS.


The specifications for this material are issued under the fixed designation A 5; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1913; Revised, 1914.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.
2. The splice bars shall be punched, slotted and, in the case of special designs, shaped at a temperature not less than 750°C.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

   Carbon.................................not under 0.45 per cent
   Phosphorus.............................not over 0.04 "

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least \( \frac{3}{8} \) in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.
5. An analysis may be made by the purchaser from a finished splice bar representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

6. The splice bars shall conform to the following minimum requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength</td>
<td>85,000 lb. per sq. in</td>
</tr>
<tr>
<td>Elongation</td>
<td>14 per cent.</td>
</tr>
</tbody>
</table>

7. The bend test specimen specified in Section 8 shall bend cold through 90 deg. around a pin the diameter of which is

8. Tension and bend test specimens shall be taken from the finished bars. Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens may be \( \frac{3}{8} \) in. square in section, or rectangular in section with two parallel faces as rolled.

9. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 7: A piece of the finished bar shall bend cold through 45 deg. around a pin the diameter of which is equal to three times the thickness of the specimen, without cracking on the outside of the bent portion.
to three times the greatest thickness of the section, without cracking on the outside of the bent portion.

10. (a) One tension and one bend test shall be made from each melt

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 and any part of the fracture is more than \( \frac{\frac{3}{4}}{\text{in.}} \) from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH.

11. (a) The splice bars shall be smoothly rolled, true to templet, and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and notching shall conform to the dimensions specified by the purchaser. A variation of \( \frac{\frac{1}{2}}{\text{in.}} \) from the specified size of holes, of \( \frac{\frac{1}{8}}{\text{in.}} \) from the specified location of holes, and of \( \frac{\frac{1}{2}}{\text{in.}} \) from the specified length of splice bar, will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The maximum camber in either plane shall not exceed \( \frac{\frac{1}{16}}{\text{in.}} \) in 24 in., except as specified in Paragraph (b).

(b) For splice bars for girder and high tee rails, any variation from a straight line in a vertical plane shall be such as will make the bars high in the center, and the maximum camber in this plane shall not exceed \( \frac{\frac{2}{3}}{\text{in.}} \) in 24 in. Any variation from a straight line in a horizontal plane shall be such as will make the bars convex toward the web of the rail, and the maximum camber in this plane shall not exceed \( \frac{\frac{1}{6}}{\text{in.}} \) in 24 in.

12. The finished splice bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

13. The name or brand of the manufacturer and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished splice bar.
VI. INSPECTION AND REJECTION.

**Inspection.**

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the splice bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the splice bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

**Rejection.**

15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

   (b) Splice bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

**Rehearing.**

16. Samples tested in accordance with Section 5, which represent rejected splice bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS

FOR

EXTRA-HIGH-CARBON-STEEL SPLICE BARS.


The specifications for this material are issued under the fixed designation A 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913; REVISED, 1914.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

2. The splice bars shall be punched, slotted, sheared and, in the case of special designs, shaped at a temperature not less than 750° C.; except that bars may be cold-sawed to length.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirement as to chemical composition:

   Phosphorus.......................... not over 0.04 per cent

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least \( \frac{1}{4} \) in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser

(43)
or his representative, and shall conform to the requirement specified in Section 3.

5. An analysis may be made by the purchaser from a finished splice bar representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

6. The splice bars shall conform to the following minimum requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>100 000</td>
</tr>
<tr>
<td>Elongation in 2 in., per cent.</td>
<td>10</td>
</tr>
</tbody>
</table>

7. The bend test specimen specified in Section 8 shall bend cold through 60 deg. around a pin the diameter of which is equal to three times the thickness of the specimen, without cracking on the outside of the bent portion.

8. Tension and bend test specimens shall be taken from the finished bars. Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens may be \( \frac{3}{4} \) in. square in section, or rectangular in section with two parallel faces as rolled.

9. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 7: A piece of the finished bar shall bend
cold through 30 deg. around a pin the diameter of which is equal
to three times the greatest thickness of the section, without
cracking on the outside of the bent portion.

10. (a) One tension and one bend test shall be made from each melt.

(b) If any test specimen shows defective machining or
develops flaws, it may be discarded and another specimen
substituted.

(c) If the percentage of elongation of any tension test speci-
men is less than that specified in Section 6 and any part of
the fracture is more than \( \frac{3}{8} \) in. from the center of the gage length,
as indicated by scribe scratches marked on the specimen before
testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH.

11. (a) The splice bars shall be smoothly rolled, true to
workmanship, and shall accurately fit the rails for which they are
intended. The bars shall be sheared to length, and the punching
and notching shall conform to the dimensions specified by the
purchaser. A variation of \( \frac{3}{32} \) in. from the specified size of holes,
of \( \frac{1}{16} \) in. from the specified location of holes, and of \( \frac{1}{2} \) in. from the
specified length of splice bar, will be permitted. Any variation
from a straight line in a vertical plane shall be such as will make
the bars high in the center. The maximum camber in either
plane shall not exceed \( \frac{1}{16} \) in. in 24 in., except as specified in Para-
graph (b).

(b) For splice bars for girder and high tee rails, any vari-
ation from a straight line in a vertical plane shall be such as will
make the bars high in the center, and the maximum camber
in this plane shall not exceed \( \frac{3}{8} \) in. in 24 in. Any variation from
a straight line in a horizontal plane shall be such as will make
the bars convex toward the web of the rail, and the maximum
camber in this plane shall not exceed \( \frac{1}{16} \) in. in 24 in.

12. The finished splice bars shall be free from injurious finish.
defects and shall have a workmanlike finish.

V. MARKING.

13. The name or brand of the manufacturer and the year of manufacture shall be rolled in raised letters and figures on
the side of the rolled bars, and a portion of this marking shall appear on each finished splice bar.

VI. INSPECTION AND REJECTION.

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the splice bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the splice bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Splice bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 5, which represent rejected splice bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
QUENCHED HIGH-CARBON-STEEL SPLICE BARS.


The specifications for this material are issued under the fixed designation A 49; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.
2. The splice bars shall be punched, slotted and, in the case of special designs, shaped at a temperature not less than 750° C., and subsequently quenched.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

- Carbon: not over 0.60 per cent
- Manganese: 0.80%
- Phosphorus: 0.04%

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made
Check Analyses.

5. An analysis may be made by the purchaser from a finished splice bar representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

6. (a) The splice bars shall conform to the following minimum requirements as to tensile properties:

- Tensile strength, lb. per sq. in. ........................................ 100,000
- Yield point, " .................................................. 65,000
- Elongation in 2 in., per cent ........................................ 10

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. The bend test specimen specified in Section 8 shall bend cold through 90 deg. around a pin the diameter of which is equal to three times the thickness of the specimen, without cracking on the outside of the bent portion.

III. PHYSICAL PROPERTIES AND TESTS.

8. Tension and bend test specimens shall be taken from the finished bars. Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit
the holders of the testing machine in such a way that the load shall be axial. Bend test specimens may be \( \frac{1}{2} \) in. square in section, or rectangular in section with two parallel faces as rolled, with corners rounded to a radius not over \( \frac{1}{16} \) in.

9. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 7: A piece of the finished bar shall bend cold through 45 deg. around a pin the diameter of which is equal to three times the greatest thickness of the section, without cracking on the outside of the bent portion.

10. (a) One tension and one bend test shall be made from each melt.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

11. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-treat such lot one or more times and retests shall be made as specified in Section 10.

IV. WORKMANSHP AND FINISH.

12. The splice bars shall be smoothly rolled, true to templet, and shall accurately fit the rails for which they are intended. The bars shall be sheared to length, and the punching and notching shall conform to the dimensions specified by the purchaser. A variation of \( \frac{3}{16} \) in. from the specified size of holes, of \( \frac{1}{16} \) in. from the specified location of holes, and of \( \frac{1}{8} \) in. from the specified length of splice bar, will be permitted. Any variation from a straight line in a vertical plane shall be such as will make the bars high in the center. The maximum camber in either plane shall not exceed \( \frac{1}{16} \) in. in 24 in.

13. The finished splice bars shall be free from injurious defects and shall have a workmanlike finish.
50  Specifications for Quenched Splice Bars.

V. MARKING.

Marking.  14. The name or brand of the manufacturer and the year of manufacture shall be rolled in raised letters and figures on the side of the rolled bars, and a portion of this marking shall appear on each finished splice bar.

VI. INSPECTION AND REJECTION.

Inspection.  15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the splice bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the splice bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.  16. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Splice bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.  17. Samples tested in accordance with Section 5, which represent rejected splice bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
QUENCHED CARBON-STEEL TRACK BOLTS.

Serial Designation: A 50-16.

The specifications for this material are issued under the fixed designation A 50; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1915; Revised, 1916.

I. MANUFACTURE.

1. (a) The steel for the bolts shall be made by the open-hearth process.

(b) The steel for the nuts shall be made by the Bessemer or open-hearth process.

2. The bolts shall enter the quenching medium at a temperature not less than 790° C. The threads may be rolled either hot or cold.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel for the bolts shall conform to the following requirements as to chemical composition:

- Carbon: not under 0.30 per cent
- Phosphorus: not over 0.04 "

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, man-
ganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least \(\frac{1}{2}\) in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a finished bolt representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

\[\text{Radius not less than } \frac{1}{8}\text{ in.} \]

\[2\frac{1}{4}\text{ in.} \]

\[2\text{" Gage Length} \]

Note: The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any form which will fit the Holders of the Testing Machine.

**Fig. 1.**

### III PHYSICAL PROPERTIES AND TESTS.

#### Tension Tests.

6. \((a)\) The bolts shall conform to the following minimum requirements as to tensile properties:

- Tensile strength, lb. per sq. in. \(\ldots 100,000\)
- Yield point, \(\ldots 70,000\)
- Elongation in 2 in., per cent \(\ldots 12\)

\((b)\) Nuts shall be capable of developing the strength of the finished bolt up to its yield point.

\((c)\) The yield point shall be determined by the drop of the beam of the testing machine.

#### Bend Tests.

7. Full-size bolts shall bend cold through 45 deg. around a pin the diameter of which is equal to the diameter of the bolt, without cracking on the outside of the bent portion.
8. Tension test specimens shall be taken from the finished bolts and shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

9. (a) One tension and one bend test shall be made from each lot of 50 kegs or fraction thereof.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is more than \(\frac{3}{4}\) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, or if the bend test specimen breaks in the threaded portion, a retest shall be allowed.

10. If the results of the physical tests of any test lot do not conform to the requirements specified, two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.

IV. WORKMANSHIP AND FINISH.

11. The bolts and nuts shall conform to the dimensions specified by the purchaser. The bolts shall be neatly formed, free from fins or nickings. The head shall be concentric with, and firmly joined to, the body of the bolt, with the under side of the head at right angles to the body of the bolt. The threads shall be sharp and true to gage and of the pattern specified by the purchaser. The nuts shall fit the bolts tightly so as to require a wrench not more than 10 in. in length to turn them down without distorting the threads or twisting the bolts. The nuts shall be screwed on before shipping, a sufficient number of turns to hold them on to destination. A variation of \(\frac{3}{2}\) in. under and \(\frac{1}{4}\) in. over the specified diameter of the body of the bolt will be permitted. The diameter of the rolled thread shall not exceed the diameter of the body of the bolt more than \(\frac{1}{16}\) in. for \(\frac{7}{8}\)-in. bolts and \(\frac{3}{16}\) in. for 1-in. bolts. The length of the bolt under the head shall not vary more than \(\frac{1}{8}\) in. from that specified. A variation in the dimensions of the elliptical shoulders under the
Specifications for Carbon-Steel Track Bolts.

head of the bolt of \( \frac{3}{8} \) in. from the specified size will be permitted. A taper of the shoulder of \( \frac{1}{8} \) in. will be permitted.

Finish

12. The finished bolts and nuts shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING

Marking.

13. A letter or brand indicating the manufacturer shall be pressed on the head of the bolt when it is formed.

VI. INSPECTION AND REJECTION.

Inspection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bolts and nuts ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bolts and nuts are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as to not interfere unnecessarily with the operation of the works.

Rejection.

15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Bolts and nuts which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

16. Samples tested in accordance with Section 5, which represent rejected bolts and nuts, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS FOR QUENCHED ALLOY-STEEL TRACK BOLTS.

Serial Designation: A 51-16.

The specifications for this material are issued under the fixed designation A 51; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1915; Revised, 1916.

I. MANUFACTURE

1. (a) The steel for the bolts shall be made by the open-hearth or electric process.
   (b) The steel for the nuts shall be made by the Bessemer or open-hearth process.

2. The bolts shall enter the quenching medium at a temperature of not less than 790° C. The threads may be rolled either hot or cold.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel for the bolts shall conform to the following requirement as to chemical composition:

   Phosphorus .................. not over 0.035 per cent.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, man-
ganese, phosphorus and sulfur, and any other elements used to obtain the physical properties specified in Sections 6 and 7. This analysis shall be made from drillings taken at least $\frac{1}{4}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirement specified in Section 3.

5. An analysis may be made by the purchaser from a finished bolt representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

Check Analyses.

Check Analyses. 

Tension Tests.

6. (a) The bolts shall conform to the following minimum requirements as to tensile properties:

- Tensile strength, lb. per sq. in. ......................... 110 000
- Yield point, " " ....................................... 85 000
- Elongation in 2 in., per cent............................... 12

(b) Nuts shall be capable of developing the full strength of the finished bolt up to its yield point.

(c) The yield point shall be determined by the drop of the beam of the testing machine.

Bend Tests.

7. Full-size bolts shall bend cold through 90 deg. around a pin the diameter of which is equal to the diameter of the bolt, without cracking on the outside of the bent portion.
8. Tension test specimens shall be taken from the finished bolts and shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

9. (a) One tension and one bend test shall be made from each lot of 50 kegs or fraction thereof.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is more than \( \frac{3}{8} \) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, or if the bend test specimen breaks in the threaded portion, a retest shall be allowed.

10. If the results of the physical tests of any test lot do not conform to the requirements specified, two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.

IV. WORKMANSHIP AND FINISH.

11. The bolts and nuts shall conform to the dimensions specified by the purchaser. The bolts shall be neatly formed, free from fins or nickings. The head shall be concentric with, and firmly joined to, the body of the bolt, with the under side of the head at right angles to the body of the bolt. The threads shall be sharp and true to gage and of the pattern specified by the purchaser. The nuts shall fit the bolts tightly so as to require a wrench not more than 10 in. in length to turn them down without distorting the threads or twisting the bolts. The nuts shall be screwed on before shipping, a sufficient number of turns to hold them on to destination. A variation of \( \frac{1}{32} \) in. under and \( \frac{3}{64} \) in. over the specified diameter of the body of the bolt will be permitted. The diameter of the rolled thread shall not exceed the diameter of the body of the bolt more than \( \frac{1}{16} \) in. for \( \frac{7}{8} \)-in. bolts and \( \frac{3}{32} \) in. for 1-in. bolts. The length of the bolt under the head shall not vary more than \( \frac{1}{4} \) in. from that specified. A variation in the dimensions of the elliptical shoulders under the head of the bolt of \( \frac{1}{32} \) in. from the speci-
Specifications for Alloy-Steel Track Bolts.

fied size will be permitted. A taper of the shoulder of \( \frac{1}{32} \) in. will be permitted.

**Finish.**

12. The finished bolts and nuts shall be free from injurious defects and shall have a workmanlike finish.

**V. MARKING.**

**Marking.**

13. A letter or brand indicating the manufacturer shall be pressed on the head of the bolt when it is formed.

**VI. INSPECTION AND REJECTION.**

**Inspection.**

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bolts and nuts ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bolts and nuts are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as to not interfere unnecessarily with the operation of the works.

**Rejection.**

15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Bolts and nuts which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

**Rehearing.**

16. Samples tested in accordance with Section 5, which represent rejected bolts and nuts, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS
FOR
STRUCTURAL STEEL FOR BRIDGES.

Serial Designation: A 7-16.

The specifications for this material are issued under the fixed designation A 7; the final number indicates the year of original issue, or in the case of revision, the year of last revision.


1. The Standard Specifications for Steel Castings (Serial Designation: A 27), adopted by the American Society for Testing Materials, shall govern the purchase of steel castings for bridges. Unless otherwise specified, Class B castings, medium grade, shall be used.

I. MANUFACTURE.

2. The steel shall be made by the open-hearth process

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Structural Steel</th>
<th>Rivet Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus Acid</td>
<td>not over 0.06 not over 0.04 per cent</td>
</tr>
<tr>
<td>Basic</td>
<td>0.04 0.04</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.05 0.045</td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.
5. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

6. (a) The material shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Properties Considered</th>
<th>Structural Steel</th>
<th>Rivet Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>55 000 - 65 000≤</td>
<td>46 000 - 56 000</td>
</tr>
<tr>
<td>Yield point, min., &quot;&quot;</td>
<td>0.5 tens. str.</td>
<td>0.5 tens. str.</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent.</td>
<td>1 500 000≤</td>
<td>1 500 000</td>
</tr>
<tr>
<td>Elongation in 2 in., &quot;&quot;</td>
<td>Tens. str.</td>
<td>Tens. str.</td>
</tr>
</tbody>
</table>

See Paragraph (b).

(b) In order to meet the required minimum tensile strength of full-size annealed eyebars, the purchaser may determine the tensile strength to be obtained in specimen tests; the range shall not exceed 14,000 lb. per sq. in., and the maximum shall not exceed 74,000 lb. per sq. in. The material shall conform to the requirements as to physical properties other than that of tensile strength, specified in Sections 6, 7 and 8(b).

(c) The yield point shall be determined by the drop of the beam of the testing machine.

7. (a) For structural steel over $\frac{3}{4}$ in. in thickness, a deduction of 1 from the percentage of elongation in 8 in. specified in Section 6 (a) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 18 per cent.

(b) For structural steel under $\frac{1}{16}$ in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Section 6 (a) shall be made for each decrease of $\frac{1}{16}$ in. in thickness below $\frac{3}{4}$ in.

8. (a) The test specimen for plates, shapes, and bars, except as specified in Paragraphs (b), (c) and (d), shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material $\frac{3}{4}$ in. or under in thickness, flat on itself; for material over $\frac{3}{4}$ in. to and including $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to the thick
ness of the specimen; and for material over 1\(\frac{3}{4}\) in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

(b) The test specimen for eyebar flats shall bend cold through 180 deg. without cracking on the outside of the bent portion as follows: For material \(\frac{3}{4}\) in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; for material over \(\frac{3}{4}\) in. to and including 1\(\frac{3}{4}\) in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen; and for material over 1\(\frac{3}{4}\) in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen.

(c) The test specimen for pins, rollers and other bars, when prepared as specified in Section 9 (c), shall bend cold through 180 deg. around a 1-in. pin without cracking on the outside of the bent portion.

(d) The test specimen for rivet steel shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

9. (a) Tension and bend test specimens shall be taken from rolled steel in the condition in which it comes from the rolls, except as specified in Paragraph (b).

(b) Tension and bend test specimens for pins and rollers shall be taken from the finished bars, after annealing when annealing is specified.
(c) Tension and bend test specimens for plates, shapes and bars, except as specified in Paragraphs (d), (e) and (f), shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel; except that bend test specimens for eyebars flats may have three rolled sides.

(d) Tension and bend test specimens for plates, and tension test specimens for eyebars flats, over 1½ in. in thickness may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in.

(c) Tension test specimens for pins, rollers and bars (except eyebar flats) over 1½ in. in thickness or diameter may conform to the dimensions shown in Fig. 2. In this case, the ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens may be 1 by ½ in. in section. The axis of the specimen shall be located at any point midway between the center and surface and shall be parallel to the axis of the bar.

(f) Tension and bend test specimens for rivet steel shall be of the full-size section of bars as rolled.

Note: The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any Form which will fit the Holders of the Testing Machine.

FIG. 2.

10. (a) One tension and one bend test shall be made from each melt; except that if material from one melt differs 3⁄8 in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.
(e) If the percentage of elongation of any tension test specimen is less than that specified in Section 6(a) and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

11. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified; except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) When Ordered to Weight per Square Foot: The weight of each lot\(^1\) in each shipment shall not vary from the weight ordered more than the amount given in Table I.

Table I.—Permissible Variations of Plates Ordered to Weight.

<table>
<thead>
<tr>
<th>Ordered Weight, lb. per sq. ft.</th>
<th>Under 48 in.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 to 121 in. or over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
</tr>
<tr>
<td>5 to 7.5 excl.</td>
<td>4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
</tr>
<tr>
<td>7.5 '10 '</td>
<td>4 3</td>
<td>4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
</tr>
<tr>
<td>10 '12.5 '</td>
<td>3.5 2.5 4</td>
<td>3 4.5 3</td>
<td>3 5.5 3</td>
<td>3 6 7</td>
<td>3 7</td>
<td>3 8</td>
<td>3 9 10</td>
<td>3 10</td>
</tr>
<tr>
<td>12.5 '15 '</td>
<td>3 2.5 3.5 5</td>
<td>3 4.5 3</td>
<td>3 5.5 3</td>
<td>3 6 7</td>
<td>3 7</td>
<td>3 8</td>
<td>3 8 12.5</td>
<td>3 15</td>
</tr>
<tr>
<td>15 '17.5 '</td>
<td>2.5 2.5 3</td>
<td>2.5 3.5 5 2.5 4</td>
<td>3 4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>6 3</td>
<td>3 7 15</td>
<td>3 17.5</td>
</tr>
<tr>
<td>17.5 '20 '</td>
<td>2 2.5 2.5 3</td>
<td>2.5 3.5 5 2.5 4</td>
<td>3 4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>6 3</td>
<td>3 7 17.5</td>
<td>3 20</td>
</tr>
<tr>
<td>20 '25 '</td>
<td>2 2 2.5 2 2</td>
<td>2.5 3.5 5 2.5 4</td>
<td>3 5 3</td>
<td>4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>3 7 25</td>
<td>3 20</td>
</tr>
<tr>
<td>25 '30 '</td>
<td>2 2 2 2 2 2</td>
<td>2.5 3.5 5 2.5 4</td>
<td>3 5 3</td>
<td>4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>3 7 25</td>
<td>3 25</td>
</tr>
<tr>
<td>30 '40 '</td>
<td>2 2 2 2 2 2</td>
<td>2.5 3.5 5 2.5 4</td>
<td>3 5 3</td>
<td>4.5 3</td>
<td>5 3</td>
<td>5.5 3</td>
<td>3 7 25</td>
<td>3 25</td>
</tr>
</tbody>
</table>

Note.—The weight per square foot of individual plates shall not vary from the ordered weight by more than 1\(^{\circ}\) times the amount given in this table.

\(^1\)The term "lot" applied to Table I means all of the plates of each group width and group weight.
Specifications for Steel for Bridges.

(b) When Ordered to Thickness: The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot in each shipment shall not exceed the amount given in Table II.

Table II.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, in.</th>
<th>Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights</th>
<th>Ordered Thickness, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1/8</td>
<td></td>
<td>Under 1/8</td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td></td>
<td>1/8 to 3/16 excl.</td>
</tr>
<tr>
<td>3/16 &quot; 1/4 &quot;</td>
<td></td>
<td>3/16 &quot; 1/4 &quot;</td>
</tr>
<tr>
<td>1/4 &quot; 5/16 &quot;</td>
<td></td>
<td>1/4 &quot; 5/16 &quot;</td>
</tr>
<tr>
<td>5/16 &quot; 3/8 &quot;</td>
<td></td>
<td>5/16 &quot; 3/8 &quot;</td>
</tr>
<tr>
<td>3/8 &quot; 7/16 &quot;</td>
<td></td>
<td>3/8 &quot; 7/16 &quot;</td>
</tr>
<tr>
<td>7/16 &quot; 1/2 &quot;</td>
<td></td>
<td>7/16 &quot; 1/2 &quot;</td>
</tr>
<tr>
<td>1/2 &quot; 5/8 &quot;</td>
<td></td>
<td>1/2 &quot; 5/8 &quot;</td>
</tr>
<tr>
<td>5/8 &quot; 3/4 &quot;</td>
<td></td>
<td>5/8 &quot; 3/4 &quot;</td>
</tr>
<tr>
<td>3/4 &quot; 1 &quot;</td>
<td></td>
<td>3/4 &quot; 1 &quot;</td>
</tr>
<tr>
<td>1 or over</td>
<td></td>
<td>1 or over</td>
</tr>
</tbody>
</table>

V. Finish.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. Marking.

13. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

1 The term "lot" applied to Table II means all of the plates of each group width and group thickness.
VII. INSPECTION AND REJECTION.

14. The inspector representing the purchaser shall have inspection, free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

15. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS

FOR

STRUCTURAL NICKEL STEEL.

Serial Designation: A 8 - 16.

The specifications for this material are issued under the fixed designation A 8; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1912; Revised, 1913, 1914, 1916.

I. MANUFACTURE

1. The steel shall be made by the open-hearth process.

2. A sufficient discard shall be made from each ingot intended for eyebars to secure freedom from injurious piping and undue segregation.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Structural Steel</th>
<th>Rivet Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>not over 0.45</td>
<td>not over 0.30 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>&quot; &quot; 0.70</td>
<td>&quot; &quot; 0.60 &quot;</td>
</tr>
<tr>
<td>Phosphorus Acid</td>
<td>&quot; &quot; 0.05</td>
<td>&quot; &quot; 0.04 &quot;</td>
</tr>
<tr>
<td>Phosphorus Basic</td>
<td>&quot; &quot; 0.04</td>
<td>&quot; &quot; 0.03 &quot;</td>
</tr>
<tr>
<td>Sulfur</td>
<td>&quot; &quot; 0.05</td>
<td>&quot; &quot; 0.045 &quot;</td>
</tr>
<tr>
<td>Nickel</td>
<td>not under 3.25</td>
<td>not under 3.25 &quot;</td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test (66)
ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. Analyses may be made by the purchaser from finished material representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

6. (a) The material shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Properties Considered</th>
<th>Rivet Steel</th>
<th>Plates, Shapes and Bars</th>
<th>Eye Bars and Rollers, etc. Unannealed</th>
<th>Eye Bars and Pins, etc. Annealed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>70,000 - 80,000</td>
<td>85,000 - 100,000</td>
<td>95,000 - 110,000</td>
<td>90,000 - 105,000</td>
</tr>
<tr>
<td>Yield point, min., lb. per sq. in.</td>
<td>45,000</td>
<td>50,000</td>
<td>55,000</td>
<td>52,000</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent.</td>
<td>1,500,000</td>
<td>1,500,000</td>
<td>1,500,000</td>
<td>20</td>
</tr>
<tr>
<td>Elongation in 2 in., min., per cent.</td>
<td>Tens. str.</td>
<td>Tens. str.</td>
<td>Tens. str.</td>
<td>16</td>
</tr>
<tr>
<td>Reduction of area, min., per cent.</td>
<td>40</td>
<td>25</td>
<td>25</td>
<td>35</td>
</tr>
</tbody>
</table>

a Tests of annealed specimens of eye bars shall be made for information only.
b See Section 7.
c Elongation shall be measured in 2 in.

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. For plates, shapes, and unannealed bars over 1 in. in thickness, a deduction of 1 from the percentage of elongation specified in Section 6 (a) shall be made for each increase of \( \frac{1}{2} \) in. in thickness above 1 in., to a minimum of 14 per cent.

8. All broken tension test specimens shall show either a silky or a very fine granular fracture, of uniform color, and free from coarse crystals.

9. (a) The test specimen for plates, shapes and bars shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material \( \frac{3}{4} \) in. or under in thickness, around a pin the diameter of which is equal to the
thickness of the specimen; and for material over \( \frac{3}{4} \) in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

\( (b) \) The test specimen for pins and rollers shall bend cold through 180 deg. around a 1-in. pin without cracking on the outside of the bent portion.

\( (c) \) The test specimen for rivet steel shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

10. Punched rivet holes pitched two diameters from a planed edge shall stand drifting until the diameter is enlarged 50 per cent, without cracking the metal.

Drift Tests.

![Drift Test Diagram](image)

Fig. 1.

Test Specimens. 11. \( (a) \) Tension and bend test specimens shall be taken from the finished material. Specimens for pins shall be taken after annealing.

\( (b) \) Tension and bend test specimens for plates, shapes and bars, except as specified in Paragraph \( (c) \), shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel; except that bend test specimens shall not be less than 2 in. in width, and that bend test specimens for eyebar flats may have three rolled sides.

\( (c) \) Tension and bend test specimens for plates and bars (except eyebar flats) over \( 1\frac{3}{4} \) in. in thickness or diameter may be machined to a thickness or diameter of at least \( \frac{3}{4} \) in. for a length of at least 9 in.
(d) The axis of tension and bend test specimens for pins and rollers shall be 1 in. from the surface and parallel to the axis of the bar. Tension test specimens shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens shall be 1 by \( \frac{1}{2} \) in. in section.

(e) Tension and bend test specimens for rivet steel shall be of the full-size section of bars as rolled.

12. (a) One tension and one bend test shall be made from each melt; except that if material from one melt differs \( \frac{3}{8} \) in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.
IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

13. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified; except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) When Ordered to Weight per Square Foot: The weight of each lot\(^1\) in each shipment shall not vary from the weight ordered more than the amount given in Table I.

<table>
<thead>
<tr>
<th>Ordered Weight, lb. per sq. ft.</th>
<th>Under 48 in.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 to 132 in. or over</th>
<th>Ordered Weight, lb. per sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Under 5</td>
</tr>
<tr>
<td>5 to 7.5 excl.</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>5 to 7.5 excl.</td>
</tr>
<tr>
<td>7.5 &quot; 10 &quot;</td>
<td>4</td>
<td>3</td>
<td>4.5</td>
<td>3</td>
<td>4.5</td>
<td>3</td>
<td>4.5</td>
<td>3</td>
<td>7.5 &quot; 10 &quot;</td>
</tr>
<tr>
<td>10 &quot; 12.5 &quot;</td>
<td>3.5</td>
<td>2.5</td>
<td>3</td>
<td>2.5</td>
<td>3</td>
<td>2.5</td>
<td>3</td>
<td>2.5</td>
<td>10 &quot; 12.5 &quot;</td>
</tr>
<tr>
<td>12.5 &quot; 15 &quot;</td>
<td>3</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>12.5 &quot; 15 &quot;</td>
</tr>
<tr>
<td>15 &quot; 17.5 &quot;</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>15 &quot; 17.5 &quot;</td>
</tr>
<tr>
<td>17.5 &quot; 20 &quot;</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td>17.5 &quot; 20 &quot;</td>
</tr>
<tr>
<td>20 &quot; 25 &quot;</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>20 &quot; 25 &quot;</td>
</tr>
<tr>
<td>25 &quot; 30 &quot;</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>25 &quot; 30 &quot;</td>
</tr>
<tr>
<td>30 &quot; 40 &quot;</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>30 &quot; 40 &quot;</td>
</tr>
<tr>
<td>40 or over</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>40 or over</td>
</tr>
</tbody>
</table>

Note.—The weight per square foot of individual plates shall not vary from the ordered weight by more than 1\(\frac{1}{2}\) times the amount given in this table.

(b) When Ordered to Thickness: The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot\(^2\) in each shipment shall not exceed the amount given in Table II.

---

\(^1\) The term "lot" applied to Table I means all of the plates of each group width and group weight.

\(^2\) The term "lot" applied to Table II means all of the plates of each group width and group thickness.
### Table II.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, in.</th>
<th>Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights</th>
<th>Ordered Thickness, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1/8</td>
<td></td>
<td>Under 1/8</td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td></td>
<td>1/8 to 3/16 excl.</td>
</tr>
<tr>
<td>3/16 &quot; 1/4 &quot;</td>
<td></td>
<td>3/16 &quot; 1/4 &quot;</td>
</tr>
<tr>
<td>1/4 &quot; 5/16 &quot;</td>
<td></td>
<td>1/4 &quot; 5/16 &quot;</td>
</tr>
<tr>
<td>5/16 &quot; 3/8 &quot;</td>
<td></td>
<td>5/16 &quot; 3/8 &quot;</td>
</tr>
<tr>
<td>3/8 &quot; 7/16 &quot;</td>
<td></td>
<td>3/8 &quot; 7/16 &quot;</td>
</tr>
<tr>
<td>7/16 &quot; 1/2 &quot;</td>
<td></td>
<td>7/16 &quot; 1/2 &quot;</td>
</tr>
<tr>
<td>1/2 &quot; 5/8 &quot;</td>
<td></td>
<td>1/2 &quot; 5/8 &quot;</td>
</tr>
<tr>
<td>5/8 &quot; 3/4 &quot;</td>
<td></td>
<td>5/8 &quot; 3/4 &quot;</td>
</tr>
<tr>
<td>3/4 &quot; 1 &quot;</td>
<td></td>
<td>3/4 &quot; 1 &quot;</td>
</tr>
<tr>
<td>1 or over</td>
<td></td>
<td>1 or over</td>
</tr>
</tbody>
</table>

#### V. FINISH.

14. The finished material shall be free from injurious Finish. defects and shall have a workmanlike finish.

#### VI. MARKING.

15. The name or brand of the manufacturer and the melt Marking. number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

#### VII. INSPECTION AND REJECTION.

16. The inspector representing the purchaser shall have Inspection. free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all
Specifications for Structural Nickel Steel.

reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 17. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 18. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

VIII. FULL-SIZE TESTS.

Tests of Eyebars. 19. (a) Full-size tests of annealed eyebars shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>85 000 - 100 000</td>
</tr>
<tr>
<td>Yield point, min.</td>
<td>48 000</td>
</tr>
<tr>
<td>Elongation in 18 ft., min., per cent.</td>
<td>10</td>
</tr>
<tr>
<td>Reduction of area,</td>
<td>30</td>
</tr>
</tbody>
</table>

(b) The yield point shall be determined by the halt of the gage of the testing machine.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS
FOR
STRUCTURAL STEEL FOR BUILDINGS.

Serial Designation: A 9–16.

The specifications for this material are issued under the fixed designation A 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.


I. MANUFACTURE.

1. (a) Structural steel, except as noted in Paragraph (b), may be made by the Bessemer or the open-hearth process.

   (b) Rivet steel, and steel for plates or angles over \( \frac{1}{4} \) in. in thickness which are to be punched, shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Structural Steel</th>
<th>Rivet Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td></td>
</tr>
<tr>
<td>Bessemer</td>
<td>not over 0.10 per cent</td>
</tr>
<tr>
<td>Open-hearth</td>
<td>0.06</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.045</td>
</tr>
</tbody>
</table>

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The
Specifications for Steel for Buildings.

chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

4. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) The material shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Properties Considered</th>
<th>Structural Steel</th>
<th>Rivet Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>55 000 - 65 000</td>
<td>46 000 - 56 000</td>
</tr>
<tr>
<td>Yield point, min.</td>
<td>0.5 tens. str.</td>
<td>0.5 tens. str.</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent.</td>
<td>1400 000&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1400 000</td>
</tr>
</tbody>
</table>

<sup>a</sup> See Section 6.

(b) The yield point shall be determined by the drop of the beam of the testing machine.

6. (a) For structural steel over 3/4 in. in thickness, a deduction of 1 from the percentage of elongation in 8 in. specified in Section 5(a) shall be made for each increase of 1/8 in. in thickness above 3/4 in., to a minimum of 18 per cent.

(b) For structural steel under 5/8 in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Section 5(a) shall be made for each decrease of 1/8 in. in thickness below 5/8 in.

7. (a) The test specimen for plates, shapes and bars, except as specified in Paragraphs (b) and (c), shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 3/4 in. or under in thickness, flat on itself; for material over 3/4 in. to and including 1 1/4 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 1/4 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.
(b) The test specimen for pins, rollers and other bars, when prepared as specified in Section 8(c), shall bend cold through 180 deg. around a 1-in. pin without cracking on the outside of the bent portion.

(c) The test specimen for rivet steel shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

8. (a) Tension and bend test specimens shall be taken from rolled steel in the condition in which it comes from the rolls, except as specified in Paragraph (b).

(b) Tension and bend test specimens for pins and rollers shall be taken from the finished bars, after annealing when annealing is specified.

(c) Tension and bend test specimens for plates, shapes and bars, except as specified in Paragraphs (d), (e) and (f), shall be of the full thickness of material as rolled; and may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(d) Tension and bend test specimens for plates over 1½ in. in thickness may be machined to a thickness or diameter of at least ⅔ in. for a length of at least 9 in.

(e) Tension test specimens for pins, rollers and bars over 1½ in. in thickness or diameter may conform to the dimensions shown in Fig. 2. In this case, the ends shall be of a form to
Specifications for Steel for Buildings.

Number of Tests.

(f) Tension and bend test specimens for rivet steel shall be of the full-size section of bars as rolled.

9. (a) One tension and one bend test shall be made from each melt; except that if material from one melt differs 3/16 in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (a) and any part of the fracture is more than 3/4 in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

10. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified; except in
the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) When Ordered to Weight per Square Foot: The weight of each lot\(^1\) in each shipment shall not vary from the weight ordered more than the amount given in Table I.

Table I.—Permissible Variations of Plates Ordered to Weight.

<table>
<thead>
<tr>
<th>Ordered Weight, lb. per sq. ft.</th>
<th>Under 48 in.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 to 132 in. excl.</th>
<th>132 in. or over</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 45 in.</td>
<td>45 to 56 in. excl.</td>
<td>56 to 67 in. excl.</td>
<td>67 to 78 in. excl.</td>
<td>78 to 89 in. excl.</td>
<td>89 to 100 in. excl.</td>
<td>100 to 112 in. excl.</td>
<td>112 to 125 in. excl.</td>
<td>125 in. or over</td>
</tr>
<tr>
<td>Under 5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>5 to 7.5 excl.</td>
<td>4.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>7.5&quot; 10&quot;</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>10&quot; 12.5&quot;</td>
<td>3.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>12.5&quot; 15&quot;</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>15&quot; 17.5&quot;</td>
<td>2.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>17.5&quot; 20&quot;</td>
<td>2.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>20&quot; 25&quot;</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>25&quot; 30&quot;</td>
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<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>30&quot; 40&quot;</td>
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<td>4</td>
<td>4</td>
<td>4</td>
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<td>4</td>
</tr>
<tr>
<td>40 or over</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Note.—The weight per square foot of individual plates shall not vary from the ordered weight by more than \(\frac{1}{2}\) times the amount given in this table.

(b) When Ordered to Thickness: The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot\(^2\) in each shipment shall not exceed the amount given in Table II.

1 The term "lot" applied to Table I means all of the plates of each group width and group weight.

2 The term "lot" applied to Table II means all of the plates of each group width and group thickness.
Specifications for Steel for Buildings.

Table II.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, in.</th>
<th>Under 48 in.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 to 132 in. excl.</th>
<th>132 in. or over.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1/8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>3/16 &quot; 1/4 &quot;</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>19</td>
<td>...</td>
</tr>
<tr>
<td>1/4 &quot; 5/16 &quot;</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>5/16 &quot; 3/8 &quot;</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>14</td>
<td>17</td>
<td>...</td>
</tr>
<tr>
<td>3/8 &quot; 7/16 &quot;</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>...</td>
</tr>
<tr>
<td>7/16 &quot; 1/2 &quot;</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>1/2 &quot; 5/8 &quot;</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>5/8 &quot; 3/4 &quot;</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>3/4 &quot; 1 &quot;</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>1 or over</td>
<td>2.5</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

V. Finish.

Finish. 11. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. Marking.

Marking. 12. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

VII. Inspection and Rejection.

Inspection. 13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being
furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

14. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

15. Samples tested in accordance with Section 4, which Rehearing represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
STRUCTURAL STEEL FOR LOCOMOTIVES.

Serial Designation: A 10–16.

The specifications for this material are issued under the fixed designation A 10; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

A Dopted, 1912; Revised, 1913, 1914, 1916.

1. These specifications apply to shapes, plates (except boiler and firebox plates) and bars over 1/2 in. in thickness.

I. MANUFACTURE.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

   Phosphorus............... not over 0.05 per cent
   Sulfur...................... " " 0.05 "

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The
chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

6. (a) The material shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>55,000 – 65,000</td>
</tr>
<tr>
<td>Yield point, min.</td>
<td>0.5 tens. str.</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent</td>
<td>1,500,000</td>
</tr>
</tbody>
</table>

(See Section 7)

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. (a) For material over \( \frac{3}{8} \) in. in thickness, a deduction of 1 from the percentage of elongation specified in Section 6 (a) shall be made for each increase of \( \frac{1}{8} \) in. in thickness above \( \frac{3}{8} \) in., to a minimum of 18 per cent.

(b) For material under \( \frac{3}{16} \) in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Section 6 (a) shall be made for each decrease of \( \frac{1}{16} \) in. in thickness below \( \frac{5}{16} \) in.

8. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows:

For material \( \frac{3}{4} \) in. or under in thickness, flat on itself; for material over \( \frac{3}{4} \) in. to and including \( 1\frac{1}{4} \) in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over \( 1\frac{1}{4} \) in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

9. (a) Tension and bend test specimens shall be taken from the finished rolled material.

(b) Tension and bend test specimens, except as specified in Paragraph (c), shall be of the full thickness of material as
Specifications for Structural Steel for Locomotives.

rolled; and may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(c) Tension and bend test specimens for plates and bars over \(1\frac{1}{8}\) in. in thickness or diameter may be machined to a thickness or diameter of at least \(3\frac{3}{4}\) in. for a length of at least 9 in.

Number of Tests.

10. (a) One tension and one bend test shall be made from each melt; except that if material from one melt differs \(\frac{3}{8}\) in. or over in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled. Shapes less than 1 sq. in. in section, and bars less than \(\frac{1}{2}\) sq. in. in section, need not be subjected to a tension test.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

11. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified; except in the
case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) When Ordered to Weight per Square Foot: The weight of each lot\(^1\) in each shipment shall not vary from the weight ordered more than the amount given in Table I.

Table I.—Permissible Variations of Plates Ordered to Weight.

<table>
<thead>
<tr>
<th>Ordered Weight, LB. PER SQ. FT.</th>
<th>Under 48 in.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 in. or over</th>
<th>Under 5</th>
<th>5 to 7.5 excl.</th>
<th>7.5 to 10 &quot;</th>
<th>10 to 12.5 &quot;</th>
<th>12.5 to 15 &quot;</th>
<th>15 to 17.5 &quot;</th>
<th>17.5 to 20 &quot;</th>
<th>20 to 25 &quot;</th>
<th>25 to 30 &quot;</th>
<th>30 to 40 &quot;</th>
<th>40 or over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 5</td>
<td>5</td>
<td>3.5</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>5 to 7.5 excl.</td>
<td>7.5 to 10 &quot;</td>
<td>10 to 12.5 &quot;</td>
<td>12.5 to 15 &quot;</td>
<td>15 to 17.5 &quot;</td>
<td>17.5 to 20 &quot;</td>
<td>20 to 25 &quot;</td>
<td>25 to 30 &quot;</td>
<td>30 to 40 &quot;</td>
<td>40 or over</td>
</tr>
<tr>
<td>5 to 7.5 excl.</td>
<td>4.5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>9</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>7.5 to 10 &quot;</td>
<td>4</td>
<td>6.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>3 to 10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>10 to 12.5 &quot;</td>
<td>3.5</td>
<td>5.5</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>9</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>12.5 to 15 &quot;</td>
<td>3</td>
<td>6.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>3 to 10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>15 to 17.5 &quot;</td>
<td>2.5</td>
<td>5.5</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>9</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>17.5 to 20 &quot;</td>
<td>2.5</td>
<td>6.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>20 to 25 &quot;</td>
<td>2</td>
<td>5.5</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>9</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>25 to 30 &quot;</td>
<td>2</td>
<td>6.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>30 to 40 &quot;</td>
<td>2</td>
<td>7.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
<tr>
<td>40 or over</td>
<td>2</td>
<td>8.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>10 &quot;</td>
<td>12.5 &quot;</td>
<td>15 &quot;</td>
<td>17.5 &quot;</td>
<td>20 &quot;</td>
<td>25 &quot;</td>
<td>30 &quot;</td>
<td>40 &quot;</td>
<td>40 or over</td>
<td></td>
</tr>
</tbody>
</table>

Note.—The weight per square foot of individual plates shall not vary from the ordered weight by more than \(\frac{1}{10}\) times the amount given in this table.

(b) When Ordered to Thickness: The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot\(^2\) in each shipment shall not exceed the amount given in Table II.

---

\(^1\) The term "lot" applied to Table I means all of the plates of each group width and group weight.

\(^2\) The term "lot" applied to Table II means all of the plates of each group width and group thickness.
84 Specifications for Structural Steel for Locomotives.

Table II.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, in.</th>
<th>Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.</th>
<th>Ordered Thickness, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1/8</td>
<td></td>
<td>Under 1/8</td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td></td>
<td>1/8 to 3/16 excl.</td>
</tr>
<tr>
<td>3/16 &quot; 1/4 &quot;</td>
<td></td>
<td>3/16 &quot; 1/4 &quot;</td>
</tr>
<tr>
<td>1/4 &quot; 5/16 &quot;</td>
<td></td>
<td>1/4 &quot; 5/16 &quot;</td>
</tr>
<tr>
<td>5/16 &quot; 3/8 &quot;</td>
<td></td>
<td>5/16 &quot; 3/8 &quot;</td>
</tr>
<tr>
<td>3/8 &quot; 7/16 &quot;</td>
<td></td>
<td>3/8 &quot; 7/16 &quot;</td>
</tr>
<tr>
<td>7/16 &quot; 1/2 &quot;</td>
<td></td>
<td>7/16 &quot; 1/2 &quot;</td>
</tr>
<tr>
<td>1/2 &quot; 5/8 &quot;</td>
<td></td>
<td>1/2 &quot; 5/8 &quot;</td>
</tr>
<tr>
<td>5/8 &quot; 3/4 &quot;</td>
<td></td>
<td>5/8 &quot; 3/4 &quot;</td>
</tr>
<tr>
<td>3/4 &quot; 1 &quot;</td>
<td></td>
<td>3/4 &quot; 1 &quot;</td>
</tr>
<tr>
<td>1 or over</td>
<td></td>
<td>1 or over</td>
</tr>
</tbody>
</table>

V. FINISH.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

13. The name or brand of the manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that small sections shall, when loaded for shipment, be properly separated and marked for identification. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

VII. INSPECTION AND REJECTION.

Inspection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of
manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

15. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

16. Samples tested in accordance with Section 5, which Rehearing represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
AMERICAN SOCIETY FOR TESTING MATERIALS  
PHILADELPHIA, PA., U. S. A.  
Affiliated with the  
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS  
FOR  
STRUCTURAL STEEL FOR CARS.  

Serial Designation: A 11-16.

The specifications for this material are issued under the fixed designation A 11; the final number indicates the year of original issue, or in the case of revision, the year of last revision.  

ADOPTED, 1914; REVISED, 1916.

Basis of Purchase.  

1. These specifications apply to shapes, plates and bars over \( \frac{\frac{1}{2}}{\text{in.}} \) in thickness.

I. MANUFACTURE.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Chemical Composition</th>
<th>STRUCTURAL STEEL AND PLATES FOR COLD PRESSING</th>
<th>RIVET STEEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>Acid not over 0.06 not over 0.04 per cent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic &quot; 0.04 &quot; 0.04 &quot;</td>
<td></td>
</tr>
<tr>
<td>Sulfur</td>
<td>&quot; 0.05 &quot; &quot; 0.045 &quot;</td>
<td></td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

(86)
5. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

6. (a) The material shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Properties Considered</th>
<th>Structural Steel</th>
<th>Rivet Steel</th>
<th>Plates for Cold Pressing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>50 000 - 65 000</td>
<td>45 000 - 60 000</td>
<td>48 000 - 58 000</td>
</tr>
<tr>
<td>Yield point, min., &quot;&quot;</td>
<td>0.5 tens. str.</td>
<td>0.5 tens. str.</td>
<td>0.5 tens. str.</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent</td>
<td>1 500 000</td>
<td>1 500 000</td>
<td>1 500 000</td>
</tr>
</tbody>
</table>

1 See Section 7.

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. (a) For material over \( \frac{\frac{3}{4}}{8} \) in. in thickness, a deduction of 1 from the percentage of elongation specified in Section 6 (a) shall be made for each increase of \( \frac{\frac{3}{4}}{8} \) in. in thickness above \( \frac{\frac{3}{4}}{8} \) in., to a minimum of 18 per cent.

(b) For material under \( \frac{\frac{5}{8}}{8} \) in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Section 6 (a) shall be made for each decrease of \( \frac{\frac{5}{8}}{8} \) in. in thickness below \( \frac{\frac{5}{8}}{8} \) in.

8. (a) The test specimen for structural steel shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material \( \frac{\frac{3}{4}}{8} \) in. or under in thickness, flat on itself; for material over \( \frac{\frac{3}{4}}{8} \) in. to and including \( \frac{1}{4} \) in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over \( \frac{1}{4} \) in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

(b) The test specimen for rivet steel and plates for cold pressing shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

9. (a) Tension and bend test specimens shall be taken from the finished rolled material.
Specifications for Steel for Cars.

(b) Tension and bend test specimens, except as specified in Paragraph (c), shall be of the full thickness of material as rolled; and may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(c) Tension and bend test specimens for plates and bars over 1½ in. in thickness or diameter may be machined to a thickness or diameter of at least 3/4 in. for a length of at least 9 in.

10. (a) One tension and one bend test shall be made from each melt; except that if material from one melt differs 3/8 in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled. Shapes

![Diagram](image.png)

FIG. 1.

less than 1 sq. in. in section, and bars, except rivet rods, less than 1/2 sq. in. in section, need not be subjected to a tension test.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.
IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

11. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified; except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) **When Ordered to Weight per Square Foot**: The weight of each lot\(^1\) in each shipment shall not vary from the weight ordered more than the amount given in Table I.

**Table I.—Permissible Variations of Plates Ordered to Weight.**

<table>
<thead>
<tr>
<th>Ordered Weight, lb. per sq. ft.</th>
<th>Under 48 in.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 to 132 in. excl. or over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordered Weight, lb. per sq. ft.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 5</td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>5 to 7.5 excl.</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>7.5 &quot; 10 &quot;</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>10 &quot; 12.5 &quot;</td>
<td>3</td>
<td>3.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>12.5 &quot; 15 &quot;</td>
<td>3</td>
<td>3.5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>15 &quot; 17.5 &quot;</td>
<td>2.5</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>17.5 &quot; 20 &quot;</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>20 &quot; 25 &quot;</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>25 &quot; 30 &quot;</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>30 &quot; 40 &quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>40 or over</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>5.5</td>
<td>5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

**Note.**—The weight per square foot of individual plates shall not vary from the ordered weight by more than \(\frac{1}{11}\) times the amount given in this table.

(b) **When Ordered to Thickness**: The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot\(^2\) in each shipment shall not exceed the amount given in Table II.

---

\(^1\) The term "lot" applied to Table I means all of the plates of each group width and group weight.

\(^2\) The term "lot" applied to Table II means all of the plates of each group width and group thickness.
Specifications for Steel for Cars.

Table II.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, in.</th>
<th>Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.</th>
<th>Ordered Thickness, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 48 in. 60 to 72 in. excl.</td>
<td>72 to 84 in. excl.</td>
</tr>
<tr>
<td>Under 1/8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>3/16 &quot; 1/4 &quot;</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>1/4 &quot; 5/16 &quot;</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>5/16 &quot; 3/8 &quot;</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3/8 &quot; 7/16 &quot;</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>7/16 &quot; 1/2 &quot;</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>1/2 &quot; 5/8 &quot;</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>5/8 &quot; 3/4 &quot;</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>3/4 &quot; 1 &quot;</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>1 or over</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

V. FINISH.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

13. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material, except that rivet bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

VII. INSPECTION AND REJECTION.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check
Analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

15. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
STRUCTURAL STEEL FOR SHIPS.¹

Serial Designation: A 12–16.

The specifications for this material are issued under the fixed designation A 12; the final number indicates the year of original issue, or in the case of revision, the year of last revision.


I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

- Phosphorus
  - Acid: not over 0.06 per cent
  - Basic: 0.04
- Sulfur: 0.05

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The

¹Note.—The requirements for castings for ships have been especially provided for in the Standard Specifications for Steel Castings (Serial Designation: A 27), adopted by the American Society for Testing Materials (see pp. 200–205).
chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

4. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) The material shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in. ................. 58 000 – 68 000
Yield point, min., “ “ .......................... 0.5 tens. str.
Elongation in 8 in., min., per cent .......... 1 500 000
   (See Section 6.)

(b) The yield point shall be determined by the drop of the beam of the testing machine.

6. (a) For material over \( \frac{3}{4} \) in. in thickness, a deduction of 1 from the percentage of elongation specified in Section 5 (a) shall be made for each increase of \( \frac{1}{8} \) in. in thickness above \( \frac{3}{4} \) in., to a minimum of 18 per cent.

(b) For material \( \frac{1}{8} \) in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

7. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material \( \frac{1}{4} \) in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; for material over \( \frac{3}{4} \) in. to and including \( 1\frac{1}{4} \) in. in thickness, around a pin the diameter of which is equal to \( 1\frac{1}{2} \) times the thickness of the specimen; and for material over \( 1\frac{1}{4} \) in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

8. (a) Tension and bend test specimens shall be taken from the finished rolled material, and shall not be annealed or otherwise treated, except as specified in Paragraph (b).
Specifications for Structural Steel for Ships.

(b) Tension and bend test specimens for material which is to be annealed or otherwise treated before use, shall be cut from properly annealed or similarly treated short lengths of the full section of the piece.

(c) Tension and bend test specimens, except as specified in Paragraph (d), shall be of the full thickness of material as rolled; and may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(d) Tension and bend test specimens for plates and bars over 1\frac{1}{3} in. in thickness or diameter may be machined to a thickness or diameter of at least \frac{3}{4} in. for a length of at least 9 in.

FIG. 1.

Number of Tests. 9. (a) One tension and one bend test shall be made from each melt; except that if material from one melt differs \frac{3}{8} in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.
IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

10. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent from that specified; except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(a) When Ordered to Weight per Square Foot: The weight of each lot\(^1\) in each shipment shall not vary from the weight ordered more than the amount given in Table I.

Table I.—Permissible Variations of Plates Ordered to Weight.

<table>
<thead>
<tr>
<th>Ordered Weight, lb. per sq. ft.</th>
<th>48 to 60 in. excl.</th>
<th>60 to 72 in. excl.</th>
<th>72 to 84 in. excl.</th>
<th>84 to 96 in. excl.</th>
<th>96 to 108 in. excl.</th>
<th>108 to 120 in. excl.</th>
<th>120 to 122 in. or over.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 7.5 excl.</td>
<td>4.5</td>
<td>3</td>
<td>5.5</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>7.5 &quot; 10 &quot;</td>
<td>2.5</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>5.5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>10 &quot; 12.5 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.5 &quot; 15 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15 &quot; 17.5 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.5 &quot; 20 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20 &quot; 25 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>25 &quot; 30 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>30 &quot; 40 &quot;</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>40 or over</td>
<td>2.5</td>
<td>3.5</td>
<td>3</td>
<td>2.5</td>
<td>5.5</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Ordered Weight, lb. per sq. ft. Under 5. 7.5 to 10. 10 to 12.5. 12.5 to 15. 15 to 17.5. 17.5 to 20. 20 to 25. 25 to 30. 30 to 40. 40 or over.

Note.—The weight per square foot of individual plates shall not vary from the ordered weight by more than \(1\frac{1}{2}\) times the amount given in this table.

(b) When Ordered to Thickness: The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot\(^2\) in each shipment shall not exceed the amount given in Table II.

\(^1\) The term "lot" applied to Table I means all of the plates of each group width and group weight.

\(^2\) The term "lot" applied to Table II means all of the plates of each group width and group thickness.
Specifications for Structural Steel for Ships.

Table II.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, in.</th>
<th>Under 48 in.</th>
<th>48 to 60 in., excl.</th>
<th>60 to 72 in., excl.</th>
<th>72 to 84 in., excl.</th>
<th>84 to 96 in., excl.</th>
<th>96 to 108 in., excl.</th>
<th>108 to 120 in., excl.</th>
<th>120 to 132 in., excl.</th>
<th>132 in. or over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1/8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/16 “ 1/4 “</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4 “ 5/16 “</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>5/16 “ 3/8 “</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>3/8 “ 7/16 “</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>7/16 “ 1/2 “</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>1/2 “ 5/8 “</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>5/8 “ 3/4 “</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>3/4 “ 1 “</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>1 or over</td>
<td>2.5</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

V. Finish.

11. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. Marking.

12. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material. The melt number shall be legibly stamped on each test specimen.

VII. Inspection and Rejection.

13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.
14. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

15. Samples tested in accordance with Section 4, which Rehearing, represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
RIVET STEEL FOR SHIPS.


The specifications for this material are issued under the fixed designation A 13; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOTED, 1901; REVISED, 1909, 1913, 1914.

A. Requirements for Rolled Bars.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

   Phosphorous
     Acid......................... not over 0.06 per cent
     Basic......................... " " 0.04 "
   Sulfur.......................... " " 0.045 "

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.
4. Analyses may be made by the purchaser from finished bars representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) The bars shall conform to the following requirements as to tensile properties:

- Tensile strength, lb. per sq. in. ............... 55,000 - 65,000
- Yield point, min. “ “ ...................... 0.5 tens. str.
- Elongation in 8 in., min., per cent ................ 1,500,000
  (See Section 6.)

(b) The yield point shall be determined by the drop of the beam of the testing machine.

6. For bars over \( \frac{3}{4} \) in. in diameter, a deduction of 1 from the percentage of elongation specified in Section 5 (a) shall be made for each increase of \( \frac{1}{2} \) in. in diameter above \( \frac{3}{4} \) in.

7. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

8. Tension and bend test specimens shall be of the full-size section of bars as rolled.

9. (a) Two tension and two bend tests shall be made from each melt, each of which shall conform to the requirements specified; except that if bars from one melt differ \( \frac{3}{8} \) in. or more in diameter, one tension and one bend test shall be made from both the greatest and the least diameters rolled.

(b) If any test specimen develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN DIAMETER.

10. The diameter of bars 1 in. or under in diameter shall not vary more than 0.01 in. from that specified; the diameter of bars
Specifications for Rivet Steel for Ships.

over 1 in. to and including 2 in. in diameter shall not vary more than \( \frac{\frac{1}{64}}{\text{in.}} \) under nor more than \( \frac{\frac{1}{32}}{\text{in.}} \) over that specified.

V. FINISH.

Finish. 11. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking. 12. Rivet bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification. The melt number shall be legibly marked on each test specimen.

VII. INSPECTION AND REJECTION.

Inspection. 13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 14. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 15. Samples tested in accordance with Section 4, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
B. Requirements for Rivets.

VIII. PHYSICAL PROPERTIES AND TESTS.

16. A copy of the results of tension tests of the rolled bars from which the rivets were made shall be furnished for each lot of rivets.

17. If the test certificate required in Section 16 cannot be furnished, the rivets shall conform to the requirements as to tensile properties specified in Sections 5 and 6, except that the elongation shall be measured on a gage length as great as the length of the rivets tested will permit.

18. The rivet shank shall bend cold through 180 deg. flat on itself, as shown in Fig. 1, without cracking on the outside of the bent portion.

19. The rivet head shall flatten, while hot, to a diameter 2 1/2 times the diameter of the shank, as shown in Fig. 2, without cracking at the edges.

20. (a) When required in accordance with Section 17, one tension test shall be made from each size in each lot of rivets offered for inspection.

(b) Three bend and three flattening tests shall be made from each size in each lot of rivets offered for inspection, each of which shall conform to the requirements specified.

IX. WORKMANSHIP AND FINISH.

21. The rivets shall be true to form, concentric, and shall be made in a workmanlike manner.

22. The finished rivets shall be free from injurious defects.
X. INSPECTION AND REJECTION.

Inspection. 23. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the rivets ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the rivets are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 24. Rivets which show injurious defects subsequent to their acceptance at the manufacturer’s works will be rejected, and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
CARBON-STEEL BARS FOR RAILWAY SPRINGS.

Serial Designation: A 14–16.

The specifications for this material are issued under the fixed designation A 14; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1914; REVISED, 1916.

1. (a) These specifications cover carbon-steel bars to be used for the manufacture of railway springs.

(b) The bars are divided into two classes, determined by the carbon ranges specified in Section 3. The choice of the class of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended. The purposes for which these classes are frequently used are as follows:

Class A, for elliptical and helical springs;    
Class B, for helical springs.

I. MANUFACTURE.

2. The steel may be made by the open-hearth, crucible or electric process.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:
4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a finished bar representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

6. The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser.

IV. FINISH.

7. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

8. The bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification.

VI. INSPECTION AND REJECTION.

9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the bars ordered. The manu-
manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

10. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

11. Samples tested in accordance with Section 5, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS

FOR

CARBON-STEEL BARS FOR VEHICLE AND AUTOMOBILE SPRINGS.

Serial Designation: A 58–16.

The specifications for this material are issued under the fixed designation A 58; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

Classes. 1. (a) These specifications cover carbon-steel bars to be used for the manufacture of vehicle and automobile springs.

(b) The bars are divided into two classes, determined by the carbon ranges specified in Section 3. The choice of the class of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended. The purposes for which these classes are frequently used are as follows:

Class A, for vehicle springs;
Class B, for automobile springs.

I. MANUFACTURE.

Process. 2. The steel may be made by the open-hearth, crucible or electric process.
II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Elements Considered</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, per cent</td>
<td>0.85-1.05</td>
<td>0.90-1.05</td>
</tr>
<tr>
<td>Manganese, per cent</td>
<td>0.25-0.50</td>
<td>0.25-0.50</td>
</tr>
<tr>
<td>Phosphorus, max., per cent</td>
<td>0.05 Acid</td>
<td>0.05</td>
</tr>
<tr>
<td>Sulfur, max., per cent</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a finished bar representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

6. The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser.

IV. FINISH.

7. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

8. The bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification.
VI. INSPECTION AND REJECTION.

Inspection. 9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 10. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.  
(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 11. Samples tested in accordance with Section 5, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
SILICO-MANGANESE-STEEL BARS FOR AUTOMOBILE
AND RAILWAY SPRINGS.

Serial Designation: A 59 - 16.

The specifications for this material are issued under the fixed designation A 59; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1916.

1. (a) These specifications cover silico-manganese-steel bars to be used for the manufacture of automobile and railway springs.
   
   (b) The bars are divided into two classes, determined by the chemical composition specified in Section 3. The choice of the class of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended.

I. MANUFACTURE.

2. The steel may be made by the open-hearth, crucible or electric process.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:
Specifications for Spring Steel.

<table>
<thead>
<tr>
<th>Elements Considered</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, per cent.</td>
<td>0.45-0.55</td>
<td>0.55-0.65</td>
</tr>
<tr>
<td>Manganese, per cent.</td>
<td>0.60-0.80</td>
<td>0.50-0.70</td>
</tr>
<tr>
<td>Phosphorus, max., per cent.</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Acid</td>
<td>0.045</td>
<td>0.045</td>
</tr>
<tr>
<td>Basic</td>
<td>0.045</td>
<td>0.045</td>
</tr>
<tr>
<td>Sulfur, max., per cent.</td>
<td>1.80-2.10</td>
<td>1.50-1.80</td>
</tr>
<tr>
<td>Silicon, per cent.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a finished bar representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

6. The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser.

IV. FINISH.

7. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

8. The bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification.

VI. INSPECTION AND REJECTION.

9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works...
which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

10. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer’s works will be rejected, and the manufacturer shall be notified.

11. Samples tested in accordance with Section 5, which Rehearing represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
CHROME-VANADIUM-STEEL BARS FOR AUTOMOBILE AND RAILWAY SPRINGS.

Serial Designation: A 60–16.

The specifications for this material are issued under the fixed designation A 60; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

I. MANUFACTURE.

1. (a) These specifications cover chrome-vanadium-steel bars to be used for the manufacture of automobile and railway springs.

(b) The bars are divided into two classes, determined by the chemical composition specified in Section 3. The choice of the class of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel may be made by the open-hearth, crucible or electric process.

3. The steel shall conform to the following requirements as to chemical composition:
4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a finished bar representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

6. The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser.

IV. FINISH.

7. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

8. The bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification.

VI. INSPECTION AND REJECTION.

9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the pur-
chaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

**Rejection.**

10. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

   (b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

**Rehearing.**

11. Samples tested in accordance with Section 5, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
HELICAL SPRINGS FOR RAILWAYS.

Serial Designation: A 61–16.

The specifications for this material are issued under the fixed designation A 61; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1916.

1. (a) These specifications cover all helical springs for suspension, draft and buffer purposes for locomotives, tenders and cars.

(b) The springs shall be made of carbon-steel bars conforming to the requirements of the Standard Specifications for Carbon-Steel Bars for Railway Springs (Serial Designation: A 14) of the American Society for Testing Materials, unless otherwise specified.

(c) If carbon-steel bars with special silicon requirements or alloy-steel bars are specified, the manufacturer and the purchaser shall agree upon the type and grade of the bars to be used; in which case the bars shall conform, for the respective types, to the Tentative Specifications for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (Serial Designation: A 14).
Specifications for Helical Railway Springs.

nation: A 68-16 T),¹ the Standard Specifications for Silico-Manganese-Steel Bars for Automobile and Railway Springs (Serial Designation: A 59), or the Standard Specifications for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (Serial Designation: A 60), of the American Society for Testing Materials.

(d) Drillings for chemical analysis shall be taken from pieces sheared from the bars during the process of manufacture, and not from a finished spring, unless otherwise agreed upon.

I. CHEMICAL PROPERTIES AND TESTS.

Check Analyses.

2. (a) An analysis may be made by the purchaser from a sample representing each size of spring steel involved. The chemical composition thus determined shall conform to the requirements specified in Section 1 (b) or (c).

(b) Drillings for analysis shall be taken from the unworked portion of the bars and shall represent the full cross-section after rejecting any decarburized material.

(c) In case of dispute, check and arbitration analyses of carbon steel shall be made in accordance with the Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33) of the American Society for Testing Materials, the carbon being determined by the "direct-combustion" method; and of alloy steel, in accordance with the Standard Methods for Chemical Analysis of Alloy Steels (Serial Designation: A 55) of the American Society for Testing Materials.

II. WORKMANSHIP.

3. The purchaser or his representative may examine all springs in each lot for workmanship and general dimensions.

4. (a) The springs shall be submitted for inspection complete in the condition required by the drawings, and shall conform to these drawings with the permissible variations specified in this section and Section 6.

(b) The springs shall be of uniform pitch with ends tapered to give a reasonably square firm bearing. The points of bars shall not protrude beyond the outside diameter of the springs.

(e) The outside dimensions of the springs, excepting the height, shall not vary more than \(\frac{1}{16}\) in. from those specified.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) From each lot of springs which has met the requirements of Section 4, the purchaser or his representative may select for physical tests at least 10 per cent, to be tested in accordance with the requirements of Section 6 and the appendix.

(b) If any of the springs representing a lot fail to meet the requirements as to physical properties specified in Section 6, but at least half of the springs representing a lot do meet these requirements, each spring of the lot shall be tested and those which meet the requirements shall be accepted. If more than half of the springs representing a lot fail to meet the requirements specified in Section 6, the lot represented will be rejected.

6. The properties specified in Paragraphs (a), (b), (c) and (d), modified if necessary to conform to the requirements of the appendix, shall be determined in the order specified. The spring shall not be rapped or otherwise disturbed during the test.

(a) Solid Height.—The solid height is the perpendicular distance between the plates of the testing machine when the spring is compressed solid with a test load at least $1\frac{1}{4}$ times that necessary to bring all the coils in contact. The solid height shall not vary more than $\frac{1}{8}$ in. from that specified.

(b) Free Height.—The free height is the height of the spring when the load specified in Paragraph (a) has been released, and is determined by placing a straight edge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the straight edge, at the approximate center of the spring. The free height shall not vary more than $\frac{1}{4}$ in. from that specified.

(c) Loaded Height.—The loaded height is the distance between the plates of the testing machine when the specified working load is applied. The loaded height shall not vary more than $\frac{3}{8}$ in. over nor more than $\frac{1}{16}$ in. under that specified.

(d) Permanent Set.—The permanent set is the difference, if any, between the free height and the height (measured at the same point and in a similar manner) after the spring has been compressed solid three times in rapid succession with the test
Specifications for Helical Railway Springs.

load specified in Paragraph (a). The permanent set shall not exceed $\frac{1}{32}$ in.

IV. MARKING.

Marking.

7. (a) The name or brand of the manufacturer, the year and month of manufacture, and if specified, the purchaser's class number, shall be legibly stamped on each spring at a place not detrimental to the life or service of the spring.

(b) Any stamping by the inspector shall be so placed as not to be detrimental to the life or service of the spring.

V. INSPECTION AND REJECTION.

Inspection.

8. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the springs ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the springs are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

9. Unless otherwise specified, any rejection based on tests made in accordance with Section 2 shall be reported within five working days from the receipt of samples.

Rehearing.

10. Samples tested in accordance with Section 2, which represent rejected springs, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

Reworking.

11. Any springs which fail to meet the requirements as to dimensions or physical tests may be again submitted after being reworked.
APPENDIX.

TEST FIBER STRESS.

12. (a) The properties and methods of testing specified in Section 6 have been established for carbon-steel springs on the assumption that the maximum fiber stress under test shall not exceed 90,000 lb. per sq. in.\(^1\)

(b) For alloy-steel springs practice has not been sufficiently well established to enable definite fiber stresses to be given. Unless otherwise agreed upon by the manufacturer and the purchaser, alloy-steel springs shall be tested under the conditions as to fiber stress specified for carbon-steel springs.

RELATION BETWEEN FIBER STRESS AND LOAD.

13. To find the maximum load under which the conditions of Section 12 (a) are fulfilled, the following formula shall be used:

\[
P = \frac{3.1416 S d^3}{8 M} \tag{1}
\]

where \(P\) = the load in pounds; \(S\) = the stress of the most strained fiber in pounds per square inch; \(d\) = the diameter of the bar in inches; and \(M\) = the mean diameter of the helix in inches; this is found by subtracting the diameter or thickness of the bar from the outside diameter of the spring.

TEST OF SPRINGS NOT IN ACCORDANCE WITH PRECEDING RULES.

14. (a) If it is desired to purchase under these specifications springs in which the maximum fiber stress exceeds that specified in Section 12 (a), the tests shall be made as specified in Section 6

\(^1\) This stress is given solely as a limiting stress not to be exceeded in testing by the methods covered by the specifications. It is not intended as a guide in the design of springs, as the proper working fiber stress will depend on the class and design of the spring and on the service for which it is intended.
Table I.—Test Loads for Helical Springs, in Pounds, Which will Correspond to a Maximum Fiber Stress of 90,000 lb. per sq. in.

| Outside Diameter of Spring, in. | Diameter of Bar, in. | 5 1/16 | 5 1/8 | 5 3/16 | 5 5/16 | 5 7/16 | 6 1/2 | 6 5/16 | 6 7/16 | 6 11/16 | 7 1/2 | 7 5/8 | 7 3/4 | 8 1/4 | 8 3/4 | 9 1/8 | 9 5/8 | 10 1/8 | 10 3/8 | 11 1/8 | 11 5/8 | 12 |
|-------------------------------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 2                             | 240                 | 1095   | 2950   | 3720   | 4040   | 4500   | 4980   | 5500   | 6020   | 6500   | 7000   | 7500   | 8000   | 8500   | 9000   | 9500   | 10000  | 10500  | 11000  | 11500  | 12000  |
| 3                             | 400                 | 1070   | 1760   | 2450   | 3140   | 3830   | 4520   | 5210   | 5900   | 6590   | 7280   | 7970   | 8660   | 9350   | 10040  | 10730  | 11420  | 12110  | 12800  | 13490  | 14180  |
| 4                             | 1265               | 1850   | 2540   | 3230   | 3920   | 4610   | 5300   | 5990   | 6680   | 7370   | 8060   | 8750   | 9440   | 10130  | 10820  | 11510  | 12200  | 12890  | 13580  | 14270  | 14960  |
| 5                             | 1980               | 2670   | 3360   | 4050   | 4740   | 5430   | 6120   | 6810   | 7500   | 8190   | 8880   | 9570   | 10260  | 10950  | 11640  | 12330  | 13020  | 13710  | 14400  | 15090  | 15780  |
| 6                             | 2810               | 3520   | 4210   | 4900   | 5590   | 6280   | 6970   | 7660   | 8350   | 9040   | 9730   | 10420  | 11110  | 11800  | 12490  | 13180  | 13870  | 14560  | 15250  | 15940  | 16630  |
| 7                             | 3660               | 4330   | 5020   | 5710   | 6400   | 7090   | 7780   | 8470   | 9160   | 9850   | 10540  | 11230  | 11920  | 12610  | 13300  | 14000  | 14690  | 15380  | 16070  | 16760  | 17450  |
| 8                             | 4450               | 5130   | 5820   | 6510   | 7200   | 7890   | 8580   | 9270   | 9960   | 10650  | 11340  | 12030  | 12720  | 13410  | 14100  | 14790  | 15480  | 16170  | 16860  | 17550  | 18240  |
| 9                             | 5100               | 5790   | 6480   | 7170   | 7860   | 8550   | 9240   | 9930   | 10620  | 11310  | 12000  | 12690  | 13380  | 14070  | 14760  | 15450  | 16140  | 16830  | 17520  | 18210  | 18900  |
| 10                            | 5740               | 6430   | 7120   | 7810   | 8500   | 9190   | 9880   | 10570  | 11260  | 11950  | 12640  | 13330  | 14020  | 14710  | 15400  | 16090  | 16780  | 17470  | 18160  | 18850  | 19540  |
| 11                            | 6390               | 7080   | 7770   | 8460   | 9150   | 9840   | 10530  | 11220  | 11910  | 12600  | 13290  | 13980  | 14670  | 15360  | 16050  | 16740  | 17430  | 18120  | 18810  | 19500  | 20190  |
| 12                            | 7040               | 7730   | 8420   | 9110   | 9800   | 10490  | 11180  | 11870  | 12560  | 13250  | 13940  | 14630  | 15320  | 16010  | 16700  | 17390  | 18080  | 18770  | 19460  | 20150  | 20840  |
except that the maximum test load to be applied in determining the properties specified in Sections 6 (a) and (d) shall not be sufficient to compress the spring solid, but shall be the load which corresponds to a fiber stress of 90,000 lb. per sq. in., as determined by Equation (1).

**Table to Facilitate Calculations.**

15. Table I appended is arranged to facilitate the calculations necessary to determine whether a spring can be tested in accordance with the specifications without exceeding the stress given in Section 12 (a). The table shows the loads at which springs of various sizes are stressed to 90,000 lb. per sq. in. These are the test loads to be used for springs tested in accordance with Section 14 (b). In testing in accordance with Section 6 (a) the load given in Table I for the given size of spring shall not be exceeded, unless with this load the spring is compressed solid.
STANDARD SPECIFICATIONS
FOR
ELLIPTICAL SPRINGS FOR RAILWAYS.

Serial Designation: A 62 - 16.

The specifications for this material are issued under the fixed designation A 62; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

1. (a) These specifications cover all elliptic springs for suspension, draft and buffer purposes for locomotives, tenders and cars.

   (b) The springs shall be made of carbon-steel bars conforming to the requirements of the Standard Specifications for Carbon-Steel Bars for Railway Springs (Serial Designation: A 14) of the American Society for Testing Materials, unless otherwise specified.

   (c) If carbon-steel bars with special silicon requirements or alloy-steel bars are specified, the manufacturer and the purchaser shall agree upon the type and grade of the bars to be used; in which case the bars shall conform, for the respective types, to the Tentative Specifications for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (Serial Designation: A 68-16 T)\(^1\), the Standard Specifications for Silico-

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Manganese-Steel Bars for Automobile and Railway Springs (Serial Designation: A 59), or the Standard Specifications for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (Serial Designation: A 60), of the American Society for Testing Materials.

(d) The bands of the springs shall be made of wrought iron conforming to the requirements of the Standard Specifications for Refined Wrought-Iron Bars (Serial Designation: A 41) of the American Society for Testing Materials; or if agreed upon, they may be made of "dead-soft" open-hearth steel, the carbon content of which shall not exceed 0.15 per cent. Bands of special design, subject to agreement between the manufacturer and the purchaser, may be made of steel castings conforming to the requirements of the Standard Specifications for Steel Castings, Class B, Soft Grade (Serial Designation: A 27), of the American Society for Testing Materials.

(e) Drillings for chemical analysis shall be taken from pieces sheared from the bars during the process of manufacture, and not from a finished spring, unless otherwise agreed upon.

(f) In determining the loaded height and loaded length of the springs, the "compression" method of Section 6 shall be used, unless the "release" method of Section 7 is specified.

I. CHEMICAL PROPERTIES AND TESTS.

2. (a) An analysis may be made by the purchaser from a sample representing each size of spring steel involved. The chemical composition thus determined shall conform to the requirements specified in Section 1 (b) or (c).

(b) Drillings for analysis shall be taken from the unworked portion of the bars and shall represent the full cross-section after rejecting any decarburized material.

(c) In case of dispute, check and arbitration analyses of carbon steel shall be made in accordance with the Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33) of the American Society for Testing Materials, the carbon being determined by the "direct-combustion" method; and of alloy steel, in accordance with the Standard Methods for Chemical Analysis of Alloy Steels (Serial Designation: A 55) of the American Society for Testing Materials.
3. The purchaser or his representative may examine all springs in each lot for workmanship and general dimensions.

4. (a) The springs shall be submitted for inspection complete in the condition required by the drawings, and shall conform to these drawings with the permissible variations specified in this Section and Sections 6 or 7. Dimensions which affect the contour only and do not affect the interchange or service of the springs need only be approximated.

(b) The springs shall have the leaves properly graduated in length, properly bent, and fitted to reasonably true circular arcs.

(c) The bands of the springs shall not vary from the specified dimensions more than $\frac{1}{16}$ in. in width and $\frac{1}{32}$ in. in thickness of straps, nor more than $\frac{1}{8}$ in. in width across the spring.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) From each lot of springs which has met the requirements of Section 4, the purchaser or his representative may select for physical tests at least 25 per cent, to be tested in accordance with the "compression" method of Section 6—or if specified, in accordance with the "release" method of Section 7—and the appendix.

(b) If any of the springs representing a lot fail to meet the requirements as to physical properties specified in Section 6 or Section 7 as required, but at least half of the springs representing a lot do meet these requirements, each spring of the lot shall be tested and those which meet the requirements shall be accepted. If more than half of the springs representing a lot fail to meet the requirements specified in Section 6 or Section 7 as required, the lot represented will be rejected.

6. When the "compression" method is to be used, the properties specified in Paragraphs (a), (b) and (c), modified if necessary to conform to the requirements of the appendix, shall be determined, in the order specified. The spring shall not be rapped or otherwise disturbed during the test. The ends of half-elliptic springs shall be supported on roller or swing bearings.
(a) **Free Height.**—The free height is the height of the spring after a test load of $1\frac{1}{2}$ times the specified working load has been applied and fully released.

(b) **Loaded Height and Loaded Length.**—The loaded height and loaded length are respectively the height and length when the specified working load is applied. The load shall be applied gradually and in such a way that the specified working load shall not be exceeded. If it is exceeded, the load shall be released to not more than one-half the specified working load and then increased to the specified working load. The loaded height shall not be less, but may be $\frac{3}{4}$ in. more than that specified. The loaded length shall not vary more than $\frac{1}{4}$ in. from that specified.

(c) **Permanent Set.**—The permanent set is the difference, if any, between the free height and the height after the test load of $1\frac{1}{2}$ times the specified working load has again been applied and fully released. The following two requirements shall be met:

1. The permanent set shall not exceed $\frac{1}{32}$ in.;
2. If there is any permanent set not exceeding $\frac{1}{32}$ in. the difference between the free height and the height after the test load of $1\frac{1}{2}$ times the specified working load has been applied and fully released two additional times, shall not be greater than the permanent set first measured.

7. When the "release" method is specified, the properties specified in Paragraphs (a), (b) and (c), modified if necessary to conform to the requirements of the appendix, shall be determined in the order specified. The spring shall not be rapped or otherwise disturbed during the test. The ends of half-elliptic springs shall be supported on roller or swing bearings.

(a) **Free Height.**—The free height is the height of the spring after a test load of $1\frac{1}{2}$ times the specified working load has been applied and fully released.

(b) **Loaded Height and Loaded Length.**—The loaded height and loaded length are respectively the height and length when a test load of $1\frac{1}{2}$ times the specified working load has been applied and is slowly released to the specified working load. If released to less than the specified working load, the load shall again be raised to $1\frac{1}{2}$ times the specified working load and then released.
to the specified working load. The loaded height shall not be more, but may be \( \frac{3}{4} \) in. less than that specified. The loaded length shall not vary more than \( \frac{1}{4} \) in. from that specified.

(c) Permanent Set.—The permanent set is the difference, if any, between the free height and the height after the test load of \( 1\frac{1}{2} \) times the specified working load has again been applied and fully released. The following two requirements shall be met:

1. The permanent set shall not exceed \( \frac{3}{4} \) in.;
2. If there is any permanent set not exceeding \( \frac{1}{2} \) in., the difference between the free height and the height after the test load of \( 1\frac{1}{2} \) times the specified working load has been applied and fully released two additional times, shall not be greater than the permanent set first measured.

IV. MARKING.

8. (a) The name or brand of the manufacturer, the year and month of manufacture, and if specified, the purchaser’s class number, shall be legibly stamped on each spring at a place not detrimental to the life or service of the spring.

(b) Any stamping by the inspector shall be so placed as not to be detrimental to the life or service of the spring.

V. INSPECTION AND REJECTION.

9. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the springs ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the springs are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 10. Unless otherwise specified, any rejection based on tests made in accordance with Section 2 shall be reported within five working days from the receipt of samples.
11. Samples tested in accordance with Section 2, which Rehearing. represent rejected springs, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

12. Any springs which fail to meet the requirements as Reworking. to dimensions or physical tests may be again submitted after being reworked.
APPENDIX.

TEST FIBER STRESS.

13. (a) The properties and methods of testing specified in Sections 6 and 7, have been established for carbon-steel springs on the assumption that the maximum fiber stress under test shall not exceed 127,500 lb. per sq. in.¹

(b) For alloy-steel springs practice has not been sufficiently well established to enable definite fiber stresses to be given. Unless otherwise agreed upon by the manufacturer and the purchaser, alloy-steel springs shall be tested under the conditions as to fiber stress specified for carbon-steel springs.

RELATION BETWEEN FIBER STRESS AND LOAD.

14. To find the maximum loads under which the conditions of Section 13 (a) are fulfilled, the following formula shall be used:

\[ P = \frac{2Snbh^2}{3L} \]

where \( P = \) the load in pounds; \( S = \) the stress of the most strained fiber in pounds per square inch; \( n = \) the number of plates in half-elliptic springs, or half the number of plates in full-elliptic springs; \( b = \) the width of each plate in inches; \( h = \) the thickness of each plate in inches; and \( L = \) the distance between supports, in inches, when the spring is loaded.

TEST OF SPRINGS NOT IN ACCORDANCE WITH PRECEDING RULES.

15. (a) If it is desired to purchase under these specifications springs in which the maximum fiber stress exceeds that specified in Section 13 (a), the tests shall be made as specified in Sections 6 or 7 except that the test load to be applied shall not be 1\( \frac{1}{2} \) times the specified working load, but shall be the load which

¹ This stress is given solely as a limiting stress not to be exceeded in testing by the methods covered by the specifications. It is not intended as a guide in the design of springs, as the proper working fiber stress will depend on the class and design of the spring and on the service for which it is intended.
corresponds to a fiber stress of 127,500 lb. per sq. in., as determined by Equation (1).

**Tests of Springs for which no Working Load is Specified.**

16. If springs are ordered to free height and length only, and no working load and no loaded dimensions are specified,

**Table I.—Test Loads for Elliptical Springs, in Pounds per Inch of Effective Width, which will CORRESPOND to a Maximum Fiber Stress of 127,500 lb. per sq. in.**

<table>
<thead>
<tr>
<th>Length of Spring, in.</th>
<th>Thickness of Plate, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3/16</td>
</tr>
<tr>
<td>20</td>
<td>170</td>
</tr>
<tr>
<td>22</td>
<td>136</td>
</tr>
<tr>
<td>24</td>
<td>125</td>
</tr>
<tr>
<td>26</td>
<td>115</td>
</tr>
<tr>
<td>28</td>
<td>107</td>
</tr>
<tr>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>32</td>
<td>106</td>
</tr>
<tr>
<td>34</td>
<td>106</td>
</tr>
<tr>
<td>36</td>
<td>148</td>
</tr>
<tr>
<td>38</td>
<td>140</td>
</tr>
<tr>
<td>40</td>
<td>133</td>
</tr>
<tr>
<td>42</td>
<td>126</td>
</tr>
<tr>
<td>44</td>
<td>126</td>
</tr>
<tr>
<td>46</td>
<td>126</td>
</tr>
<tr>
<td>48</td>
<td>126</td>
</tr>
<tr>
<td>50</td>
<td>126</td>
</tr>
<tr>
<td>52</td>
<td>126</td>
</tr>
<tr>
<td>54</td>
<td>126</td>
</tr>
<tr>
<td>56</td>
<td>126</td>
</tr>
<tr>
<td>58</td>
<td>126</td>
</tr>
<tr>
<td>60</td>
<td>126</td>
</tr>
</tbody>
</table>

the tests specified in Sections 6 or 7 shall be made, using instead of the “specified working load” the load which corresponds to a fiber stress of 75,000 lb. per sq. in., as determined by Equation (1).

**Table to Facilitate Calculations.**

17. Table I appended is arranged to facilitate the calculations necessary to determine whether a spring can be tested in accordance with the specifications without exceeding the stress given in Section 13 (a). The table shows, for various lengths and for various thicknesses of plate, the loads per inch of effective width of spring corresponding to a fiber stress of
127,500 lb. per sq. in. These are the maximum allowable test loads, and shall not be exceeded in any tests.

The loads are given per inch of effective width of spring. The effective width of spring is understood to mean the width of the individual plate multiplied by the number of plates as defined in Section 14. Consequently the total load in pounds for any spring is found by multiplying the value from Table I by the product of the width of plate into the number of plates.
STANDARD SPECIFICATIONS
FOR
BILLET-STEEL CONCRETE REINFORCEMENT BARS.


The specifications for this material are issued under the fixed designation A 15; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1911; Revised, 1912, 1913, 1914.

1. (a) These specifications cover three classes of billet-steel concrete reinforcement bars, namely: plain, deformed, and cold-twisted.

   (b) Plain and deformed bars are of three grades, namely: structural-steel, intermediate and hard.

2. (a) The structural-steel grade shall be used unless otherwise specified.

   (b) If desired, cold-twisted bars may be purchased on the basis of tests of the hot-rolled bars before twisting, in which case such tests shall govern and shall conform to the requirements specified for plain bars of structural-steel grade.

I. MANUFACTURE.

3. (a) The steel may be made by the Bessemer or open-hearth process.

   (b) The bars shall be rolled from new billets. No rerolled material will be accepted.

4. Cold-twisted bars shall be twisted cold with one complete twist in a length not over 12 times the thickness of the bar.

(131)
II. CHEMICAL PROPERTIES AND TESTS.

5. The steel shall conform to the following requirements as to chemical composition:

\[
\text{Phosphorus} \begin{cases} \text{Bessemer} & \text{not over 0.10 per cent} \\ \text{Open-hearth} & \text{" 0.05 "} \end{cases}
\]

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 5.

7. Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel, and each melt, or lot of ten tons, of Bessemer steel. The phosphorus content thus determined shall not exceed that specified in Section 5 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

8. (a) The bars shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Tensile Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Properties Considered.</strong></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
</tr>
<tr>
<td>Yield point, min., lb. per sq. in.</td>
</tr>
<tr>
<td>Elongation in 8 in., min., per cent</td>
</tr>
</tbody>
</table>

(a) See Section 9.

(b) The yield point shall be determined by the drop of the beam of the testing machine.

9. (a) For plain and deformed bars over \( \frac{3}{4} \) in. in thickness or diameter, a deduction of 1 from the percentages of elongation
specified in Section 8 (a) shall be made for each increase of \( \frac{1}{8} \) in. in thickness or diameter above \( \frac{3}{4} \) in.

(b) For plain and deformed bars under \( \frac{1}{16} \) in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 8 (a) shall be made for each decrease of \( \frac{1}{16} \) in. in thickness or diameter below \( \frac{7}{16} \) in.

10. The test specimen shall bend cold around a pin without cracking on the outside of the bent portion, as follows:

**Bend-Test Requirements.**

<table>
<thead>
<tr>
<th>Thickness or Diameter of Bar</th>
<th>Plain Bars</th>
<th>Deformed Bars</th>
<th>Cold-twisted Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural-Steel Grade</td>
<td>Intermediate Grade</td>
<td>Structural-Steel Grade</td>
<td>Intermediate Grade</td>
</tr>
<tr>
<td>Under ( \frac{3}{4} ) in.</td>
<td>180 deg.</td>
<td>180 deg.</td>
<td>180 deg.</td>
</tr>
<tr>
<td>( d = t )</td>
<td>( d = 2t )</td>
<td>( d = 3t )</td>
<td>( d = t )</td>
</tr>
<tr>
<td>( \frac{3}{4} ) in. or over...</td>
<td>180 deg.</td>
<td>90 deg.</td>
<td>90 deg.</td>
</tr>
<tr>
<td>( d = t )</td>
<td>( d = 2t )</td>
<td>( d = 3t )</td>
<td>( d = 2t )</td>
</tr>
</tbody>
</table>

**Explanatory Note:** \( d \) = the diameter of pin about which the specimen is bent; \( t \) = the thickness or diameter of the specimen.

11. (a) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

(b) Tension and bend test specimens for cold-twisted bars shall be taken from the finished bars, without further treatment; except as specified in Section 2 (b).

12. (a) One tension and one bend test shall be made from each melt of open-hearth steel, and from each melt, or lot of ten tons, of Bessemer steel; except that if material from one melt differs \( \frac{3}{8} \) in. or more in thickness or diameter, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.
(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 8 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT.

13. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

V. FINISH.

14. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

VI. INSPECTION AND REJECTION.

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

16. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 7 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

17. Samples tested in accordance with Section 7, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
RAIL-STEEL CONCRETE REINFORCEMENT BARS.


The specifications for this material are issued under the fixed designation A 16; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913; REvised, 1914.

1. These specifications cover three classes of rail-steel concrete reinforcement bars, namely: plain, deformed, and hot-twisted.

I. MANUFACTURE.

2. The bars shall be rolled from standard section Tee rails. Process.

3. Hot-twisted bars shall have one complete twist in a length not over 12 times the thickness of the bar. Hot-twisted Bars.

II. PHYSICAL PROPERTIES AND TESTS.

4. (a) The bars shall conform to the following minimum Tension Tests. requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Properties Considered</th>
<th>Plain Bars</th>
<th>Deformed and Hot-twisted bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>80 000</td>
<td>80 000</td>
</tr>
<tr>
<td>Yield point, lb. per sq. in.</td>
<td>50 000</td>
<td>50 000</td>
</tr>
<tr>
<td>Elongation in 8 in., percent</td>
<td>1 200 000</td>
<td>1 000 000</td>
</tr>
</tbody>
</table>

Tens. str. Tens. str.

1 See Section 5.
(b) The yield point shall be determined by the drop of the beam of the testing machine.

5. (a) For bars over \( \frac{7}{16} \) in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 4 (a) shall be made for each increase of \( \frac{1}{8} \) in. in thickness or diameter above \( \frac{7}{16} \) in.

(b) For bars under \( \frac{7}{16} \) in. in thickness or diameter, a deduction of 1 from the percentages of elongation specified in Section 4 (a) shall be made for each decrease of \( \frac{1}{16} \) in. in thickness or diameter below \( \frac{7}{16} \) in.

6. The test specimen shall bend cold around a pin without cracking on the outside of the bent portion, as follows:

<table>
<thead>
<tr>
<th>Thickness or Diameter of Bar</th>
<th>Plain Bars</th>
<th>Deformed and Hot-twisted Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under ( \frac{3}{4} ) in</td>
<td>180 deg. d = 3 t</td>
<td>180 deg. d = 4 t</td>
</tr>
<tr>
<td>( \frac{3}{4} ) in. or over</td>
<td>90 deg. d = 3 t</td>
<td>90 deg. d = 4 t</td>
</tr>
</tbody>
</table>

Explanatory Note: \( d \) = the diameter of pin about which the specimen is bent; \( t \) = the thickness or diameter of the specimen.

7. (a) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

(b) Tension and bend test specimens for hot-twisted bars shall be taken from the finished bars, without further treatment.

8. (a) One tension and one bend test shall be made from each lot of ten tons or less of each size of bar rolled from rails varying not more than 10 lb. per yd. in nominal weight.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 4 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.
III. PERMISSIBLE VARIATIONS IN WEIGHT.

9. The weight of any lot of bars shall not vary more than 5 per cent from the theoretical weight of that lot.

IV. FINISH.

10. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

V. INSPECTION AND REJECTION.

11. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

12. Bars which show injurious defects subsequent to their acceptance at the manufacturer’s works will be rejected, and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
BLOOMS, BILLETS AND SLABS FOR CARBON-STEEL FORGINGS.


The specifications for this material are issued under the fixed designation A 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913.

Classes.

1. (a) These specifications cover five classes of billets, determined by their carbon ranges as specified in Section 6.
   (b) The purposes for which these classes are frequently used are as follows:
   Class A, for welding and case hardening;
   Class B, for case hardening when subsequently heat treated;
   Class C, for special purposes;
   Class D, for axles, shafts, connecting rods and similar forgings;
   Class E, for Class D forgings when they are to be heat-treated.

Definition of Terms.

Basis of Purchase.

2. The term “billets” will be used in these specifications to designate blooms, billets and slabs.

3. (a) Billets shall be purchased as semi-finished rolled or forged material. In ordering, all dimensions shall be expressed in feet and inches.
   (b) Unless otherwise specified, the billets shall be made from ingots of at least four times the sectional area of the billet.
I. MANUFACTURE.

4. The steel shall be made by the open-hearth process.

5. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

II. CHEMICAL PROPERTIES AND TESTS.

6. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Elements Considered</th>
<th>Class.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Carbon, per cent</td>
<td>0.08-0.18</td>
</tr>
<tr>
<td>Manganese, per cent</td>
<td>0.30-0.50</td>
</tr>
<tr>
<td>Phosphorus, max., per cent</td>
<td>0.045</td>
</tr>
<tr>
<td>Sulfur, max., per cent</td>
<td>0.05</td>
</tr>
</tbody>
</table>

7. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 6. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 6.

8. (a) An analysis may be made by the purchaser from at least one billet representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 6. Drillings for analysis shall be taken from the billet with a \( \frac{3}{8} \)-in. drill, parallel to the axis of the ingot as cast, at any point midway between the center and surface.

(b) In addition to the complete analysis specified in Paragraph (a), a carbon determination may be made by the purchaser of drillings taken from the center of the billet with a \( \frac{3}{8} \)-in. drill, parallel to the axis of the ingot as cast, to determine by the variation in carbon the amount of segregation.

III. WORKMANSHIP AND FINISH.

9. The billets may be chipped to a depth not over \( \frac{1}{2} \) in., unless otherwise specified. Chipping shall be done in such a way as to prevent injurious piping of the ingot.

\(^1\) The chemical requirements as to manganese and phosphorus have purposely been made somewhat lower than those in the standard specifications for finished products for the protection of the purchaser of billets, so that with reasonable variations from segregation in the billets the finished product will meet the specified chemical requirements.
manner as not to cause laps when the billets are properly forged.

10. The billets shall be free from injurious defects and shall have a workmanlike finish.

IV. MARKING.

11. The melt number shall be legibly stamped on each billet 6 in. or over in thickness; and the top end of all "top cut" billets of such sizes shall be hot-stamped with the letter "T" and such ends criss-crossed with green paint. The melt number shall be legibly stamped on billets of smaller section when specified.

V. INSPECTION AND REJECTION.

12. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the billets ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the billets are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the billets in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

13. (a) Unless otherwise specified, any rejections based on tests made in accordance with Section 12 (b) shall be reported within five working days from the receipt of samples.

(b) Billets which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rehearing. 14. Samples tested in accordance with Section 12 (b), which represent rejected billets, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
CARBON-STEEL AND ALLOY-STEEL FORGINGS.

Serial Designation: A 18–16.

The specifications for this material are issued under the fixed designation A 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

A Docted, 1901; Revised, 1905, 1914, 1916.

1. (a) These specifications cover the various classes of carbon-steel and alloy-steel forgings now commonly used and not covered by other existing specifications of the American Society for Testing Materials.

(b) The purposes for which these classes are frequently used are as follows:

Class A, for forgings which may be welded or case-hardened;
Class B, for mild-steel forgings for structural purposes, for minor ship fittings, etc.;
Class C, for mild-steel forgings for structural purposes, for ships, etc.;
Classes D, E, F, G, H and I, for various machinery forgings, choice depending upon design and upon the stresses and services to be imposed.
Classes K, L and M, for various machinery forgings, choice depending upon design and upon the stresses and services to be imposed, and upon the character of machining operations to be done.

I. MANUFACTURE.

2. The steel may be made by the open-hearth or any other process approved by the purchaser.
3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. The manufacturer and the purchaser shall agree upon forgings on which a prolongation for test purposes shall be provided.

5. If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. Heat treatment, if required, shall consist of either annealing or quenching and tempering, as specified.

   (a) For annealing, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an “annealing charge”), and allowed to cool uniformly.

   (b) For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a “quenching charge”), and quenched in some medium under substantially uniform conditions for each quenching charge. Finally, they shall be uniformly reheated to the proper temperature for tempering or “drawing back” (a group thus reheated being known as a “tempering charge”), and allowed to cool uniformly.

II. CHEMICAL PROPERTIES AND TESTS.

7. (a) The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Elements Considered</th>
<th>A.</th>
<th>B, C, D, E, F, G</th>
<th>H, I.</th>
<th>K, L.</th>
<th>M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese, per cent</td>
<td>0.30 - 0.55</td>
<td>0.40 - 0.80</td>
<td>0.40 - 0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus, per cent</td>
<td>not over 0.05</td>
<td>not over 0.05</td>
<td>not over 0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid</td>
<td>0.05</td>
<td>0.05</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td></td>
<td></td>
<td></td>
<td>not over 0.05</td>
<td>not over 0.04</td>
</tr>
<tr>
<td>Sulfur, per cent</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Nickel, per cent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


(b) The composition of alloy steel, other than phosphorus and sulfur, to be used in forgings of classes K, L and M, shall be agreed upon by the manufacturer and the purchaser.\(^1\)

8. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese and the elements specified in Section 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 7.

9. An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings; or turnings may be taken from a test specimen.

III. PHYSICAL PROPERTIES AND TESTS.

10. (a) The forgings shall conform to the requirements as to tensile properties specified in Tables I, II and III.

(b) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) The yield point shall be determined by the drop of the beam of the testing machine.

\(^1\)The question of chemical composition of the several types of alloy steels is not yet sufficiently standardized to warrant the inclusion of formal requirements covering chemical composition of such alloy steels in standard specifications.

The following compositions are quoted as being as nearly typical as any now regularly manufactured:

<table>
<thead>
<tr>
<th>Elements Considered</th>
<th>Chrome-Vanadium Steel</th>
<th>Chrome-Nickel Steel</th>
<th>Chromium Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classes K and L</td>
<td>Class M</td>
<td>Classes K and L</td>
</tr>
<tr>
<td>Carbon, per cent.</td>
<td>0.28 - 0.42</td>
<td>0.35 - 0.50</td>
<td>0.28 - 0.42</td>
</tr>
<tr>
<td>Manganese, per cent.</td>
<td>0.40 - 0.70</td>
<td>0.50 - 0.90</td>
<td>0.40 - 0.70</td>
</tr>
<tr>
<td>Vanadium, per cent.</td>
<td>not under 0.15</td>
<td>not under 0.15</td>
<td>not under 0.15</td>
</tr>
<tr>
<td>Nickel, per cent.</td>
<td>not under 1.25</td>
<td>not under 2.75</td>
<td>not under 1.25</td>
</tr>
</tbody>
</table>
Specifications for Steel Forgings.

(d) The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

Note: The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any Form which will fit the Holders of the Testing Machine.

Fig. 1.

(e) Tests of forgings shall be made only after final treatment. 11. (a) Tension test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross-section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.
(c) The specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

**Table I.—Tensile Properties (Classes A to F, inclusive).**

**For forgings whose maximum outside diameter or over-all thickness is not over 20 in.**

<table>
<thead>
<tr>
<th>Class</th>
<th>Size.</th>
<th>Tensile Strength, min. (except Class A), lb. per sq. in.</th>
<th>Yield Point, min., lb. per sq. in.</th>
<th>Elongation in 2 in., min., per cent.</th>
<th>Reduction of Area, min., per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inverse Ratio, Not under</td>
<td>Inverse Ratio, Not under</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A UNTREATED</td>
<td>All sizes, . . . . .</td>
<td>47 000 to 60 000</td>
<td>0.5 tens. str.</td>
<td>1 500 000</td>
<td>2 500 000</td>
</tr>
<tr>
<td>B UNTREATED</td>
<td>Not over 12 in.</td>
<td>60 000</td>
<td>0.5 tens. str.</td>
<td>1 550 000</td>
<td>2 400 000</td>
</tr>
<tr>
<td></td>
<td>Over 12 to 20 in., inclusive</td>
<td>60 000</td>
<td>0.5 tens str</td>
<td>1 480 000</td>
<td>2 220 000</td>
</tr>
<tr>
<td>C ANNEALED</td>
<td>Not over 12 in.</td>
<td>60 000</td>
<td>0.5 tens. str.</td>
<td>1 700 000</td>
<td>2 700 000</td>
</tr>
<tr>
<td></td>
<td>Over 12 to 20 in., inclusive</td>
<td>60 000</td>
<td>0.5 tens. str.</td>
<td>1 000 000</td>
<td>2 320 000</td>
</tr>
<tr>
<td>D UNTREATED</td>
<td>Not over 8 in.</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 600 000</td>
<td>2 200 000</td>
</tr>
<tr>
<td></td>
<td>Over 8 to 12 in., inclusive</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 500 000</td>
<td>2 000 000</td>
</tr>
<tr>
<td></td>
<td>Over 12 to 20 in., inclusive</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 400 000</td>
<td>1 800 000</td>
</tr>
<tr>
<td>E ANNEALED</td>
<td>Not over 8 in.</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 800 000</td>
<td>2 800 000</td>
</tr>
<tr>
<td></td>
<td>Over 8 to 12 in., inclusive</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 725 000</td>
<td>2 640 000</td>
</tr>
<tr>
<td></td>
<td>Over 12 to 20 in., inclusive</td>
<td>73 000</td>
<td>0.5 tens. str.</td>
<td>1 650 000</td>
<td>2 400 000</td>
</tr>
<tr>
<td>F ANNEALED</td>
<td>Not over 8 in.</td>
<td>80 000</td>
<td>0.5 tens. str.</td>
<td>1 800 000</td>
<td>2 800 000</td>
</tr>
<tr>
<td></td>
<td>Over 8 to 12 in., inclusive</td>
<td>80 000</td>
<td>0.5 tens. str.</td>
<td>1 725 000</td>
<td>2 640 000</td>
</tr>
<tr>
<td></td>
<td>Over 12 to 20 in., inclusive</td>
<td>80 000</td>
<td>0.5 tens. str.</td>
<td>1 650 000</td>
<td>2 400 000</td>
</tr>
</tbody>
</table>

12. Unless otherwise specified by the purchaser, tests shall be made as follows:

(a) For untreated forgings, one tension test shall be made from each melt.
# Specifications for Steel Forgings.

## Table II.—Tensile Properties (Classes G, H, and I).

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>Tensile Strength, min. lb. per sq. in.</th>
<th>Elastic Limit, min. lb. per sq. in.</th>
<th>Elongation in 2 in., min., per cent.</th>
<th>Reduction of Area, min., per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tens. str.</td>
<td>Inverse Ratio. Not under</td>
<td></td>
<td>Inverse Ratio. Not under</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>90 000</td>
<td>2 100 000</td>
<td>19.5</td>
<td>3 600 000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55 000</td>
<td>2 000 000</td>
<td>3 800 000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 900 000</td>
<td></td>
<td>3 600 000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 000</td>
<td></td>
<td>3 400 000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>85 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 000</td>
<td>2 000 000</td>
<td>3 600 000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 000</td>
<td></td>
<td>3 400 000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>85 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>70 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>190 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>65 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Forgings whose Maximum Outside Diameter or Thickness is not over 10 in. when Solid, and not over 20 in. when Bored.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G Quenched and Tempered.</td>
<td>Up to 4 in. in outside diameter or thickness, 2-in. max. wall</td>
<td>90 000</td>
<td>55 000</td>
<td>2 100 000</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3/4-in. max. wall</td>
<td>1 900 000</td>
<td>3 800 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall</td>
<td>1 900 000</td>
<td>3 600 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall</td>
<td>1 800 000</td>
<td>3 400 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H Nickel Steel, Annealed.</td>
<td>Outside diameter or over-all thickness not over 12 in.</td>
<td>80 000</td>
<td>50 000</td>
<td>2 000 000</td>
<td>19.5</td>
</tr>
<tr>
<td>I Nickel Steel, Quenched and Tempered.</td>
<td>Up to 4 in. in outside diameter or thickness, 2-in. max. wall</td>
<td>100 000</td>
<td>70 000</td>
<td>2 200 000</td>
<td>4 500 000</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3/4-in. max. wall</td>
<td>100 000</td>
<td>65 000</td>
<td>2 100 000</td>
<td>4 300 000</td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall</td>
<td>90 000</td>
<td>60 000</td>
<td>2 000 000</td>
<td>4 100 000</td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall</td>
<td>85 000</td>
<td>55 000</td>
<td>1 900 000</td>
<td>3 900 000</td>
</tr>
<tr>
<td>Class</td>
<td>Size</td>
<td>Tensile Strength, lb. per sq. in.</td>
<td>Elastic Limit, min., lb. per sq. in.</td>
<td>Elongation in 2 in., min., per cent.</td>
<td>Reduction of Area, min., per cent.</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------------</td>
<td>----------------------------------</td>
<td>--------------------------------------</td>
<td>--------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td></td>
<td>Up to 2 in. in outside diameter or thickness, 1-in. max. wall...</td>
<td>95 000 - 115 000</td>
<td>70 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>K Alloy Steel, Quenched and Tempered.</td>
<td>Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall</td>
<td>90 000 - 110 000</td>
<td>65 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3/4-in. max. wall</td>
<td>90 000 - 110 000</td>
<td>65 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall</td>
<td>90 000 - 110 000</td>
<td>65 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall</td>
<td>85 000 - 105 000</td>
<td>60 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>L Alloy Steel, Quenched and Tempered.</td>
<td>Up to 2 in. in outside diameter or thickness, 1-in. max. wall...</td>
<td>105 000 - 125 000</td>
<td>80 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall</td>
<td>100 000 - 120 000</td>
<td>75 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3/4-in. max. wall</td>
<td>100 000 - 120 000</td>
<td>75 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall</td>
<td>100 000 - 120 000</td>
<td>75 000</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall</td>
<td>95 000 - 115 000</td>
<td>70 000</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Minimum.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Up to 2 in. in outside diameter or thickness, 1-in. max. wall...</td>
<td>125 000</td>
<td>105 000</td>
<td>18</td>
<td>50</td>
</tr>
<tr>
<td>M Alloy Steel, Quenched and Tempered.</td>
<td>Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall</td>
<td>115 000</td>
<td>95 000</td>
<td>16</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3/4-in. max. wall</td>
<td>115 000</td>
<td>95 000</td>
<td>16</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall</td>
<td>110 000</td>
<td>85 000</td>
<td>16</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall</td>
<td>105 000</td>
<td>70 000</td>
<td>18</td>
<td>45</td>
</tr>
</tbody>
</table>
(b) For annealed forgings, one tension test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension test shall be made from each melt.

(c) For quenched and tempered forgings, one tension test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension test shall be made from each melt.

(d) If more than one class of forgings by size is represented in any lot, one tension test from a forging of each class by size shall be made as specified in Sections 10 and 11.

(e) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(f) If the percentage of elongation of any test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than 3/4 in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests.

13. (a) If the results of the physical tests of any test lot of forgings in classes A to I, inclusive, do not conform to the requirements specified, the manufacturer may re-treat such lot one or more times and retests shall be made as specified in Section 12.

(b) If the results of the physical tests of any test lot of forgings in classes K, L or M do not conform to the requirements specified, the manufacturer may retemper or requench and temper such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 12.

IV. WORKMANSHIP AND FINISH.

Workmanship.

14. The forgings shall conform to the sizes and shapes specified by the purchaser. When centered, 60-deg. centers with clearance drilled for points shall be used.

Finish.

15. The forgings shall be free from injurious defects and shall have a workmanlike finish.
V. MARKING.

16. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. INSPECTION AND REJECTION.

17. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

18. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 17 (b) shall be reported within five working days from the receipt of samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

19. Samples tested in accordance with Section 17 (b), which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
QUENCHED-AND-TEMPERED CARBON-STEEL AXLES, SHAFTS, AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS.

Serial Designation: A 19–16.

The specifications for this material are issued under the fixed designation A 19; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1911; Revised, 1912, 1914, 1916.

1. When used for forgings for locomotives, these specifications cover quenched-and-tempered carbon-steel driving axles, engine and trailing-truck axles, main and side rods, straps, crank pins and piston rods.

I. MANUFACTURE.

2. The steel may be made by the open-hearth or any other process approved by the purchaser.

3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. For test purposes, a prolongation shall be left on each forging, unless otherwise specified by the purchaser.

5. (a) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring and rough turning shall be done before quenching.

(b) If boring is specified, the diameter of the hole shall
be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a “quenching charge”), and quenched in some medium under substantially uniform conditions for each quenching charge. Finally, they shall be uniformly reheated to the proper temperature for tempering or “drawing back” (a group thus reheated being known as a “tempering charge”), and allowed to cool uniformly.

II. CHEMICAL PROPERTIES AND TESTS.

7. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Carbon</th>
<th>First Class by Size</th>
<th>0.25 - 0.60 per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Second</td>
<td>0.35 - 0.60</td>
</tr>
<tr>
<td></td>
<td>Third</td>
<td>0.35 - 0.65</td>
</tr>
<tr>
<td></td>
<td>Fourth</td>
<td>0.35 - 0.70</td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td>0.40 - 0.70</td>
</tr>
<tr>
<td>Phosphorus</td>
<td></td>
<td>not over 0.05</td>
</tr>
<tr>
<td>Sulfur</td>
<td></td>
<td>0.05</td>
</tr>
</tbody>
</table>

8. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 7.

9. (a) An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings; or turnings may be taken from a test specimen.

(b) In addition to the complete analysis specified in Paragraph (a), a phosphorus determination may be made by the
purchaser from each broken tension test specimen. The phosphorus content thus determined shall conform to the requirement specified in Section 7.

III. PHYSICAL PROPERTIES AND TESTS.

10. (a) The forgings shall conform to the minimum requirements as to tensile properties specified in Table I.

<table>
<thead>
<tr>
<th>Size</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Elastic Limit, lb. per sq. in.</th>
<th>Elongation in 2 in., per cent.</th>
<th>Reduction of Area, per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 4 in. in outside diameter or thickness, 2-in. max. wall</td>
<td>90 000</td>
<td>55 000</td>
<td>2 100 000 Tens. str.</td>
<td>20.5</td>
</tr>
<tr>
<td>Over 4 to 7 in. in outside diameter or thickness, 3-in. max. wall</td>
<td>85 000</td>
<td>50 000</td>
<td>2 000 000 Tens. str.</td>
<td>20.5</td>
</tr>
<tr>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall</td>
<td>85 000</td>
<td>50 000</td>
<td>1 900 000 Tens. str.</td>
<td>19.5</td>
</tr>
<tr>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall</td>
<td>82 500</td>
<td>48 000</td>
<td>1 800 000 Tens. str.</td>
<td>19</td>
</tr>
</tbody>
</table>

(b) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.
Tests of forgings shall be made only after final treatment.

11. If specified by the purchaser, bend tests shall be made as follows:
   (a) For the first and second classes by size, the test specimen shall bend cold through 180 deg. around a 1-in. flat mandrel having a rounded edge of \(\frac{1}{2}\)-in. radius, without cracking on the outside of the bent portion.
   (b) For the third and fourth classes by size, the test specimen shall bend cold through 180 deg. around a 1\(\frac{1}{2}\)-in. flat mandrel having a rounded edge of \(\frac{3}{4}\)-in. radius, without cracking on the outside of the bent portion.

12. Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.\(^1\)

13. (a) Tension and bend test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross-section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.
   (b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.
   (c) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.
   (d) Bend test specimens shall be \(\frac{1}{2}\) in. square in section with corners rounded to a radius not over \(\frac{1}{16}\) in., and need not exceed 6 in. in length.

14. (a) One tension and, if specified by the purchaser, one bend test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension and, if specified, one bend test shall be

\(^1\) For information relative to proof tests of finished forgings, see Appendix, pp. 157-158.
Specifications for Quenched-and-Tempered Forgings.

made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and, if specified, one bend test shall be made from each melt.

(b) If more than one class of forgings by size is represented in any lot, one tension and, if specified, one bend test from a forging of each class by size shall be made as specified in Sections 10, 11 and 13.

(c) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(d) If the percentage of elongation of any tension test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than $\frac{3}{8}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests.

15. (a) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retemper or requench and temper such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 14.

(b) If the fracture of any tension test specimen shows over 15 per cent crystallin, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystallin, the forgings represented by such specimen shall be
retempered or requenched and tempered. The fracture shall be considered crystallin if the crystals which it contains are so large that the cleavage planes or sides of these crystals are easily visible to the eye.

IV. WORKMANSHIP AND FINISH.

16. The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough-turned all over with an allowance of 1/8 in. on the surface for finishing. In centering, 60-deg. centers with clearance drilled for points shall be used.

17. The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

18. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. INSPECTION AND REJECTION.

19. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

20. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 19 (b) shall be reported within five working days from the receipt of samples.
(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rehearing. 21. Samples tested in accordance with Section 19 (b), which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
APPENDIX.

As a guide in determining a proof test for quenched-and-tempered forgings, the following particulars regarding three methods of proof testing now being used are given:

The Pennsylvania Railroad Co. and the Standard Steel Works Co. require that axles, shafts and similar forgings shall receive an impact proof test on an M.C.B. drop-test machine, with supports 3 ft. apart, two blows being struck with a tup weighing 1640 or 2240 lb. The former company requires that

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height of Drop, ft. and in.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 1/2</td>
<td>0 ft. 11 in.</td>
<td></td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 &quot; 3 &quot;</td>
<td></td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>6 1/2</td>
<td>1 &quot; 8 &quot;</td>
<td>1 ft. 2 in.</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2 &quot; 2 &quot;</td>
<td>1 &quot; 7 &quot;</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>6 1/2</td>
<td>2 &quot; 9 &quot;</td>
<td>2 &quot; 0 &quot;</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3 &quot; 5 &quot;</td>
<td>2 &quot; 6 &quot;</td>
<td>3500</td>
<td></td>
</tr>
<tr>
<td>7 1/2</td>
<td>1 &quot; 3 &quot;</td>
<td>3 &quot; 4 &quot;</td>
<td>4700</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>5 &quot; 1 &quot;</td>
<td>3 &quot; 8 &quot;</td>
<td>6000</td>
<td></td>
</tr>
<tr>
<td>8 1/2</td>
<td>6 &quot; 2 &quot;</td>
<td>4 &quot; 6 &quot;</td>
<td>7500</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>7 &quot; 3 &quot;</td>
<td>5 &quot; 3 &quot;</td>
<td>9000</td>
<td></td>
</tr>
<tr>
<td>9 1/2</td>
<td>8 &quot; 7 &quot;</td>
<td>6 &quot; 3 &quot;</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>9 &quot; 9 &quot;</td>
<td>7 &quot; 4 &quot;</td>
<td>11000</td>
<td></td>
</tr>
<tr>
<td>10 1/2</td>
<td>10 &quot; 7 &quot;</td>
<td>8 &quot; 6 &quot;</td>
<td>12,000</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>11 &quot; 5 &quot;</td>
<td>9 &quot; 10 &quot;</td>
<td>14,000</td>
<td></td>
</tr>
<tr>
<td>11 1/2</td>
<td>13 &quot; 3 &quot;</td>
<td>11 &quot; 1 &quot;</td>
<td>14,000</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>17 &quot; 1 &quot;</td>
<td>12 &quot; 8 &quot;</td>
<td>15,000</td>
<td></td>
</tr>
</tbody>
</table>

both blows be struck at the center of the forging, which is to be turned 90 deg. after the first blow. The other requires that the forging be supported at one end for the first blow and at the other end for the second blow; and that the forging be turned 180 deg. after the first blow. The requirements as to height of drop given in the accompanying table are derived from the following formulas:

For the 1640-lb. tup: \( H = 0.01D^3; \)

" " 2240 " " \( H = 0.0073D^3; \)

in which \( H \) is height of drop in feet and \( D \) is diameter of the forging at the center in inches.

The New York Central Lines and the Carnegie Steel Co. require that forgings shall be submitted to an impact proof test by having them supported at the ends and being struck in the center one blow by a tup delivering the number of foot-pounds shown in the accompanying table.
STANDARD SPECIFICATIONS
FOR
CARBON-STEEL FORGINGS FOR LOCOMOTIVES.

Serial Designation: A 20–16.

The specifications for this material are issued under the fixed designation A 20; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1912; Revised, 1913, 1914, 1916.

1. (a) These specifications cover untreated and annealed basis of purchase. carbon-steel driving axles, engine and trailing-truck axles, main and side rods, straps, crank pins and piston rods.

(b) The manufacturer may, at his option, furnish annealed forgings when untreated forgings are specified by the purchaser, provided they conform to the requirements specified for untreated forgings.

I. MANUFACTURE.

2. The steel may be made by the open-hearth or any other process approved by the purchaser.

3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. The manufacturer and the purchaser shall agree upon prolongations for tests. forgings on which a prolongation for test purposes shall be provided.

5. For annealing, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an "annealing charge"), and allowed to cool uniformly.
II. CHEMICAL PROPERTIES AND TESTS.

6. The steel shall conform to the following requirements as to chemical composition:

- Manganese: 0.40 - 0.70 per cent
- Phosphorus: not over 0.05 "
- Sulfur: " " 0.05 "

7. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon and the elements specified in Section 6. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 6.

8. An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 6. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface; or turnings may be taken from a test specimen.

III. PHYSICAL PROPERTIES AND TESTS.

9. (a) The forgings shall conform to the following minimum requirements as to tensile properties:

**Tensile Properties.**

<table>
<thead>
<tr>
<th>Size. Outside Diameter or Over-all Thickness</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Yield Point, lb. per sq. in.</th>
<th>Elongation in 2 in., per cent.</th>
<th>Reduction of Area, per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inverse Ratio. Not under</td>
<td>Inverse Ratio. Not under</td>
</tr>
<tr>
<td>Not over 8 in.</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 000 000</td>
<td>2 000 000</td>
</tr>
<tr>
<td>Over 8 to 12 in., inclusive</td>
<td>75 000</td>
<td>0.5 tens. str.</td>
<td>1 500 000</td>
<td>2 000 000</td>
</tr>
</tbody>
</table>

**Annealed.**

<table>
<thead>
<tr>
<th>Size. Outside Diameter or Over-all Thickness</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Yield Point, lb. per sq. in.</th>
<th>Elongation in 2 in., per cent.</th>
<th>Reduction of Area, per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inverse Ratio. Not under</td>
<td>Inverse Ratio. Not under</td>
</tr>
<tr>
<td>Not over 8 in.</td>
<td>80 000</td>
<td>0.5 tens. str.</td>
<td>1 800 000</td>
<td>2 800 000</td>
</tr>
<tr>
<td>Over 8 to 12 in., inclusive</td>
<td>80 000</td>
<td>0.5 tens. str.</td>
<td>1 725 000</td>
<td>2 640 000</td>
</tr>
<tr>
<td>Over 12 to 20 in., inclusive</td>
<td>80 000</td>
<td>0.5 tens. str.</td>
<td>1 650 000</td>
<td>2 400 000</td>
</tr>
</tbody>
</table>
(b) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) The yield point shall be determined by the drop of the beam of the testing machine.

(d) Tests of forgings shall be made only after final treatment.

10. (a) Tension test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross-section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

Radius not less than \( \frac{1}{8} \)"

\[ 2\frac{1}{4}'' \]

\[ 2'' \text{Gage Length} \]

Note: The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any Form which will fit the Holders of the Testing Machine.

FIG. 1.

(b) The axis of the specimen shall be located at any point midway between the center and surface of the forging, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) The specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

11. Unless otherwise specified by the purchaser, tests shall be made as follows:

(a) For untreated forgings, one tension test shall be made from each melt.

(b) For annealed forgings, one tension test shall be made from each annealing charge. If more than one melt is represented
in an annealing charge, one tension test shall be made from each melt.

(c) If more than one class of forgings by size is represented in any lot, one tension test from a forging of each class by size shall be made as specified in Sections 9 and 10.

(d) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(e) If the percentage of elongation of any test specimen is less than that specified in Section 9 (a) and any part of the fracture is more than \(\frac{3}{4}\) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests.

12. (a) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-anneal such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 11.

(b) When annealed forgings are specified, if the fracture of any test specimen shows over 15 per cent crystallin, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystallin, the forgings represented by such specimen shall be re-annealed. The fracture shall be considered crystallin if the crystals which it contains are so large that the cleavage planes or sides of these crystals are easily visible to the eye.

IV. WORKMANSHIP AND FINISH.

Workmanship. 13. The forgings shall conform to the sizes and shapes specified by the purchaser. When centered, 60-deg. centers with clearance drilled for points shall be used.

Finish. 14. The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 15. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.
VI. INSPECTION AND REJECTION.

16. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 16 (b) shall be reported within five working days from the receipt of samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

18. Samples tested in accordance with Section 16 (b), which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
QUENCHED-AND-TEMPERED ALLOY-STEEL AXLES,
SHAFTS, AND OTHER FORGINGS FOR
LOCOMOTIVES AND CARS.

Serial Designation: A 63-16.

The specifications for this material are issued under the fixed designation A 63; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

Classes. 1. (a) These specifications cover the various classes of alloy-steel forgings now commonly used in locomotive and car construction.

    (b) The purposes for which these classes are frequently used are as follows:

    Class K, for forgings for main and side rods, straps, piston rods, and all other forgings which are to be machined with milling cutters or complicated forming tools;

    Class L, for forgings for driving and trailing-truck axles, crank pins, and other parts not requiring the use of milling cutters or complicated forming tools.

I. MANUFACTURE.

Process. 2. The steel may be made by the open-hearth or any other process approved by the purchaser.
3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. For test purposes, a prolongation shall be left on each forging, unless otherwise specified by the purchaser.

5. (a) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring and rough turning shall be done before quenching.

   (b) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "quenching charge"), and quenched in some medium under substantially uniform conditions for each quenching charge. Finally, they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a "tempering charge"), and allowed to cool uniformly.

II. CHEMICAL PROPERTIES AND TESTS.

7. (a) The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Acid.</th>
<th>Basic.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>not over 0.05</td>
</tr>
<tr>
<td>Sulfur</td>
<td>&quot; 0.05</td>
</tr>
</tbody>
</table>

   (b) The composition of alloy steel, other than phosphorus and sulfur, shall be agreed upon by the manufacturer and the purchaser.¹

¹The question of chemical composition of the several types of alloy steels is not yet sufficiently standardized to warrant the inclusion of formal requirements covering chemical composition of such alloy steels in standard specifications.

The following compositions for classes K and L are quoted as being as nearly typical as any now regularly manufactured:

<table>
<thead>
<tr>
<th>Elements Considered</th>
<th>Chrome-Vanadium Steel</th>
<th>Chrome-Nickel Steel</th>
<th>Chromium Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, per cent</td>
<td>0.28 - 0.42</td>
<td>0.28 - 0.42</td>
<td>0.28 - 0.42</td>
</tr>
<tr>
<td>Manganese, per cent</td>
<td>0.40 - 0.70</td>
<td>0.40 - 0.70</td>
<td>0.40 - 0.70</td>
</tr>
<tr>
<td>Chromium, per cent</td>
<td>0.75 - 1.25</td>
<td>not under 0.70</td>
<td>0.60 - 0.90</td>
</tr>
<tr>
<td>Vanadium, per cent</td>
<td>not under 0.15</td>
<td>not under 1.25</td>
<td></td>
</tr>
<tr>
<td>Nickel, per cent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese and the elements specified in Section 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 7.

Check Analyses.

9. (a) An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings; or turnings may be taken from a test specimen.

(b) In addition to the complete analysis specified in Paragraph (a), a phosphorus determination may be made by the purchaser from each broken tension test specimen. The phosphorus content thus determined shall conform to the requirement specified in Section 7.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

10. (a) The forgings shall conform to the requirements as to tensile properties specified in Table I.

(b) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The
extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

(d) Tests of forgings shall be made only after final treatment.

11. If specified by the purchaser, bend tests shall be made Bend Tests.

(a) For the first and second classes by size, the test specimen shall bend cold through 180 deg. around a 1-in. flat mandrel having a rounded edge of \( \frac{1}{2} \)-in. radius, without cracking on the outside of the bent portion.

(b) For the third and fourth classes by size, the test specimen shall bend cold through 180 deg. around a 1\( \frac{1}{2} \)-in. flat mandrel having a rounded edge of \( \frac{3}{4} \)-in. radius, without cracking on the outside of the bent portion.

#### Table I.—Tensile Properties.

For forgings whose Maximum Outside Diameter or Thickness is not over 10 in. when Solid, and not over 20 in. when Bored.

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Elastic Limit, min. lb. per sq. in.</th>
<th>Elongation in 2 in., min., per cent.</th>
<th>Reduction of Area, min., per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Alloy Steel, Quenched and Tempered.</td>
<td>Up to 2 in. in outside diameter or thickness, 1-in. max. wall.</td>
<td>95 000 - 115 000</td>
<td>70 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall.</td>
<td>90 000 - 110 000</td>
<td>65 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3( \frac{1}{4} )-in. max. wall.</td>
<td>90 000 - 110 000</td>
<td>65 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall.</td>
<td>90 000 - 110 000</td>
<td>65 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall.</td>
<td>85 000 - 105 000</td>
<td>60 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>L Alloy Steel, Quenched and Tempered.</td>
<td>Up to 2 in. in outside diameter or thickness, 1-in. max. wall.</td>
<td>105 000 - 125 000</td>
<td>80 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 2 to 4 in. in outside diameter or thickness, 2-in. max. wall.</td>
<td>100 000 - 120 000</td>
<td>75 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 4 to 7 in. in outside diameter or thickness, 3( \frac{1}{4} )-in. max. wall.</td>
<td>100 000 - 120 000</td>
<td>75 000</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 7 to 10 in. in outside diameter or thickness, 5-in. max. wall.</td>
<td>100 000 - 120 000</td>
<td>75 000</td>
<td>18</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Outside diameter or thickness not over 20 in., 5 to 8-in. wall.</td>
<td>95 000 - 115 000</td>
<td>70 000</td>
<td>18</td>
<td>45</td>
</tr>
</tbody>
</table>
Proof Tests.

12. Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.\(^1\)

Test Specimens.

13. (a) Tension and bend test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross-section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

\[\text{Fig. 1.}\]

Radius not less than \(\frac{1}{8}\) in.\]

\[2\text{ in.} \quad \text{Gage Length} \quad \]

\[\text{Note: The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.}\]

(b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(d) Bend test specimens shall be \(\frac{3}{8}\) in. square in section with corners rounded to a radius not over \(\frac{1}{16}\) in., and need not exceed 6 in. in length.

\(^1\text{For information relative to proof tests of finished forgings, see Appendix, pp. 171-172.}\)
14. (a) One tension and, if specified by the purchaser, one bend test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension and, if specified, one bend test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and, if specified, one bend test shall be made from each melt.

(b) If more than one class of forgings by size is represented in any lot, one tension and, if specified, one bend test from a forging of each class by size shall be made as specified in Sections 10, 11 and 13.

(c) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(d) If the percentage of elongation of any tension test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

15. (a) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retemper or requench and temper such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 14.

(b) If the fracture of any tension test specimen shows over 15 per cent crystallin, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystallin, the forgings represented by such specimen shall be retempered or requenched and tempered. The fracture shall be considered crystallin if the crystals which it contains are so large that the cleavage planes or sides of these crystals are easily visible to the eye.

IV. WORKMANSHIP AND FINISH.

16. The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough-turned all over with an allowance of \( \frac{1}{4} \) in. on the surface for finishing. In centering, 60-deg. centers with clearance drilled for points shall be used.
17. The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

18. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. INSPECTION AND REJECTION.

19. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

     (b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

     (c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

20. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 19 (b) shall be reported within five working days from the receipt of samples.

     (b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

21. Samples tested in accordance with Section 19 (b), which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time,
As a guide in determining a proof test for quenched-and-tempered forgings, the following particulars regarding three methods of proof testing now being used are given:

The Pennsylvania Railroad Co. and the Standard Steel Works Co. require that axles, shafts and similar forgings shall receive an impact proof test on an M.C.B. drop-test machine, with supports 3 ft. apart, two blows being struck with a tup

\[ \text{Energy of Blow, ft. lb.} \]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height of Drop, ft. and in.</td>
<td>1640-lb. Tup.</td>
</tr>
<tr>
<td>4(\frac{1}{2})</td>
<td>0 ft. 11 in.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 &quot; 3 &quot;</td>
<td></td>
</tr>
<tr>
<td>5(\frac{1}{2})</td>
<td>1 &quot; 5 &quot;</td>
<td>1 ft. 2 in.</td>
</tr>
<tr>
<td>6</td>
<td>2 &quot; 2 &quot;</td>
<td>1 &quot; 7 &quot;</td>
</tr>
<tr>
<td>6(\frac{1}{2})</td>
<td>2 &quot; 9 &quot;</td>
<td>2 &quot; 0 &quot;</td>
</tr>
<tr>
<td>7</td>
<td>3 &quot; 5 &quot;</td>
<td>2 &quot; 6 &quot;</td>
</tr>
<tr>
<td>7(\frac{1}{2})</td>
<td>4 &quot; 3 &quot;</td>
<td>3 &quot; 1 &quot;</td>
</tr>
<tr>
<td>8</td>
<td>5 &quot; 1 &quot;</td>
<td>3 &quot; 8 &quot;</td>
</tr>
<tr>
<td>8(\frac{1}{2})</td>
<td>6 &quot; 2 &quot;</td>
<td>4 &quot; 6 &quot;</td>
</tr>
<tr>
<td>9</td>
<td>7 &quot; 3 &quot;</td>
<td>5 &quot; 3 &quot;</td>
</tr>
<tr>
<td>9(\frac{1}{2})</td>
<td>8 &quot; 7 &quot;</td>
<td>6 &quot; 3 &quot;</td>
</tr>
<tr>
<td>10</td>
<td>10 &quot; 0 &quot;</td>
<td>7 &quot; 4 &quot;</td>
</tr>
<tr>
<td>10(\frac{1}{2})</td>
<td>11 &quot; 7 &quot;</td>
<td>8 &quot; 6 &quot;</td>
</tr>
<tr>
<td>11</td>
<td>13 &quot; 5 &quot;</td>
<td>9 &quot; 10 &quot;</td>
</tr>
<tr>
<td>11(\frac{1}{2})</td>
<td>15 &quot; 3 &quot;</td>
<td>11 &quot; 1 &quot;</td>
</tr>
<tr>
<td>12</td>
<td>17 &quot; 4 &quot;</td>
<td>12 &quot; 8 &quot;</td>
</tr>
</tbody>
</table>

\[ ^1 \text{For more detailed information concerning these methods of proof testing, see Report of Committee A-1 on Standard Specifications for Steel, Appendix IV, "Report on Proof Tests of Finished Forgings," Proceedings, Am. Soc. Test. Mats., Vol. XIV, Part II, p. 120 (1914).} \]
Specifications for Quenched-and-Tempered Forgings.

weighing 1640 or 2240 lb. The former company requires that both blows be struck at the center of the forging, which is to be turned 90 deg. after the first blow. The other requires that the forging be supported at one end for the first blow and at the other end for the second blow; and that the forging be turned 180 deg. after the first blow. The requirements as to height of drop given in the accompanying table are derived from the following formulas:

For the 1640-lb. tup: \( H = 0.01D^2 \);

For the 2240-lb. tup: \( H = 0.0073D^2 \);

in which \( H \) is height of drop in feet and \( D \) is diameter of the forging at the center in inches.

The New York Central Lines and the Carnegie Steel Co. require that forgings shall be submitted to an impact proof test by having them supported at the ends and being struck in the center one blow by a tup delivering the number of foot-pounds shown in the accompanying table.
I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

   Carbon....................... 0.35 - 0.55 per cent
   Manganese.................... not over 0.70 "
   Phosphorus................... " 0.05 "
   Sulfur........................ " 0.06 "

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 2. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

4. An analysis may be made by the purchaser from an axle representing each melt. The chemical composition thus
determined shall conform to the requirements specified in Section 2. Drillings for analysis may be taken from the axle or from a full-size prolongation of the same, at any point midway between the center and surface.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) The test axle shall be so placed on supports that the tup will strike it midway between the ends. It shall be turned over after the first and third blows, and, when required, after the fifth and seventh blows. When tested in accordance with the following conditions, the axle shall stand the specified number of blows without fracture and the deflection after the first blow shall not exceed that specified:

<table>
<thead>
<tr>
<th>Diameter of Axle at Center, in.</th>
<th>Distance between Supports, ft.</th>
<th>Weight of Tup, lb.</th>
<th>Height of Drop, ft.</th>
<th>Number of Blows</th>
<th>Max. Deflection after First Blow, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 1/4</td>
<td>3</td>
<td>1640</td>
<td>24</td>
<td>5</td>
<td>8 1/4</td>
</tr>
<tr>
<td>4 3/8</td>
<td>3</td>
<td>1640</td>
<td>26</td>
<td>5</td>
<td>8 1/4</td>
</tr>
<tr>
<td>4 7/16</td>
<td>3</td>
<td>1640</td>
<td>28 1/2</td>
<td>5</td>
<td>8 1/4</td>
</tr>
<tr>
<td>4 3/4</td>
<td>3</td>
<td>1640</td>
<td>31</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>5 3/8</td>
<td>3</td>
<td>1640</td>
<td>34</td>
<td>5</td>
<td>7 3/4</td>
</tr>
<tr>
<td>5 7/8</td>
<td>3</td>
<td>1640</td>
<td>43</td>
<td>5</td>
<td>6 1/2</td>
</tr>
<tr>
<td>6 7/16</td>
<td>3</td>
<td>1640</td>
<td>43</td>
<td>9</td>
<td>3 1/2</td>
</tr>
</tbody>
</table>

(b) The deflection is the difference between the distance from a straight edge to the middle point of the axle, measured before the first blow, and the distance measured in the same manner after the blow. The straight edge shall rest only on the collars or the ends of the axle.

(c) The temperature of the test axle shall be between 40 and 120° F.

6. The anvil of the drop-test machine shall be supported on 12 springs, shall be free to move in a vertical direction, and shall weigh 17,500 lb. The radii of the striking face of the tup and of the supports shall be 5 in.

7. One drop test shall be made from each melt. Not less than 30 axles shall be offered from any one melt, unless otherwise agreed upon by the manufacturer and the purchaser.
IV. WORKMANSHIP AND FINISH.

8. The axles shall conform to the sizes and shapes specified by the purchaser. When centered, 60-deg. centers with clearance drilled for points shall be used.

9. The axles shall be free from injurious defects and have a workmanlike finish.

V. MARKING.

10. Identification marks shall be legibly stamped on each axle. The purchaser shall indicate the location of such identification marks.

VI. INSPECTION AND REJECTION.

11. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the axles ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the axles are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the chemical tests to govern the acceptance or rejection of the axles in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

12. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 11(b) shall be reported within five working days from the receipt of samples.

(b) Axles which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

13. Samples tested in accordance with Section 11(b), which represent rejected axles, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
COLD-ROLLED STEEL AXLES.

Serial Designation: A 22 – 16.

The specifications for this material are issued under the fixed designation A 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913; REVISED, 1914, 1916.

I. MANUFACTURE.

1. (a) The steel may be made by the open-hearth or any other process approved by the purchaser.
   
   (b) The axles shall be cold-rolled to finished size from hot-rolled bars.

2. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

   Carbon: not over 0.40 per cent
   Manganese: 0.40 – 0.80 “
   Phosphorus: not over 0.05 “
   Sulfur: “ 0.05 “

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements
specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from an axle representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3. Drillings for analysis may be taken from the axle or from a full-size prolongation of the same, at any point midway between the center and surface; or turnings may be taken from a test specimen.

III. PHYSICAL PROPERTIES AND TESTS.

6. (a) The axles shall conform to the following minimum Tension Tests. requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>70 000</td>
</tr>
<tr>
<td>Elastic limit, &quot;</td>
<td>60 000</td>
</tr>
<tr>
<td>Elongation in 2 in., per cent</td>
<td>18</td>
</tr>
<tr>
<td>Reduction of area, &quot;</td>
<td>35</td>
</tr>
</tbody>
</table>

(b) The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

7. The test specimen shall bend cold through 180 deg. Bend Tests. around a 1-in. pin or mandrel, without cracking on the outside of the bent portion.

8. (a) Tension and bend test specimens shall be taken Test Specimens. from the full-size prolongation of the axle. The axis of the specimen shall be located at any point midway between the center and surface and shall be parallel to the axis of the axle.
(b) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(c) Bend test specimens shall be \( \frac{1}{2} \) in. square in section with corners rounded to a radius not over \( \frac{1}{16} \) in., and need not exceed 6 in. in length.

9. (a) One tension and one bend test shall be made from each lot of 50 axles or less from each melt. (b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

![Diagram of axles with dimensions and notes](image)

*Note:* The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any form which will fit the Holders of the Testing Machine.

**FIG. 1.**

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6(a) and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. WORKMANSHIP AND FINISH.

10. The axles shall conform to the sizes and shapes specified by the purchaser, and shall not vary more than 0.002 in. from the diameter specified. When centered, 60-deg. centers with clearance drilled for points shall be used.

11. The axles, either finished or plain, shall be straight and free from injurious defects, and shall have a workmanlike finish.
V. MARKING.

12. Identification marks shall be legibly stamped on each marking. The purchaser shall indicate the location of such identification marks.

VI. INSPECTION AND REJECTION.

13. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the axles ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the axles are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the axles in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

14. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 13 (b) shall be reported within five working days from the receipt of samples.

(b) Axles which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

15. Samples tested in accordance with Section 13 (b), which represent rejected axles, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
AMERICAN SOCIETY FOR TESTING MATERIALS  
PHILADELPHIA, PA., U. S. A.  
AFFILIATED WITH THE  
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.  

STANDARD SPECIFICATIONS  
FOR  
WROUGHT SOLID CARBON-STEEL WHEELS  
FOR STEAM RAILWAY SERVICE.  

Serial Designation: A 57 - 16.  
The specifications for this material are issued under the fixed designation A 57; the final number indicates the year of original issue, or in the case of revision, the year of last revision.  

ADOPTED, 1912; REVISED, 1916.  

I. MANUFACTURE.  
1. The steel shall be made by the open-hearth process.  
2. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.  

II. CHEMICAL PROPERTIES AND TESTS.  
3. The steel shall conform to the following requirements as to chemical composition:  

<table>
<thead>
<tr>
<th>Element</th>
<th>Acid</th>
<th>Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.60 – 0.80</td>
<td>0.65 – 0.85 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.55 – 0.80</td>
<td>0.55 – 0.80</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>not over 0.05</td>
<td>not over 0.05</td>
</tr>
<tr>
<td>Sulfur</td>
<td>“ 0.05</td>
<td>“ 0.05</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.15 – 0.35</td>
<td>0.10 – 0.30</td>
</tr>
</tbody>
</table>

(180)
4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined, together with such identifying records as may be desired, shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a wheel representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3. A sample may be taken from any one point in the plate; or two samples may be taken, in which case they shall be on radii at right angles to each other. Samples shall not be taken in such a way as to impair the usefulness of the wheel. Drillings for analysis shall be taken by boring entirely through the sample parallel to the axis of the wheel; they shall be clean and free from scale, oil and other foreign substances. All drillings from any one wheel shall be thoroughly mixed together.

III. MATING.

6. The wheels shall be mated as to tape sizes and shipped in Mating.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.¹

7. The wheels shall conform to the dimensions specified within the following permissible variations:

**FLANGE.**

(a) **Height of Flange.**—The height of flange shall not be less, but may be \( \frac{1}{6} \) in. more than that specified.

(b) **Thickness of Flange.**—The thickness of flange shall not vary more than \( \frac{1}{16} \) in. from that specified.

(c) **Radius of Throat.**—The radius of throat shall not vary more than \( \frac{1}{16} \) in. from that specified.

¹To facilitate the use of the specifications, the various dimensions are illustrated in Fig. 1, and the permissible variations in those dimensions are also given in tabular form in Table 1.
## Table I.—Permissible Variations in Dimensions of Wrought-Steel Wheels for Steam Railway Service.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Permissible Variations in Dimensions (Over)</th>
<th>Permissible Variations in Dimensions (Under)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flange</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Height</td>
<td>$\frac{1}{8}$ in.</td>
<td>0</td>
</tr>
<tr>
<td>(b) Thickness</td>
<td>$\frac{1}{16}$ in.</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td>(c) Radius of Throat</td>
<td>$\frac{1}{16}$ in.</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td><strong>Rim</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Thickness, from Inner Edge to Intersection of Throat and Tread</td>
<td>$\frac{1}{16}$ in.</td>
<td>$\frac{3}{16}$ in.</td>
</tr>
<tr>
<td>(e) Width</td>
<td>$\frac{1}{8}$ in.</td>
<td>$\frac{1}{8}$ in.</td>
</tr>
<tr>
<td>(f) Maximum Departure of any Circle on Back Face from Plane</td>
<td>$\frac{1}{16}$ in.</td>
<td></td>
</tr>
<tr>
<td>(g) Maximum Departure of Tread from Roundity</td>
<td>$\frac{1}{16}$ in.</td>
<td></td>
</tr>
<tr>
<td>(h) Maximum Height of Block Marks on Tread</td>
<td>$\frac{1}{8}$ in.</td>
<td></td>
</tr>
<tr>
<td>(i) Tape Sizes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j) Limit-of-Wear Groove:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Maximum Departure from Specified Position</td>
<td>$\frac{1}{8}$ in.</td>
<td></td>
</tr>
<tr>
<td>2. Minimum Distance from Inner Edge of Rim</td>
<td>$\frac{3}{8}$ in.</td>
<td></td>
</tr>
<tr>
<td><strong>Plate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(k) Thickness, Variation for each $\frac{1}{8}$ in. of thickness</td>
<td>$\frac{1}{32}$ in.</td>
<td></td>
</tr>
<tr>
<td><strong>Hub</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(l) 1. Diameter</td>
<td>Limited by wall thickness.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* 2. Minimum Thickness of Wall, for Bore 7 in. or under</td>
<td>$1\frac{3}{8}$ in.</td>
</tr>
<tr>
<td></td>
<td>3. Minimum Thickness of Wall, for Bore over 7 in.</td>
<td>$1\frac{3}{8}$ in.</td>
</tr>
<tr>
<td></td>
<td>4. Maximum Variation in Thickness of Wall in any One Wheel</td>
<td>$\frac{3}{8}$ in.</td>
</tr>
<tr>
<td>(m) Length</td>
<td>$\frac{1}{8}$ in.</td>
<td>$\frac{1}{8}$ in.</td>
</tr>
<tr>
<td>(n) Depression below Front Face of Rim</td>
<td>$\frac{1}{8}$ in.</td>
<td>0</td>
</tr>
<tr>
<td>(o) Projection beyond Back Face of Rim</td>
<td>$\frac{1}{8}$ in.</td>
<td>0</td>
</tr>
<tr>
<td><strong>Bore</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(p) Diameter of Rough Bore</td>
<td>$\frac{1}{16}$ in.</td>
<td>$\frac{1}{8}$ in.</td>
</tr>
<tr>
<td>(q) Maximum Depth of Black Spots in Rough Bore within 2 in. of End of Bore</td>
<td>$\frac{1}{16}$ in.</td>
<td></td>
</tr>
<tr>
<td>(r) Maximum Eccentricity of Rough Bore in Relation to Tread</td>
<td>$\frac{3}{64}$ in.</td>
<td></td>
</tr>
</tbody>
</table>

*Note.—The letter used for each dimension in this table and in Fig. 1 is the same as that of the paragraph of Section 7 covering that dimension.*
Serial Designation: A 57-16.

Fig. 1.—Diagram showing Points at which the Dimensions covered by the Specifications are Measured. For the Permissible Variations in these Dimensions see Table I or Section 7.
Specifications for Wheels for Steam Service.

Rim.

(d) Thickness of Rim.—The rim may vary in thickness, but the variation less than that specified shall not exceed $\frac{3}{16}$ in. The thickness of rim shall be measured from the inner edge of the rim to a base line drawn from the intersection of the throat radius and the tread, parallel to the axis of the wheel.

(e) Width of Rim.—The width of rim shall not vary more than $\frac{1}{8}$ in. from that specified.

(f) Plane.—The wheels shall be gaged with a ring gage placed concentric with and perpendicular to the axis of the wheel. For all points on the back face of the rim equidistant from the center, the variation from the plane of the gage when so placed shall not exceed $\frac{1}{16}$ in.

(g) Rotundity.—The tread shall be gaged with a ring gage, and the opening between the tread and this gage at any point shall not exceed $\frac{1}{8}$ in.

(h) Block Marks on Tread.—Block marks shall not exceed $\frac{3}{4}$ in. in height.

(i) Tape Sizes.—The wheels shall not vary more than 9 tapes over nor more than 5 tapes under the size specified.

(j) Limit-of-Wear Groove.—When a limit-of-wear groove is specified, its location shall not vary more than $\frac{1}{8}$ in. from that specified, and its distance from the inner edge of the rim shall not at any point be less than $\frac{3}{4}$ in.

Plate.

(k) Thickness of Plate.—The plate may vary in thickness, but the variation less than that specified shall not exceed $\frac{1}{32}$ in. for each $\frac{1}{8}$ in. in the thickness of the plate.

Hub.

(l) Diameter of Hub.—The diameter of hub may vary, but the thickness of wall of the finished bored hub shall not be less than $1\frac{1}{8}$ in. at any point for bores 7 in. or under in diameter, nor less than $1\frac{3}{8}$ in. for bores over 7 in. in diameter, unless otherwise specified. The thickness of wall of the hub shall not vary more than $\frac{3}{8}$ in. at any two points on the same wheel.

(m) Length of Hub.—The length of hub shall not vary more than $\frac{1}{8}$ in. from that specified.
(n) Depression of Hub.—For car and tender wheels and wheels of similar design, the depression of the hub below the front face of the rim shall not be less, but may be $\frac{1}{8}$ in. more than that specified.

(o) Projection of Hub.—For locomotive-truck wheels and wheels of similar design, the projection of the hub beyond the back face of the rim shall not be less, but may be $\frac{1}{8}$ in. more than that specified.

Bore.

(p) Diameter of Rough Bore.—The diameter of rough bore shall not vary more than $\frac{1}{16}$ in. over nor more than $\frac{1}{16}$ in. under that specified. When finished-bore diameter only is specified, the rough-bore diameter shall be made $\frac{1}{4}$ in. less with the permissible variations specified above.

(q) Black Spots in Bore.—Black spots in rough bore within 2 in. of either face of the hub shall not exceed $\frac{1}{16}$ in. in depth.

(r) Eccentricity of Bore.—The eccentricity between the tread at its center line and the rough bore shall not exceed $\frac{3}{64}$ in.

V. Finish.

8. (a) The wheels shall be free from injurious defects and Finish. shall have a workmanlike finish.

(b) Wheels shall not be offered for inspection if covered with paint, rust, or any other substance to such an extent as to hide defects.

VI. MARKING.

9. (a) The name or brand of the manufacturer, date, and Marking. serial number shall be legibly stamped on each wheel in such a way that the wheel may be readily identified.

(b) The tape size shall be legibly marked on each wheel.

VII. INSPECTION AND REJECTION.

10. (a) The gages and tapes used shall be based on Master Inspection. Car Builders’ standards, as illustrated in Fig. 2.

(b) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser
Specifications for Wheels for Steam Service.

(a) Plane Gage.  (b) Rotundity Gage.

(c) Tape for Wheel Circumference Measure.

Fig. 2.—Master Car Builder's Standards.
is being performed, to all parts of the manufacturer's works which concern the manufacture of the wheels ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the wheels are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(c) The purchaser may make the tests to govern the acceptance or rejection of wheels in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(d) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

11. (a) Unless otherwise specified, any rejection based on rejection, tests made in accordance with Section 10 (c) shall be reported within five working days from the receipt of samples.

(b) Wheels which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

12. Samples tested in accordance with Section 10 (c), rehearing, which represent rejected wheels, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS
FOR
WROUGHT SOLID CARBON-STEEL WHEELS FOR ELECTRIC RAILWAY SERVICE.

Serial Designation: A 25–16.

The specifications for this material are issued under the fixed designation A 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913; REVISED, 1916.

Classes.

1. These specifications cover two classes of wheels, as follows:

   Class A: Wheels furnished rough-bored with hub faced on both sides, and other surfaces as rolled or forged.

   Class B: Wheels furnished rough-bored with hubs faced on both sides, and front face of rim, tread, flange, and back face of rim machined.

Basis of Purchase.

2. The class of wheel to be furnished shall be agreed upon by the manufacturer and the purchaser. Wheels ordered to Class A may be machined if necessary, but the permissible variations from the dimensions specified shall remain those given in Section 9 for Class A.

I. MANUFACTURE.

Process.

3. The steel shall be made by the open-hearth process.

Discard.

4. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

(188)
II. CHEMICAL PROPERTIES AND TESTS.

5. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>ACID.</th>
<th>BASIC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.60 - 0.80</td>
<td>0.65 - 0.85 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.55 - 0.80</td>
<td>0.55 - 0.80 &quot;</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>not over 0.05</td>
<td>not over 0.05 &quot;</td>
</tr>
<tr>
<td>Sulfur</td>
<td>&quot; &quot; 0.05</td>
<td>&quot; &quot; 0.05 &quot;</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.15 - 0.35</td>
<td>0.10 - 0.30 &quot;</td>
</tr>
</tbody>
</table>

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 5. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined, together with such identifying records as may be desired, shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 5.

7. An analysis may be made by the purchaser from a wheel representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 5. A sample may be taken from any one point in the plate; or two samples may be taken, in which case they shall be on radii at right angles to each other. Samples shall not be taken in such a way as to impair the usefulness of the wheel. Drillings for analysis shall be taken by boring entirely through the sample parallel to the axis of the wheel; they shall be clean and free from scale, oil and other foreign substances. All drillings from any one wheel shall be thoroughly mixed together.

III. MATING.

8. The wheels shall be mated as to tape sizes and shipped in pairs.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.¹

9. The wheels shall conform to the dimensions specified within the following permissible variations:

¹To facilitate the use of the specifications, the various dimensions are illustrated in Fig. 1, and the permissible variations in those dimensions are also given in tabular form in Table I.
### Table I.—Permissible Variations in Dimensions of Wrought Steel Wheels for Electric Railway Service.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Permissible Variations in Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class A</td>
</tr>
<tr>
<td><strong>FLANGE.</strong></td>
<td></td>
</tr>
<tr>
<td>(a) Height</td>
<td></td>
</tr>
<tr>
<td>(b) Thickness</td>
<td></td>
</tr>
<tr>
<td>(c) Radius of Throat</td>
<td></td>
</tr>
<tr>
<td><strong>RIM.</strong></td>
<td></td>
</tr>
<tr>
<td>(d) Thickness, from Inner Edge to Intersection of Throat and Tread</td>
<td>$\frac{1}{8}$ in.</td>
</tr>
<tr>
<td>(e) Width</td>
<td></td>
</tr>
<tr>
<td>(f) Maximum Departure of any Circle on Back Face from Plane</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td>(g) Maximum Departure of Tread from Rotundity</td>
<td>$\frac{1}{64}$ in.</td>
</tr>
<tr>
<td>(h) Maximum Height of Block Marks on Tread</td>
<td>$\frac{1}{64}$ in.</td>
</tr>
<tr>
<td>(i) Tape Sizes:</td>
<td></td>
</tr>
<tr>
<td>1. For Treads under 3 in. in Width</td>
<td>6</td>
</tr>
<tr>
<td>2. For Treads 3 in. or over in Width</td>
<td>9</td>
</tr>
<tr>
<td>(j) Limit-of-Wear Groove: Maximum Departure from Specified Position</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td><strong>PLATE.</strong></td>
<td></td>
</tr>
<tr>
<td>(k) Thickness, Variation for each $\frac{1}{4}$ in. of Thickness</td>
<td>$\frac{3}{32}$ in.</td>
</tr>
<tr>
<td><strong>HUB.</strong></td>
<td></td>
</tr>
<tr>
<td>(l) 1. Diameter</td>
<td>$\frac{3}{4}$ in.</td>
</tr>
<tr>
<td>2. Minimum Thickness of Wall, for Bore 6 in. or under</td>
<td>1 in.</td>
</tr>
<tr>
<td>3. Minimum Thickness of Wall, for Bore over 6 in.</td>
<td>$\frac{1}{4}$ in.</td>
</tr>
<tr>
<td>4. Maximum Variation in Thickness of Wall in any One Wheel</td>
<td>$\frac{3}{8}$ in.</td>
</tr>
<tr>
<td>(m) Length</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td>(n) Projection beyond Back Face of Rim</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td><strong>BORE.</strong></td>
<td></td>
</tr>
<tr>
<td>(If not specified, Rough Bore shall be $\frac{1}{4}$ in. less than Finished Bore.)</td>
<td></td>
</tr>
<tr>
<td>(p) Diameter of Rough Bore</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td>(q) Maximum Depth of Black Spots in Rough Bore within 2 in. of End of Bore</td>
<td>$\frac{1}{16}$ in.</td>
</tr>
<tr>
<td>(r) Maximum Eccentricity of Rough Bore in Relation to Tread</td>
<td>$\frac{3}{64}$ in.</td>
</tr>
</tbody>
</table>

**Note.**—The letter used for each dimension in this table and in Fig. 1 is the same as that of the paragraph of Section 9 covering that dimension.
Fig. 1.—Diagram showing Points at which the Dimensions covered by the Specifications are Measured. For the Permissible Variations in these Dimensions see Table I or Section 9.
Specifications for Wheels for Electric Service.

Flange.

(a) Height of Flange.—The height of flange shall not vary from that specified more than $\frac{1}{16}$ in. for Class A or $\frac{3}{32}$ in. for Class B wheels.

(b) Thickness of Flange.—The thickness of flange shall not vary from that specified more than $\frac{1}{16}$ in. for Class A or $\frac{3}{32}$ in. for Class B wheels.

(c) Radius of Throat.—The radius of throat shall not vary from that specified more than $\frac{1}{16}$ in. for Class A or $\frac{3}{32}$ in. for Class B wheels.

Rim.

(d) Thickness of Rim.—The thickness of rim shall not vary more than $\frac{1}{8}$ in. over nor more than $\frac{1}{8}$ in. under that specified. The thickness of rim shall be measured from the inner edge of the rim to a base line drawn from the intersection of the throat radius and the tread, parallel to the axis of the wheel.

(e) Width of Rim.—The width of rim shall not vary from that specified more than $\frac{1}{8}$ in. for Class A or $\frac{1}{16}$ in. for Class B wheels.

(f) Plane.—The wheels shall be gaged with a ring gage placed concentric with and perpendicular to the axis of the wheel. For all points on the back of the rim equidistant from the center, the variation from the plane of the gage when so placed shall not exceed $\frac{1}{16}$ in. for Class A or $\frac{1}{32}$ in. for Class B wheels.

(g) Rotundity.—The tread shall be gaged with a ring gage, and the opening between the tread and this gage at any point shall not exceed $\frac{1}{16}$ in. for Class A wheels or $\frac{1}{64}$ in. for Class B wheels.

(h) Block Marks on Tread.—Block marks shall not exceed $\frac{1}{64}$ in. in height.

(i) Tape Sizes.—Wheels with treads under 3 in. in width shall not vary more than 6 tapes over nor more than 4 tapes under the size specified. Wheels with treads 3 in. or over in width shall not vary more than 9 tapes over nor more than 5 tapes under the size specified.

(j) Limit-of-Wear Groove.—When a limit-of-wear groove is specified, its location shall not vary more than $\frac{1}{16}$ in. from that specified.
Serial Designation: A 25–16.

Plate.

(k) Thickness of Plate.—The plate may vary in thickness, but the variation less than that specified shall not exceed \( \frac{1}{32} \) in. for each \( \frac{1}{8} \) in. in the thickness of the plate.

Hub.

(l) Diameter of Hub.—The diameter of hub shall not be less, but may be \( \frac{3}{8} \) in. more than that specified. The thickness of wall of the finished bored hub shall not be less than 1 in. at any point for bores 6 in. or under in diameter, nor less than 1\( \frac{3}{4} \) in. for bores over 6 in. in diameter, unless otherwise specified. The thickness of wall of the hub shall not vary more than \( \frac{3}{8} \) in. at any two points on the same wheel.

(m) Length of Hub.—The length of hub shall not vary more than \( \frac{1}{6} \) in. from that specified.

(o) Projection of Hub.—The projection of the hub beyond the back face of the rim shall not vary more than \( \frac{1}{16} \) in. from that specified.

Bore.

(p) Diameter of Rough Bore.—The diameter of rough bore shall not vary more than \( \frac{1}{16} \) in. over nor more than \( \frac{1}{8} \) in. under that specified. When finished-bore diameter only is specified, the rough-bore diameter shall be made \( \frac{1}{4} \) in. less with the permissible-variations specified above.

(q) Black Spots in Bore.—Black spots in rough bore within 2 in. of either face of the hub shall not exceed \( \frac{1}{16} \) in. in depth.

(r) Eccentricity of Bore.—The eccentricity between the tread at its center line and the rough bore shall not exceed \( \frac{3}{8} \) in.

V. Finish.

10. (a) The wheels shall be free from injurious defects and Finish shall have a workmanlike finish.

(b) Wheels shall not be offered for inspection if covered with paint, rust or any other substance to such an extent as to hide defects.
VI. MARKING.

Marking. 11. (a) The name or brand of the manufacturer, date, and serial number, shall be legibly stamped on each wheel in such a way that the wheel may be readily identified.
(b) The tape size shall be legibly marked on each wheel.

VII. INSPECTION AND REJECTION.

Inspection. 12. (a) The manufacturer shall provide suitable gages and tapes, which shall conform to the contour and dimensions specified.
(b) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wheels ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the wheels are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.
(c) The purchaser may make the tests to govern the acceptance or rejection of wheels in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.
(d) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 13. (a) Unless otherwise specified any rejection based on tests made in accordance with Section 12 (c) shall be reported within ten working days from receipt of samples.
(b) Wheels which show injurious defects while being finished by purchaser will be rejected, and the manufacturer shall be notified.

Rehearing. 14. Samples tested in accordance with Section 12 (c), which represent rejected wheels, shall be preserved for one month from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
STEEL TIRES.

Serial Designation: A 26 - 16.

The specifications for this material are issued under the fixed designation A 26; the final number indicates the year of original issue, or in the case of revision, the year of last revision.


1. (a) These specifications cover three classes of tires. (Classes)
(b) The purposes for which these classes are frequently used are as follows:
   - Class A, for driving tires for passenger locomotives;
   - Class B, for driving tires for freight locomotives and tires for locomotive-truck, tender-truck, trailer and car wheels, and miscellaneous service;
   - Class C, for driving tires for switching locomotives.

I. MANUFACTURE.

2. The steel shall be made by the open-hearth process. (Process)

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

(195)
Specifications for Steel Tires.

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis to represent each melt may be made by the purchaser from turnings taken from a tire or from a tension test specimen, if the tension test is specified. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

6. If tension tests from representative bars in accordance with Section 7 are specified by the purchaser, the tensile properties shown shall conform to the following minimum requirements:

<table>
<thead>
<tr>
<th></th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>105,000</td>
<td>115,000</td>
<td>125,000</td>
</tr>
<tr>
<td>Elongation in 2 in., per cent.</td>
<td>12</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Reduction of area, %</td>
<td>16</td>
<td>14</td>
<td>12</td>
</tr>
</tbody>
</table>

Tension Test Specimens.

7. (a) The tension test specimen representing each melt shall be taken from a test ingot taken during the pouring of the melt, and shall have received approximately the same amount of work as the tires which it represents.

   (b) The specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests.

8. (a) If specified by the purchaser, one tension test shall be made from each melt.
(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any test specimen is less than that specified in Section 6 and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

9. If the results of the tension test for any melt do not conform to the requirements of Section 6, a retest may be made on a specimen cut from a tire of the same melt furnished at the expense of the manufacturer. This retest shall give results conforming to the requirements of Section 6.

IV. MATING.

10. The tires shall be grouped as to outside diameters and shipped in sets.

V. PERMISSIBLE VARIATIONS IN DIMENSIONS.

11. Tires may be furnished with all surfaces as rolled, and shall conform to the dimensions specified within the following permissible variations:

(a) Height of Flange.—The height of flange shall not vary more than \( \frac{3}{32} \) in. from that specified.

Note: The Gage Length, Parallel Portions and Fillets shall be as shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

Fig. 1.
Specifications for Steel Tires.

(b) Thickness of Flange.—The thickness of flange shall not vary more than \( \frac{1}{16} \) in. from that specified.

c) Radius of Throat.—The radius of throat shall not vary more than \( \frac{1}{8} \) in. over nor more than \( \frac{1}{16} \) in. under that specified.

d) Width of Tire.—The width of tire shall not vary more than \( \frac{1}{8} \) in. over nor more than \( \frac{1}{16} \) in. under that specified.

e) Inside Diameter.—The rough inside diameter shall not be more, but may be \( \frac{1}{4} \) in. less than that specified. When finished inside diameter only is specified, the rough diameter shall be from \( \frac{3}{16} \) to \( \frac{7}{16} \) in. less than this diameter.

(f) Outside Diameter.—Unless otherwise specified, the outside diameter when 54 in. or under shall not be less, but may be \( \frac{1}{2} \) in. more than that specified; and when over 54 in. shall not vary more than \( \frac{1}{8} \) in. under nor more than \( \frac{3}{8} \) in. over that specified.

(g) Set Diameters.—The tires shall be furnished in sets and the variation in outside diameters in each set shall not exceed \( \frac{1}{16} \) in. for tires 33 in. or under in outside diameter, nor exceed \( \frac{3}{2} \) in. for tires over 33 in. in outside diameter.

(h) Rotundity.—Tires shall not be out of round more than \( \frac{1}{16} \) in. for tires 33 in. or under in outside diameter, nor more than \( \frac{3}{8} \) in. for tires over 33 in. in outside diameter.

VI. Finish.

12. The tires shall be free from injurious defects and shall have a workmanlike finish.

VII. Marking.

13. The name or brand and serial number of the manufacturer shall be legibly stamped on the tire close to the inside edge, where they will not be removed at the last turning. Set numbers shall be legibly stenciled on each tire.

VIII. Inspection and Rejection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tires ordered. The manufacturer shall afford the inspector, free of cost, all reason-
able facilities to satisfy him that the tires are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

15. (a) Unless otherwise specified, any rejection based on Rejection tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(b) Tires which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

16. Samples tested in accordance with Section 5, which Rehearing represent rejected tires, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
STEEL CASTINGS.

Serial Designation: A 27-16.

The specifications for this material are issued under the fixed designation A 27; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1901; Revised, 1905, 1912, 1913, 1914, 1916.

1. These specifications cover two classes of castings, namely: 
   Class A, ordinary castings for which no physical requirements are specified;
   Class B, castings for which physical requirements are specified. These are of three grades: hard, medium, and soft.

2. (a) Patterns shall be made so that sufficient finish is allowed to provide for all variations in shrinkage.
   (b) Patterns shall be painted three colors to represent metal, cores, and finished surfaces. It is recommended that core prints shall be painted black and finished surfaces red.

3. The purchaser shall indicate his intention to substitute the test to destruction specified in Section 11 for the tension and bend tests, and shall designate the patterns from which castings for this test shall be made.

I. MANUFACTURE.

4. The steel may be made by the open-hearth, crucible, or any other process approved by the purchaser.

5. (a) Class A castings need not be annealed unless so specified.
(b) Class B castings shall be properly annealed, the treatment depending upon the design and chemical composition of the castings.

II. CHEMICAL PROPERTIES AND TESTS.

6. The castings shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>not over 0.30 per cent</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.06</td>
</tr>
<tr>
<td>Sulfur</td>
<td>....</td>
</tr>
</tbody>
</table>

7. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least \( \frac{1}{4} \) in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 6.

8. (a) Analyses of Class A castings may be made by the purchaser. The phosphorus content thus determined shall not exceed that specified in Section 6 by more than 20 per cent. Drillings for analysis shall be taken not less than \( \frac{1}{4} \) in. beneath the surface.

(b) Analyses of Class B castings may be made by the purchaser from a broken tension or bend test specimen. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 6 by more than 20 per cent. Drillings for analysis shall be taken not less than \( \frac{1}{4} \) in. beneath the surface.

III. PHYSICAL PROPERTIES AND TESTS.

(For Class B Castings Only.)

9. (a) The castings shall conform to the following minimum Tension Tests requirements as to tensile properties:

<table>
<thead>
<tr>
<th></th>
<th>HARD</th>
<th>MEDIUM</th>
<th>SOFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in...</td>
<td>80 000</td>
<td>70 000</td>
<td>60 000</td>
</tr>
<tr>
<td>Yield Point, lb. per sq. in...</td>
<td>0.45 tens. str</td>
<td>0.45 tens. str</td>
<td>0.45 tens. str</td>
</tr>
<tr>
<td>Elongation in 2 in., per cent...</td>
<td>15</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>Reduction of area, &quot;...</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
</tbody>
</table>
(b) The yield point shall be determined by the drop of the beam of the testing machine.

10. (a) The test specimen for soft castings shall bend cold through 120 deg., and for medium castings through 90 deg., around a 1-in. pin, without cracking on the outside of the bent portion.

(b) Hard castings shall not be subject to bend test requirements.

11. In the case of small or unimportant castings, a test to destruction on three castings from a lot may, upon agreement between the manufacturer and the purchaser, be substituted for the tension and bend tests. This test shall show the material to be ductile, free from injurious defects, and suitable for the purpose intended. Unless otherwise agreed upon between the manufacturer and the purchaser, a lot shall consist of all castings from one melt, in the same annealing charge.

12. (a) Sufficient test bars, from which the test specimens required in Section 13 (a) may be selected, shall be attached to castings weighing 500 lb. or over, when the design of the castings will permit. If the castings weigh less than 500 lb., or are of such a design that test bars cannot be attached, two test bars shall be cast to represent each melt; or the quality of the castings shall be determined by tests to destruction as specified in Section 11. All test bars shall be annealed with the castings they represent.
(b) The manufacturer and purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars.

(c) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens shall be machined to 1 by \( \frac{1}{2} \) in. in section with corners rounded to a radius not over \( \frac{1}{16} \) in.

13. (a) One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension and one bend test shall be made from each melt.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 9 (a) and any part of the fracture is more than \( \frac{3}{4} \) in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

14. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-anneal such lot not more than twice and retests shall be made as specified in Sections 9 and 10.

IV. WORKMANSHIP AND FINISH.

15. The castings shall substantially conform to the sizes and shapes of the patterns, and shall be made in a workman-like manner.

16. (a) The castings shall be free from injurious defects. Finish.

(b) Minor defects which do not impair the strength of the castings may, with the approval of the purchaser or his representative, be welded by an approved process. The defects shall first be cleaned out to solid metal; and after welding, the castings shall be annealed, if specified by the purchaser or his representative.
Specifications for Steel Castings.

(c) Castings shall not be offered for inspection if covered with paint, rust, or any other substance to such an extent as to hide defects.

V. INSPECTION AND REJECTION.

17. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

18. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 8 shall be reported within five working days from the receipt of samples.

(b) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

19. Samples tested in accordance with Section 8, which represent rejected castings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

VI. SPECIAL REQUIREMENTS FOR CASTINGS FOR SHIPS.

20. In addition to the preceding requirements, castings for ships, when so specified, shall conform to the following requirements:

21. All castings shall be annealed.

22. (a) One tension and one bend test shall be made from each of the following castings: stern frames, stern posts, twin screw spectacle frames, propellor shaft brackets, rudders, steering quadrants, tillers, stems, anchors, and other castings when specified.
(b) When a casting is made from more than one melt, four tension and four bend tests shall be made from each casting.

23. (a) A percussion test shall be made on each of the following castings: stern frames, stern posts, twin screw spectacle frames, propellor shaft brackets, rudders, steering quadrants, tillers, stems, anchors, and other castings when specified.

(b) For this test, the casting shall be suspended by chains and hammered all over with a hammer of a weight approved by the purchaser or his representative. If cracks, flaws, defects, or weakness appear after such treatment, the casting will be rejected.

VII. SPECIAL REQUIREMENTS FOR CASTINGS FOR RAILWAY ROLLING STOCK.

24. Castings for railway rolling stock, when so specified, shall conform to the requirements for Class B castings, Sections 1 to 19, inclusive, except that check analyses made in accordance with Section 8 (b) shall conform to the requirements as to phosphorus and sulfur specified in Section 6.
STANDARD SPECIFICATIONS
FOR
LAP-WELDED AND SEAMLESS STEEL BOILER TUBES,
BOILER FLUES, SUPERHEATER PIPES, SAFE
ENDS, AND ARCH TUBES FOR
LOCOMOTIVES.

Serial Designation: A 28–16.

The specifications for this material are issued under the fixed designation A 28; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1912; Revised, 1913, 1916.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

   Carbon........................................... 0.08 – 0.18 per cent
   Manganese....................................... 0.30 – 0.50 "
   Phosphorus...................................... not over 0.04 "
   Sulfur........................................... " 0.045 "

3. (a) Analyses of two tubes in each lot of 250 or less may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

   (b) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes
from the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

4. (a) For all tubes except superheater pipes, a test specimen Flange Tests. not less than 4 in. in length shall have a flange turned over at right angles to the body of the tube, without showing cracks or flaws. This flange, as measured from the outside of the tube, shall be \( \frac{3}{8} \) in. wide for tubes 2\( \frac{1}{2} \) in. or under in outside diameter, and \( \frac{1}{2} \) in. wide for tubes over 2\( \frac{1}{2} \) in. in outside diameter.

(b) In making the flange test, it is recommended that the flaring tool and die block shown in Fig. 1 be used.

5. (a) For all tubes except superheater pipes, a test specimen Flattening Tests. 4 in. in length shall stand flattening or hammering until the inside of the walls are in contact, without cracking at the edges or elsewhere. For lap-welded tubes, care shall be taken that the weld is not located at the point of maximum bending.

(b) For superheater pipes, a test specimen 4 in. in length shall stand flattening by pressure or hammering until the distance between the inside of the walls is equal to twice the thickness of the material, without cracking at the edges or elsewhere.

6. (a) For all tubes except superheater pipes, a test specimen Crush Tests. 2\( \frac{1}{2} \) in. in length shall stand crushing longitudinally until the outside folds are in contact, without showing cracks or flaws.

(b) For superheater pipes, a test specimen 2\( \frac{1}{2} \) in. in length shall stand crushing longitudinally down to 1\( \frac{1}{4} \) in., without showing cracks or flaws.
7. Tubes under 5 in. in diameter shall stand an internal hydrostatic pressure of 1000 lb. per sq. in.; and tubes 5 in. or over in diameter shall stand an internal hydrostatic pressure of 800 lb. per sq. in.

8. (a) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.
   
   (b) All specimens shall be tested cold.

9. One flange, one flattening, and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydrostatic test.

10. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 4, 5, or 6, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

11. The standard weights for tubes of various outside diameters and thicknesses, are as indicated in Table I.

12. The weight of the tubes shall not vary more than 5 per cent from that specified in Table I.

V. WORKMANSHIP AND FINISH.

13. The finished tubes shall be circular within 0.02 in., and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. The thickness at any point shall not vary more than 10 per cent from that specified. In the case of boiler tubes which are expanded and swaged, the thickness of the expanded end may be 1 3/16 gages lighter, and of the swaged end 2 gages heavier than the thickness specified. The length shall not be less, but may be 0.125 in. more than that ordered.

14. The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be free from kinks, bends, and buckles.
VI. MARKING

15. The name or brand of the manufacturer, and "Tested at 1000 lb." for tubes under 5 in. in diameter, and "Tested at 800 lb." for tubes 5 in. or over in diameter, shall be legibly stenciled in white on each tube.

VII. INSPECTION AND REJECTION.

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five working days from the receipt of samples.

(b) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Superheater pipes when properly manipulated shall stand all forging, welding, and bending operations necessary for application without developing defects. Tubes or superheater pipes which fail in either of the above operations will be rejected, and the manufacturer shall be notified.

18. Samples tested in accordance with Section 3, which represent rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS

FOR

LAP-WELDED AND SEAMLESS STEEL AND
WROUGHT-IRON BOILER TUBES FOR
STATIONARY SERVICE.


The specifications for this material are issued under the fixed designation A 52; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

I. MANUFACTURE.

1. (a) Lap-welded tubes shall be made of open-hearth process steel or knobbled hammered charcoal iron.

(b) Seamless tubes shall be made of open-hearth steel.

II. CHEMICAL PROPERTIES AND TESTS.

2. (a) The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.08 - 0.18 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.30 - 0.50 &quot;</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>not over 0.04 &quot;</td>
</tr>
<tr>
<td>Sulfur</td>
<td>&quot; 0.045 &quot;</td>
</tr>
</tbody>
</table>

(b) Chemical analysis will not be required for charcoal-iron tubes.
3. (a) Analyses of two tubes in each lot of 250 steel tubes or less may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

(b) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

Flange Tests.

4. (a) A test specimen not less than 4 in. in length shall have a flange turned over at right angles to the body of the tube, without showing cracks or flaws. This flange, as measured from the outside of the tube, shall be \( \frac{3}{8} \) in. wide for steel and \( \frac{5}{16} \) in. wide for iron tubes.

(b) In making the flange test, it is recommended that the flaring tool and die block shown in Fig. 1 be used.

5. A test specimen 3 in. in length shall stand flattening or hammering until the inside of the walls are brought parallel and separated by a distance equal to three times the wall thickness, without showing cracks or flaws. In the case of lap-welded tubes, the test shall be made with the weld at the point of maximum bend.

6. Tubes under 5 in. in diameter shall stand an internal hydrostatic pressure of 1,000 lb. per sq. in.; and tubes 5 in. or over in diameter shall stand an internal hydrostatic pressure
of 800 lb. per sq. in. Lap-welded tubes shall be struck near both ends, while under pressure, with a 2-lb. hand hammer or the equivalent.

7. A cross-section of charcoal-iron tube may be turned or ground to a perfectly true surface, polished free from dirt or cracks, and etched until the soft parts are sufficiently dissolved for the iron tube to show a decided ridged surface, with the weld very distinct, while a steel tube would show a homogeneous surface.

8. (a) All test specimens shall be taken from tubes before being cut to finished lengths and shall be smooth on the ends and free from burrs.

(b) All specimens shall be tested cold.

9. One flange and one flattening test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydrostatic test.

10. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 4 or 5, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. WORKMANSHIP AND FINISH.

11. (a) Finished tubes 3\(\frac{1}{2}\) in. or under in diameter shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. For tubes over 3\(\frac{1}{2}\) in. in diameter, these variations shall not exceed 0.5 per cent of the outside diameter. The measurements to determine whether the tubes meet these requirements shall be made near the ends of the tubes.

(b) All tubes shall be gaged with a B.w.g. gage and shall not be less than the thickness specified, except that tubes will be accepted on which the gage will go on tightly at the thinnest point.

(c) The length shall not be less, but may be 0.125 in. more than that ordered.

Etch Tests for Charcoal-Iron Tubes.\(^1\)

12. The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be practically free from kinks, bends and buckles.

V. MARKING.

13. The name or brand of the manufacturer, the material from which it is made, whether steel or charcoal iron, and "Tested at 1000 lb." for tubes under 5 in. in diameter, and "Tested at 800 lb." for tubes 5 in. or over in diameter, shall be legibly stenciled on each tube.

VI. INSPECTION AND REJECTION.

14. Inspection and all tests except check analyses shall be made at the place of manufacture. The manufacturer shall furnish the purchaser of each lot of tubes a statement of the kind of material of which the tubes are made, and that the tubes have been tested and have met all the requirements of the specifications.

15. Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner will be rejected and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
WELDED STEEL AND WROUGHT-IRON PIPE.


The specifications for this material are issued under the fixed designation A 53; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

1. (a) All pipe to be used on locomotives and cars shall be of coiling or bending quality.

(b) Unless otherwise specified on the purchase order, inspection and all tests except the hydrostatic pressure test shall be made by the purchaser at destination, and at his expense.

I. MANUFACTURE.

2. (a) Steel Pipe.—Steel used in the manufacture of pipe shall be of a soft weldable quality made by the Bessemer or other approved process.

(b) Wrought-Iron Pipe.—The iron shall be made from muck bars, made from puddled pig iron, free from any admixture of iron scrap or steel.

(c) All pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 in. in nominal diameter shall be lap-welded.
3. Iron Scrap.—This term applies only to foreign or bought scrap and does not include local mill products, free from foreign or bought scrap.

II. PHYSICAL PROPERTIES AND TESTS.

4. (a) The material shall conform to the following minimum requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile Strength (lb. per sq. in.)</th>
<th>Yield Point (&quot;), &quot;</th>
<th>Elongation in 8 in. (per cent.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrought Iron</td>
<td>45,000</td>
<td>24,000</td>
<td>12</td>
</tr>
<tr>
<td>Steel</td>
<td>50,000</td>
<td>30,000</td>
<td>18</td>
</tr>
</tbody>
</table>

(b) The yield point shall be determined by the drop of the beam of the testing machine. For wrought-iron pipe, the speed of the cross-head of the machine shall not exceed $1\frac{1}{2}$ in. per minute.

5. All pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

6. A section of steel pipe 6 in. in length shall be flattened until the maximum distance between the walls is equal to three times the thickness of the material, without developing cracks, except at the weld.

7. A section of wrought-iron pipe 6 in. in length shall be broken by repeated light blows of a hammer or by pressure; the fracture developed shall have a fibrous appearance.

8. (a) For steel pipe, a sufficient length of pipe shall bend cold through 180 deg. around a mandrel the diameter of which is 18 times the nominal diameter of the pipe, without developing cracks in any portion, and without opening at the weld.

(b) For wrought-iron pipe, the test specified in Paragraph (a) shall be omitted, except for coiling or bending pipe.

9. (a) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(b) Tension test specimens shall be longitudinal.

(c) All specimens shall be tested cold.

10. One of each of the tests specified in Sections 4, 6 or 7, and 8, may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

11. If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 or 7,
and 8, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

**III. STANDARD WEIGHTS.**

12. *(a)* The standard weights for pipe of various inside diameters are given in Table II.

*(b)* Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

**Table I.**—**HYDROSTATIC Pressures FOR WELDED Pipe.**

(Pressure expressed in Pounds per Square Inch.)

<table>
<thead>
<tr>
<th>Inside Diameter, in.</th>
<th>Standard-Grade Pipe</th>
<th>Extra-Strength Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8</td>
<td>700</td>
<td>.....</td>
</tr>
<tr>
<td>1/4</td>
<td>700</td>
<td>.....</td>
</tr>
<tr>
<td>3/8</td>
<td>700</td>
<td>.....</td>
</tr>
<tr>
<td>1/2</td>
<td>700</td>
<td>.....</td>
</tr>
<tr>
<td>3/4</td>
<td>700</td>
<td>.....</td>
</tr>
<tr>
<td>1</td>
<td>700</td>
<td>.....</td>
</tr>
<tr>
<td>1 1/4</td>
<td>700</td>
<td>1000</td>
</tr>
<tr>
<td>1 1/2</td>
<td>700</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>700</td>
<td>1000</td>
</tr>
<tr>
<td>2 1/2</td>
<td>800</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>800</td>
<td>1000</td>
</tr>
<tr>
<td>3 1/2</td>
<td>...</td>
<td>1000</td>
</tr>
<tr>
<td>4</td>
<td>...</td>
<td>1000</td>
</tr>
<tr>
<td>4 1/2</td>
<td>...</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>...</td>
<td>1000</td>
</tr>
<tr>
<td>6</td>
<td>...</td>
<td>1000</td>
</tr>
</tbody>
</table>

13. The weight of the pipe shall not vary more than 5 per cent from that specified in Section 12 *(a).*

**IV. WORKMANSHIP AND FINISH.**

14. *(a)* For pipe 1 1/2 in. or under, the outside diameter, at any point, shall not vary more than 1/64 in. over nor more than 1/32 in. under the standard. For pipe 2 to 6 in., inclusive, the outside diameter shall not vary more than 1 per cent over nor more than 3/64 in. under the standard.
(b) All standard-weight pipe shall be provided with the prevailing standard thread, which will make a tight joint when tested to the internal hydrostatic pressure at the mill. The threads shall not vary more than one and one-half turns either way, when tested with a Pratt & Whitney standard gage. All burrs at the end of the pipe shall be removed.

(c) Unless otherwise ordered, pipe shall be furnished in random lengths of 16 to 22 ft., but not more than 5 per cent of the total number of lengths furnished may be “jointers,” which are two pieces coupled together. When ordered with plain ends, 5 per cent may be furnished in lengths of 12 ft. or over.

(d) Each standard-weight pipe shall be provided with a coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. For steel pipe, couplings may be of

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Standard-Grade Pipe</th>
<th>Extra-Strong Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Diameter, in.</td>
<td>Number of Threads per Inch</td>
<td>Outside Diameter, in.</td>
</tr>
<tr>
<td>1 8</td>
<td>27</td>
<td>0.405</td>
</tr>
<tr>
<td>1 4</td>
<td>18</td>
<td>0.540</td>
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<tr>
<td>1 2</td>
<td>18</td>
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<td>0.840</td>
</tr>
<tr>
<td>1 1 2</td>
<td>14</td>
<td>1.050</td>
</tr>
<tr>
<td>1 1 2</td>
<td>11 1 2</td>
<td>1.315</td>
</tr>
<tr>
<td>1 1 2</td>
<td>11 1 2</td>
<td>1.660</td>
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<td>2.375</td>
</tr>
<tr>
<td>2 3</td>
<td>8</td>
<td>2.875</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>3.500</td>
</tr>
<tr>
<td>3 4</td>
<td>8</td>
<td>4.000</td>
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<tr>
<td>4</td>
<td>8</td>
<td>4.500</td>
</tr>
<tr>
<td>4 5</td>
<td>8</td>
<td>5.000</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>5.563</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>6.625</td>
</tr>
</tbody>
</table>
wrought iron or steel. For wrought-iron pipe, couplings shall be of wrought iron.

(e) Unless otherwise specified, extra-strong pipe shall be furnished in random lengths, with plain ends.

15. The finished pipe shall be reasonably straight and free Finish. from injurious defects.

V. INSPECTION AND REJECTION.

16. (a) The inspector representing the purchaser shall have Inspection. free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the pipe are being furnished in accordance with these specifications.

(b) When tests and inspection are made at the place of manufacture, they shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. Pipe which develop injurious defects in shop working Rejection. or application will be rejected, and the manufacturer shall be notified.

18. Samples tested in accordance with Section 1 (b), which Rehearing. represent rejected pipe, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
AUTOMOBILE CARBON AND ALLOY STEELS.

Serial Designation: A 29–16.

The specifications for this material are issued under the fixed designation A 29; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1912; Revised, 1913, 1914, 1915, 1916.

1. Automobile steels shall be purchased on the basis of the requirements as to chemical composition specified in Sections 5, 6 and 7. Requirements as to physical properties have been omitted for all steels except castings, because the majority of automobile steels, except castings, are either worked or given special heat treatments by the purchaser. It is recommended that tension and bend tests shall be specified for the material as shipped, whenever it is practicable to do so. When physical requirements are specified, requirements as to carbon shall be omitted.


I. MANUFACTURE.

3. The steels may be made by the Bessemer, open-hearth, crucible, electric, or any other process approved by the purchaser.

4. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.
II. CHEMICAL PROPERTIES AND TESTS.

5. The steels shall conform to the requirements as to chemical composition specified in Tables I to VI, appended to these specifications, and which are entitled as follows:

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Automobile Carbon Steels</td>
</tr>
<tr>
<td>II.</td>
<td>Automobile Nickel Steels</td>
</tr>
<tr>
<td>III.</td>
<td>Automobile Nickel-Chromium Steels</td>
</tr>
<tr>
<td>IV.</td>
<td>Automobile Chromium Steels</td>
</tr>
<tr>
<td>V.</td>
<td>Automobile Chromium-Vanadium Steels</td>
</tr>
<tr>
<td>VI.</td>
<td>Automobile Silico-Manganese Steels</td>
</tr>
</tbody>
</table>

6. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Tables I to VI. This analysis shall be made from drillings taken at least \( \frac{1}{4} \) in. beneath the surface of a test ingot obtained during the pouring of the melt, and in as sound metal as possible. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Tables I to VI.

7. (a) Analyses may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified in Tables I to VI.

   (b) Drillings for analyses of bars, billets, or other regular shapes shall be taken parallel to the axis, at any point midway between the center and surface.

   (c) Drillings for analyses may be taken from broken tension or bend test specimens, if physical requirements are specified.

   (d) Drillings or cuttings for analyses of irregularly shaped pieces for which no physical requirements are specified, shall be taken from both the thickest and the thinnest sections. Surface drillings shall be discarded.

   (e) Wire, tubing, sheets, and rods less than \( 1\frac{1}{4} \) in. in thickness, shall be sampled through or across the entire section.

III. PHYSICAL PROPERTIES AND TESTS.

8. If physical requirements are specified, the following Physical Properties Sections 9 to 13 shall form a part of the modified specifications.

9. The yield point shall be determined by the drop of the Yield Point beam of the testing machine.
10. The elastic limit called for by these specifications shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer shall then be removed from the specimen, and the test continued to determine the tensile strength.

![Diagram of Bend Tests](image)

**Fig. 1.**

11. The bend test shall be made cold.

12. (a) Tension and bend test specimens shall be taken from the rolled or forged material; except that in the case of irregularly shaped forgings, they may be taken from a full-size prolongation. Specimens shall not be annealed or otherwise treated, except as specified in Paragraph (b).

(b) Tension and bend test specimens for material which is to be annealed or otherwise treated before use shall be cut, for rolled material, from properly annealed or similarly treated short lengths of the full section of the piece, and for forged material from the treated forgings.

(c) Tension and bend test specimens for plates and shapes shall be of the full thickness of material as rolled; and may be
machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(d) Tension and bend test specimens for rolled bars and forgings of uniform cross-section 1 1/2 in. or under in thickness or diameter, may be of the full-size section of material as rolled or forged, or may be machined to a thickness or diameter of at least 3/4 in. for a length of at least 9 in. Tension test specimens shall be of 8-in. gage length.

(e) The axis of tension and bend test specimens for rolled bars and forgings of uniform cross-section over 1 1/2 in. in thickness or diameter, and for forgings of irregular sections, when practicable, shall be located at any point midway between the center and surface when solid, and at any point midway between the inner and outer surfaces of the wall when bored, and shall be parallel to the axis of the piece in the direction in which the metal is most drawn out. Tension test specimens shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens shall be 1 1/2 in. square in section with corners rounded to a radius not over 3/16 in., and need not exceed 6 in. in length.

13. (a) Unless otherwise specified by the purchaser, one tension and one bend test shall be made from each melt; except that if material rolled from one melt differs 3/8 in. or more in
thickness, one tension and one bend test shall be made from both the thickest and the thinnest material.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

(c) If the percentage of elongation of any tension test specimen is less than that specified and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. FINISH.

14. The material shall be free from injurious defects and shall have a workmanlike finish.

V. INSPECTION AND REJECTION.

Inspection. 15. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 15 (b) shall be reported within ten working days from the receipt of samples.

(b) Material which shows injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.
17. Samples tested in accordance with Section 15(b), which represent rejected material, shall be preserved for one month from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

**Table I.—Automobile Carbon Steels.**

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Manganese</th>
<th>Phos.</th>
<th>Sulf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.05-0.15</td>
<td>0.45</td>
<td>0.30-0.60</td>
</tr>
<tr>
<td>0.20</td>
<td>0.15-0.25</td>
<td>0.45</td>
<td>0.30-0.60</td>
</tr>
<tr>
<td>0.25</td>
<td>0.20-0.30</td>
<td>0.65</td>
<td>0.50-0.80</td>
</tr>
<tr>
<td>0.35</td>
<td>0.30-0.40</td>
<td>0.65</td>
<td>0.50-0.80</td>
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<tr>
<td>0.45</td>
<td>0.40-0.50</td>
<td>0.65</td>
<td>0.50-0.80</td>
</tr>
<tr>
<td>0.65</td>
<td>0.90-1.05</td>
<td>0.35</td>
<td>0.25-0.50</td>
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</tbody>
</table>

**Screw Stock.**

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>0.14</td>
<td>0.08-0.20</td>
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<td>0.55</td>
<td>0.30-0.80</td>
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<tr>
<td>0.12</td>
<td>0.06-0.12</td>
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</tbody>
</table>

**Steel Castings, Class B.**

As required for the chemical and physical properties. See Standard Specifications for Steel Castings (Serial Designation: A 27).

All values are expressed in per cent.

**Table II.—Automobile Nickel Steels.**

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>0.10-0.20</td>
<td>0.65</td>
<td>0.50-0.80</td>
<td>0.04</td>
</tr>
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<td>0.20</td>
<td>0.15-0.25</td>
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<tr>
<td>0.30</td>
<td>0.25-0.35</td>
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<tr>
<td>0.35</td>
<td>0.30-0.40</td>
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<tr>
<td>0.40</td>
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</tbody>
</table>

All values are expressed in per cent.
## Table III.—Automobile Nickel-Chromium Steels.

### With 1.25 per cent Nickel.

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</thead>
<tbody>
<tr>
<td>0.20</td>
<td>0.15-0.25</td>
<td>0.65</td>
<td>0.50-0.80</td>
<td>0.04</td>
<td>0.045</td>
<td>1.25</td>
<td>1.00-1.50</td>
<td>0.60</td>
<td>0.45-0.75</td>
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</tr>
<tr>
<td>0.25</td>
<td>0.20-0.30</td>
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<tr>
<td>0.30</td>
<td>0.25-0.35</td>
<td>**</td>
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<tr>
<td>0.35</td>
<td>0.30-0.40</td>
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<tr>
<td>0.40</td>
<td>0.35-0.45</td>
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### With 1.75 per cent Nickel.

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<tbody>
<tr>
<td>0.20</td>
<td>0.15-0.25</td>
<td>0.45</td>
<td>0.30-0.60</td>
<td>0.04</td>
<td>0.04</td>
<td>1.75</td>
<td>1.50-2.00</td>
<td>1.10</td>
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<tr>
<td>0.30</td>
<td>0.25-0.35</td>
<td>**</td>
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<tr>
<td>0.40</td>
<td>0.35-0.45</td>
<td>**</td>
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<tr>
<td>0.50</td>
<td>0.45-0.55</td>
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### With 3.00 per cent Nickel.

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</thead>
<tbody>
<tr>
<td>0.15</td>
<td>0.10-0.20</td>
<td>0.60</td>
<td>0.45-0.75</td>
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<td>0.04</td>
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<td>0.60-0.95</td>
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<tr>
<td>0.35</td>
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<td></td>
</tr>
<tr>
<td>0.50</td>
<td>0.45-0.55</td>
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### With 3.50 per cent Nickel.

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<tbody>
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<td>0.20</td>
<td>0.15-0.25</td>
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<td>0.30-0.60</td>
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<td>0.04</td>
<td>3.50</td>
<td>3.25-3.75</td>
<td>1.50</td>
<td>1.25-1.75</td>
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<tr>
<td>0.30</td>
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<td>0.40</td>
<td>0.35-0.45</td>
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</tr>
</tbody>
</table>

All values are expressed in per cent.
### Table IV. — Automobile Chromium Steels.

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Manganese</th>
<th>Phos.</th>
<th>Sulf.</th>
<th>Chromium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired</td>
<td>Permissible Range</td>
<td>Desired</td>
<td>Permissible Range</td>
<td>Not Over</td>
</tr>
<tr>
<td>0.20</td>
<td>0.15-0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.40</td>
<td>0.35-0.45</td>
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</tr>
<tr>
<td>0.65</td>
<td>0.60-0.70</td>
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<td></td>
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</tr>
<tr>
<td>0.95</td>
<td>0.90-1.05</td>
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<td>0.20-0.45</td>
<td>0.03</td>
</tr>
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<td>1.20</td>
<td>1.10-1.30</td>
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<td></td>
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<td>0.95</td>
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<tr>
<td>1.20</td>
<td>1.10-1.30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*In these three grades the specified percentages of manganese and silicon may be either of the following: manganese, 0.35 desired (permissible range, 0.25 - 0.50) and silicon, not over 0.20; or manganese, 0.70 desired (permissible range, 0.60 - 0.80) and silicon, 0.15 - 0.50.

All values are expressed in per cent.

### Table V. — Automobile Chromium-Vanadium Steels.

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Manganese</th>
<th>Phos.</th>
<th>Sulf.</th>
<th>Chromium</th>
<th>Vanadium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired</td>
<td>Permissible Range</td>
<td>Desired</td>
<td>Permissible Range</td>
<td>Not Over</td>
<td>Not Over</td>
</tr>
<tr>
<td>0.20</td>
<td>0.15-0.25</td>
<td>0.65</td>
<td>0.50-0.80</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>0.25</td>
<td>0.20-0.30</td>
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<td>&quot;</td>
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</tr>
<tr>
<td>0.30</td>
<td>0.25-0.35</td>
<td>&quot;</td>
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<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>0.35</td>
<td>0.30-0.40</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>0.40</td>
<td>0.35-0.45</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>0.45</td>
<td>0.40-0.50</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>0.50</td>
<td>0.45-0.55</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>0.95</td>
<td>0.90-1.05</td>
<td>0.35</td>
<td>0.20-0.45</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>

All values are expressed in per cent.

### Table VI. — Automobile Silico-Manganese Steels.

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Manganese</th>
<th>Phos.</th>
<th>Sulf.</th>
<th>Silicon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired</td>
<td>Permissible Range</td>
<td>Desired</td>
<td>Permissible Range</td>
<td>Not Over</td>
</tr>
<tr>
<td>0.50</td>
<td>0.45-0.55</td>
<td>0.70</td>
<td>0.60-0.80</td>
<td>0.045</td>
</tr>
<tr>
<td>0.60</td>
<td>0.55-0.65</td>
<td>0.60</td>
<td>0.50-0.70</td>
<td>0.045</td>
</tr>
</tbody>
</table>

*Steels made by the acid process may contain 0.05 maximum phosphorus.

All values are expressed in per cent.
STANDARD SPECIFICATIONS
FOR
BOILER AND FIREBOX STEEL FOR
LOCOMOTIVES.

Serial Designation: A 30-16.

The specifications for this material are issued under the fixed designation A 30; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1901; Revised, 1909, 1912, 1913, 1914, 1916.

1. These specifications cover two grades of steel for boilers for locomotives, namely: flange and firebox.

I. MANUFACTURE.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>FLANGE</th>
<th>FIREBOX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td></td>
<td>0.12 - 0.25 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.30 - 0.60</td>
<td>0.30 - 0.50</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Acid: not over 0.05</td>
<td>not over 0.04</td>
</tr>
<tr>
<td></td>
<td>Basic: &quot; 0.04</td>
<td>&quot; 0.035</td>
</tr>
<tr>
<td>Sulfur</td>
<td>&quot; 0.05</td>
<td>&quot; 0.04</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td>&quot; 0.05</td>
</tr>
</tbody>
</table>

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements (228)
specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

6. (a) The material shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile strength, lb. per sq. in.</th>
<th>Yield point, min.</th>
<th>Elongation in 8 in., min., per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plange</td>
<td>55,000 - 65,000</td>
<td>0.5 tens. str.</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Firebox</td>
<td>52,000 - 62,000</td>
<td>0.5 tens. str.</td>
<td>1,500,000</td>
</tr>
</tbody>
</table>

(See Section 7)

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. (a) For material over $\frac{3}{4}$ in. in thickness, a deduction of 0.5 from the percentages of elongation specified in Section 6(a) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in. 

(b) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

8. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:
The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about \(\frac{1}{6}\) in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about \(\frac{1}{4}\) in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

Test Specimens.  
10. (a) Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimens shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimens at right angles to that axis.

(b) Tension and bend test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.
11. (a) One tension and one bend test shall be made from each plate as rolled.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

12. When Ordered to Thickness.—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot1 in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

Table I.—Permissible Overweights of Plates Ordered to Thickness.

<table>
<thead>
<tr>
<th>Ordered Thickness, IN.</th>
<th>Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.</th>
<th>Ordered Thickness, IN.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 48 in.</td>
<td>48 to 60 in. excl.</td>
</tr>
<tr>
<td>Under 1/8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>1/8 to 3/16 excl.</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>3/16 &quot; 1/4 &quot;</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>14 &quot; 5/16 &quot;</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>5/16 &quot; 3/8 &quot;</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3/8 &quot; 7/16 &quot;</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>7/16 &quot; 1/2 &quot;</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>1/2 &quot; 5/8 &quot;</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>5/8 &quot; 3/4 &quot;</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>3/4 &quot; 1 &quot;</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>1 or over</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

1 The term "lot" applied to Table I means all of the plates of each group width and group thickness.
V. Finish.

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. Marking.

14. (a) The name or brand of the manufacturer, melt or slab number, grade, and lowest tensile strength for its grade specified in Section 6 (a), shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen.

(b) When specified on the order, plates shall be match-marked as defined in Paragraph (c) so that the test specimens representing them may be identified. When more than one plate is sheared from a single slab or ingot, each shall be match-marked so that they may all be identified with the test specimen representing them.

(c) Each match mark shall consist of two over-lapping circles each not less than 1\(\frac{1}{2}\) in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(d) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

VII. Inspection and Rejection.

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

16. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.
(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS
FOR
BOILER RIVET STEEL.


The specifications for this material are issued under the fixed designation A 31; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1901; Revised, 1909, 1912, 1913, 1914.

A. Requirements for Rolled Bars.

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

Manganese......................... 0.30 - 0.50 per cent
Phosphorus......................... not over 0.04 "
Sulfur.............................. "  " 0.045 "

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.
4. Analyses may be made by the purchaser from finished bars representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 2.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) The bars shall conform to the following requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>45 000 - 55 000</td>
</tr>
<tr>
<td>Yield point, min.</td>
<td>0.5 tens. str.</td>
</tr>
<tr>
<td>Elongation in 8 in., min.</td>
<td>1 500 000</td>
</tr>
<tr>
<td></td>
<td>Tens. str.</td>
</tr>
<tr>
<td></td>
<td>but not exceed 30 per cent.</td>
</tr>
</tbody>
</table>

(b) The yield point shall be determined by the drop of the beam of the testing machine.

6. (a) Cold-bend Tests.—The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

(b) Quench-bend Tests.—The test specimen, when heated to a light cherry red as seen in the dark (not less than 1200° F.), and quenched at once in water the temperature of which is between 80° and 90° F., shall bend through 180 deg. flat on itself without cracking on the outside of the bent portion.

7. Tension and bend test specimens shall be of the full-size section of bars as rolled.

8. (a) Two tension, two cold-bend, and two quench-bend tests shall be made from each melt, each of which shall conform to the requirements specified.

(b) If any test specimen develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 (a) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN DIAMETER.

9. The diameter of each bar shall not vary more than 0.01 in. from that specified.
V. WORKMANSHIP AND FINISH.

Workmanship.
10. The finished bars shall be circular within 0.01 in.

Finish.
11. The finished bars shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking.
12. Rivet bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification. The melt number shall be legibly marked on each test specimen.

VII. INSPECTION AND REJECTION

Inspection.
13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.
14. (a) Unless otherwise specified, any rejection based on tests made in accordance with Section 4 shall be reported within five working days from the receipt of samples.

(b) Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.
15. Samples tested in accordance with Section 4, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
B. Requirements for Rivets.

VIII. PHYSICAL PROPERTIES AND TESTS.

16. The rivets, when tested, shall conform to the requirements as to tensile properties specified in Section 5, except that the elongation shall be measured on a gage length not less than four times the diameter of the rivet.

17. The rivet shank shall bend cold through 180 deg. flat on itself, as shown in Fig. 1, without cracking on the outside of the bent portion.

18. The rivet head shall flatten, while hot, to a diameter of 2½ times the diameter of the shank, as shown in Fig. 2, without cracking at the edges.

19. (a) When specified, one tension test shall be made from each size in each lot of rivets offered for inspection.

(b) Three bend and three flattening tests shall be made from each size in each lot of rivets offered for inspection, each of which shall conform to the requirements specified.

IX. WORKMANSHIP AND FINISH.

20. The rivets shall be true to form, concentric, and shall be made in a workmanlike manner.

21. The finished rivets shall be free from injurious defects.

X. INSPECTION AND REJECTION.

22. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is
Specifications for Boiler Rivet Steel.

being performed, to all parts of the manufacturer’s works which concern the manufacture of the rivets ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the rivets are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 23. Rivets which show injurious defects subsequent to their acceptance at the manufacturer’s works will be rejected, and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
COLD-DRAWN BESSEMER STEEL AUTOMATIC
SCREW STOCK.


The specifications for this material are issued under the fixed designation A 32; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1914.

1. These specifications cover a free-cutting steel of any Material Desired. specified section suitable for high-speed screw machine work, leaving a smooth finish after machining.

II. MANUFACTURE.

2. The steel shall be made by the Bessemer process, and Process. shall be cold-rolled or cold-drawn or turned to size.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.08 – 0.16 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.60 – 0.80</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.09 – 0.13</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.075 – 0.15</td>
</tr>
</tbody>
</table>

(239)
4. Samples for analysis shall be taken by machining off the entire cross-section of the bar, or by drilling parallel to the axis of the bar at any point midway between the center and surface with a drill not under \( \frac{1}{2} \) nor over \( \frac{3}{4} \) in. in diameter. Samples shall be clean, free from oil, uniformly fine and well mixed.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

5. The variation from the specified diameter, or distance between parallel faces, and the allowable eccentricity shall not exceed the following limits:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 0.3 in.</td>
<td>0</td>
<td>1% of diameter</td>
<td>0.5% of diameter</td>
<td></td>
</tr>
<tr>
<td>Over 0.3 in. to and including 1 in.</td>
<td>0</td>
<td>0.003 in.</td>
<td>0.0015 in.</td>
<td></td>
</tr>
<tr>
<td>Over 1 in. to and including 2( \frac{1}{2} ) in.</td>
<td>0</td>
<td>0.004 &quot;</td>
<td>0.0020 &quot;</td>
<td></td>
</tr>
<tr>
<td>Over 2( \frac{1}{2} ) in.</td>
<td>0</td>
<td>0.005 &quot;</td>
<td>0.0025 &quot;</td>
<td></td>
</tr>
</tbody>
</table>

IV. FINISH.

6. The material shall be free from injurious defects and shall have a bright smooth surface.

V. INSPECTION AND REJECTION.

7. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

8. Material which fails to conform to the above specifications will be rejected, and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
COLD-DRAWN OPEN-HEARTH STEEL AUTOMATIC SCREW STOCK.


The specifications for this material are issued under the fixed designation A 54; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

1. These specifications cover a free-cutting steel of any specified section suitable for high-speed screw machine work, leaving a smooth finish after machining.

I. MANUFACTURE.

2. The steel shall be made by the open-hearth process, and shall be cold-rolled or cold-drawn or turned to size.

II. CHEMICAL PROPERTIES AND TESTS.

3. The steel shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.15 - 0.25 per cent</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.60 - 0.90</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>not over 0.06</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.075 - 0.15</td>
</tr>
</tbody>
</table>

(241)
Test Samples. 4. Samples for analysis shall be taken by machining off the entire cross-section of the bar, or by drilling parallel to the axis of the bar at any point midway between the center and surface with a drill not under $\frac{1}{2}$ nor over $\frac{3}{4}$ in. in diameter. Samples shall be clean, free from oil, uniformly fine and well mixed.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

5. The variation from the specified diameter, or distance between parallel faces, and the allowable eccentricity shall not exceed the following limits:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 0.3 in.</td>
<td>0</td>
<td>1% of diameter</td>
<td>0.3% of diameter</td>
<td></td>
</tr>
<tr>
<td>Over 0.3 in. to and including 1 in.</td>
<td>0</td>
<td>0.003 in.</td>
<td>0.0015 in.</td>
<td></td>
</tr>
<tr>
<td>Over 1 in. to and including 2½ in.</td>
<td>0</td>
<td>0.004 &quot;</td>
<td>0.0020 &quot;</td>
<td></td>
</tr>
<tr>
<td>Over 2½ in.</td>
<td>0</td>
<td>0.005 &quot;</td>
<td>0.0025 &quot;</td>
<td></td>
</tr>
</tbody>
</table>

IV. FINISH.

6. The material shall be free from injurious defects and shall have a bright smooth surface.

V. INSPECTION AND REJECTION.

7. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

8. Material which fails to conform to the above specifications will be rejected, and the manufacturer shall be notified.
STANDARD TESTS
FOR
MAGNETIC PROPERTIES OF IRON AND STEEL.


These tests are issued under the fixed designation A 34; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1911; REVISED, 1912, 1914.

CORE LOSS.

The power consumption in electrical sheet steel when subjected to an alternating magnetization is known as the core loss. The standard core loss is the total power in watts consumed in each kilogram of material at a temperature of 25° C., when subjected to a harmonically varying induction having a maximum of 10,000 gausses and a frequency of 60 cycles per second, when measured as specified below. It is represented by the symbol $W_{10/60}$.

The aging coefficient is the percentage change in the standard core loss after continued heating at 100° C. for 600 hours.

The standard core loss shall be measured under the following conditions:

The magnetic circuit shall consist of 10 kg. (22 lb.) of the test material, cut with a sharp shear into strips 50 cm. ($19\frac{1}{2}$ in.) long and 3 cm. ($1\frac{3}{8}$ in.) wide, half parallel and half at right angles to
Tests for Magnetic Properties of Iron and Steel.

the direction of rolling, made up into four equal bundles, two containing material parallel and two containing material at right angles to the direction of rolling, and finally built into the four sides of a square with butt joints and opposite sides consisting of material cut in the same manner. No insulation other than the natural scale of the material (except in the case of scale-free material) shall be used between laminations, but the corner joints shall be separated by tough paper 0.01 cm. (0.004 in.) thick.

The magnetizing winding shall consist of four solenoids surrounding the four sides of the magnetic circuit and joined in series. A secondary coil shall be used for energizing the voltmeter and the potential coil of the wattmeter.

These solenoids shall be wound on a form of any non-magnetic non-conducting material of the following dimensions:

- Inside cross-section: 4 by 4 cm.
- Thickness of wall: not over 0.3 cm.
- Winding length: 42 cm.

The primary winding on each solenoid shall consist of 150 turns of copper wire uniformly wound over the 42-cm. length. The total resistance of the magnetizing winding shall be between 0.3 and 0.5 ohm. The secondary winding of 150 turns of copper wire on each solenoid shall be similarly wound beneath the primary winding. Its resistance shall not exceed 1 ohm.

A voltmeter and the voltage coil of a wattmeter shall be connected in parallel to the terminals of the secondary winding of the apparatus. The current coil of the wattmeter shall be connected in series with the primary winding.

A sine wave electromotive force shall be applied to the primary winding and adjusted until the voltage of the secondary circuit is given by the equation:

\[ E = \frac{4fNnBM}{4lD10^6} \]

in which:

- \( f \) = form factor of primary E.M.F. = 1.11 for sine wave
- \( N \) = number of secondary turns = 600
- \( n \) = number of cycles per second = 60
- \( B \) = maximum induction = 10,000

\[ M = \text{total mass in grams} = 10,000 \]
\[ l = \text{length of strips in centimeters} = 50 \]
\[ D = \text{specific gravity} = 7.5 \text{ for high-resistance steel} \]
\[ = 7.7 \text{ for low-resistance steel} \]
\[ E = 106.6 \text{ volts for high resistance steel for sine voltage} \]
\[ = 103.8 \text{ volts for low-resistance steel for sine voltage} \]

A specific gravity of 7.5 is assumed for all steels having a resistance of over 2 ohms per meter-gram, and 7.7 for all steels having a resistance of less than 2 ohms per meter-gram. These steels are designated as high and low-resistance steels, respectively.

Fig. 1.

Fig. 2.

The wattmeter gives the power consumed in the iron and the secondary circuit. The loss in the secondary circuit is given in terms of the total resistance and voltage. Subtracting this correction term from the total power gives the net power consumed in the steel as hysteresis and eddy-current loss. Dividing this value by ten gives the core loss in watts per kilogram.

Sampling.—The core-loss material shall be cut from two or more sheets taken at random from the shipment. The strips should be distributed symmetrically over the sheet, as nearly as may be practicable. For example, see Figs. 1 and 2.

It is recommended that a test sample shall represent not more than 5000 kg. (11,000 lb.).
Tests for Magnetic Properties of Iron and Steel.

The Procedure.—1. Cut the test material into strips 3 by 50 cm. as indicated under "Sampling."

2. Place on the balance a pile of strips weighing 2.5 kg. Add a second pile of the same kind, bringing the weight up to 5 kg. In each case the weight is taken to the nearest strip. Add in succession two piles of 2.5 kg. each, of the other kind of strips, bringing the weight up to 7.5 kg. and 10 kg. respectively.

3. Secure each bundle by string or tape (not wire) and insert in the apparatus as indicated.

4. Apply the alternating voltage to the primary coil and tap the joints together until the current has a minimum value, as shown by an ammeter in series. Then clamp the corners firmly by some suitable device.

5. Shunt the ammeter and adjust the primary current until the voltmeter indicates the proper value. This adjustment may be made by an auto-transformer, by varying the field of the alternator, or by both, but not by the insertion of resistance or inductance in the primary circuit. Simultaneously the frequency must be adjusted to 60 cycles.

6. Read the wattmeter.

7. Calculations. Subtract from the wattmeter reading the instrument losses, which will be constant for any set of instruments and voltage, and divided by 10. The result is the standard core loss.

Normal Induction.

The normal magnetic induction is the induction produced by a magnetizing force in a given piece of magnetic material which has been previously demagnetized and then subjected to many reversals of the given magnetizing force.

Both the induction $B$ and the magnetizing force $H$ shall be expressed in terms of the c. g. s. electromagnetic unit (gauss).

Sheet Metal.—The standard normal induction data for sheet material shall consist of the magnetizing forces corresponding to inductions of 2000, 4000, 6000, 8000, 10,000, 12,000, 14,000, 16,000, 18,000, 20,000 gausses, or such as may be obtained without exceeding a magnetizing force of 200 gausses.

The following details are to be observed:
The permeability sample for sheet material shall consist of an even number of strips cut parallel to the direction of rolling and an even number cut perpendicular to this direction, selected from material sampled as for core loss.

The sample shall weigh not less than 1 nor more than 2 kg.

The magnetic circuit shall be a rectangle having the test material for one pair of opposite sides, and the same or different material for the other pair, which may be shorter. The joints at each corner are alternately butt and lap, or may be clamped on the edges.

The magnetomotive force is applied in two sections. The main magnetizing coils shall consist of two equal and uniformly wound solenoids surrounding the test material. The compensating coils shall consist of four short coils, each having the same number of turns wound closely over the ends of the magnetizing coils.

A test coil surrounds the middle portion of each bundle of test material. Four other test coils each of half the number of turns are placed over the four positions of the test material, approximately midway between the yokes and the center. The two center test coils are joined in series and the four end test coils are joined in series. The corresponding ballistic deflections, due to these two sets of test coils, are measures of the magnetic fluxes through the underlying portions of the magnetic circuit. By connecting the two test coils so that the induced electromotive force opposes that of the four coils, and adjusting the current through the compensating magnetizing coils so that there is no resulting ballistic deflection, an approximate uniformity of flux is secured through the greater portion of the test material, and the induction may be measured ballistically in the regular manner. The magnetizing force when the flux is adjusted to uniformity is that calculated from the uniform winding of the main magnetizing solenoids.

The cross-section of the magnetic circuit is determined as in the standard core-loss test.

Rods.—The standard test for rods for use in electromagnets shall consist of the magnetizing forces corresponding to inductions of 2000, 4000, 6000, 8000, 10,000, 12,000, 14,000, 16,000, 18,000, 20,000 gausses, or such as may be obtained without exceeding a magnetizing force of 200 gausses.
The standard test for rods intended for permanent magnets shall consist in the measurement of the magnetizing force, the residual induction, and the coercive force corresponding to a maximum induction of 14,000 gausses.

Standard tests shall be made by the Burrows compensated double-yoke method (described in Standard Electrical Engineer’s Handbook, and also in Technical Paper No. 117 of the Bureau of Standards).
Determination of Carbon by the Direct-Combustion Method.

The method of direct combustion of the metal in oxygen is recommended, the carbon dioxide obtained being absorbed in barium-hydroxide solution, the precipitated barium carbonate filtered off, washed, dissolved in a measured excess of hydrochloric acid and the excess titrated against standard alkali.

The use of potassium-hydroxide solution or soda lime for the absorption of carbon dioxide, with suitable purifying train following the furnace, is recognized as being capable of very satisfactory refinement and as possessing merit where the time element is of prime significance.

Owing to the diversity of apparatus by which correct results may be obtained in the determination of carbon, the recommendations are intended more to indicate what is acceptable than to prescribe definitely what shall be used.
Methods for Analysis of Carbon Steel.

Apparatus.

Purifying Train.—The method employed eliminates the necessity of a purifying train following the furnace, inasmuch as no precautions are necessary to prevent access of water vapor, or sulfur trioxide—the impurities usually guarded against—from the absorbing apparatus. All that is needed is a calcium-chloride tower filled with stick sodium hydroxide placed before the furnace, or between the furnace and catalyzer, if, as recommended, the latter is used for the purpose of oxidizing organic matter in the oxygen.

Material for Lining Boats.—Alundum, "RR Alundum, alkali-free, specially prepared for carbon determination," as supplied by dealers is suitable, and is recommended. The 90-mesh or finer grades are used. Chromite, properly sized and freed from materials causing a blank, may also be employed. No substance containing alkali or alkaline earth metals, or carbon as carbonates or in other form, should be used as a lining material. Quartz sand, owing to its liability to fuse or to slag with the oxides of iron, causing bubbles of gas to be enclosed, is objectionable. Aluminum oxide, made by calcining alum or otherwise, often contains sulfate not easily destroyed, or may contain objectionable substances of an alkaline nature.

Catalyzers.—Suitable catalyzers are copper oxide, platinized quartz or asbestos, or platinum gauze. One of these should be used in the forward part of the combustion apparatus, as well as in the purifying train preceding the combustion tube (see above). Platinized materials sometimes give off volatile substances on heating, and whatever material is used should not be subject to this defect.

Combustion Apparatus.—Any apparatus heated by gas or electricity which will bring the sample to a temperature of 950 to 1100° C. may be used. Combustion tubes may be porcelain, glazed on one or both sides, quartz or platinum. Quartz is liable to devitrification when used continuously at temperatures above 1000° C., and may then become porous. Combustion crucibles of platinum may be heated by blast or by Meker burners.
Boats or Other Containers of Samples being Burned.—These may be of porcelain, quartz, alundum, clay, platinum, or nickel, and should always receive a lining of granular alundum.

Purifying Train before Combustion Apparatus.—This consists of a tower filled with stick sodium hydroxide, preceded by a catalyzer.

The Train after the Combustion Apparatus.—This consists merely of the Meyer tube for absorption of the carbon dioxide, protected by a soda-lime tube at the far end. Meyer tubes with 7 to 10 bulbs of 10 to 15-cc. capacity each, and large bulbs at the ends, having volumes equal to the combined capacity of the small bulbs, have been used and found satisfactory.

Filtering Apparatus.—In filtration for accurate work, care should be taken to protect the solution from access of extraneous carbon dioxide. This is accomplished in the apparatus shown in Fig. 1. For work requiring less accuracy, the barium carbonate may be filtered off on a filter made by fitting a carbon funnel with a perforated porcelain disk and filtering by suction. The precipitate is then washed with distilled water from which the carbon dioxide has been removed by boiling.

Reagents.

Oxygen.—Oxygen of not less than 97-per-cent purity is recommended. Endeavor should be made to obtain oxygen which gives no blank, since the correction for or elimination of this is troublesome and uncertain. For the most accurate work, particularly with low-carbon products, such as ingot iron, etc., the blank should be completely eliminated by the use of a catalyzer before the furnace, with a carbon-dioxide absorbent interposed between furnace and catalyzer.

Tenth-normal Hydrochloric Acid.—This may be standardized by any of the accepted methods, or as follows: Twenty cubic centimeters of the approximately N/10 acid is measured out with a pipette, and the silver chloride precipitated by an excess of silver-nitrate solution in a volume of 50 to 60 cc. After digesting at 70 to 80° C., until the supernatant liquid is clear, the chloride is filtered off on a tared Gooch filter and washed with water containing 2 cc. of nitric acid per 100 cc. of water until freed from silver nitrate. After drying to constant weight at 130° C., the increase of weight over the original tare is noted.
and from this weight, corresponding to the silver chloride, the strength of the hydrochloric acid is calculated, after which it is adjusted to the strength prescribed. The standardization should be based upon several concordant determinations using varying amounts of acid.

\[ 1 \text{ cc.} \text{ N/10 HCl} = 0.0006 \text{ g. carbon}. \]

*Methyl Orange.*—Dissolve 0.02 g. in 100 cc. of hot distilled water and filter.

*Tenth-normal Sodium-Hydroxide Solution.*—This is standardized against the hydrochloric acid. Methyl orange is used as the indicator. The sodium-hydroxide solution should be stored in a large bottle from which it may be driven out by air pressure, protecting against carbon dioxide by soda-lime tubes.

*Barium-Hydroxide Solution.*—A saturated solution is filtered and stored in a large reservoir from which it is delivered by air pressure, protecting from carbon dioxide by a soda-lime tube. Three or four small bulbs of the Meyer tube are filled, and CO₂-free water is added until the remaining small bulbs are filled.

**Factors Influencing Rapid Combustion.**

*Size of Particles of Sample.*—The finer the chips the better, except with samples which burn too vigorously (see under "Rate of Admitting Oxygen"). Particles too coarse to pass a 20-mesh sieve are not recommended, nor long curly drillings which will not pack closely. A \( \frac{1}{2} \)-in. flat drill may be used for taking the sample and the pressure and speed of the drill-press regulated to secure the desired result; or, better still, the sample may be obtained with a small milling machine suitable for sampling, or by a shaping machine. Oil, dust, and other foreign matter should be carefully excluded.

*Manner of Distributing Sample in Boat.*—This is of considerable importance. With all samples, close packing in a small space is conducive to rapid combustion. In the case of samples which burn too vigorously, a satisfactory regulation may sometimes be attained by spreading the sample loosely over the lining in the boat.

*Rate of Admitting Oxygen.*—The rate at which oxygen is
admitted is also a factor in the velocity of combustion. Assuming the combustion apparatus to be heated to the temperature range recommended above (950 to 1100° C.), it is possible, if the material is closely packed and if oxygen is admitted at too rapid a rate, that the combustion may be so violent as to cause excessive spattering of fused oxides, and such fluidity of the molten slag that the boat or other container may be injured or destroyed; therefore a moderate rate of burning is to be sought. This is desirable also from the standpoint of the complete absorption of the carbon dioxide by the barium-hydroxide solution. The factors, temperature of combustion apparatus, manner of distribution of sample, and rate of admission of oxygen, can be governed so as to burn successfully steels of a very wide range of compositions, in either fine or coarse particles.

**Method.**

After having properly set up and tested the apparatus, place 2 g. of steel (see note No. 1) in the form recommended above, in a moderately packed condition on the bed material and introduce the boat into the combustion apparatus, already heated to the proper temperature. After about a minute (to allow the sample and container to reach the temperature of the furnace), admit oxygen somewhat more rapidly than it is consumed, as shown by the rate of bubbling in the Meyer tube (see note No. 2). The sample burns completely in 1 or 2 minutes, and all that is now necessary is to sweep all the carbon dioxide into the absorption apparatus. This can be accomplished in 6 to 8 minutes by passing about 1 or 2 liters of oxygen. Detach the Meyer tube (see note No. 2) and filter and wash the barium carbonate, using the special filtering apparatus shown. After solution in a measured excess of hydrochloric acid (the Meyer tube being washed out with a portion of the acid, to remove adhering barium carbonate), titrate the excess of acid against alkali and from the data thus obtained calculate the percentage of carbon.

**Notes.**

1. When working with steels high in carbon (above 1 per cent) it is advisable not to use more than 1 g. in order that filtration may be sufficiently rapid.
2. As a precaution against error resulting from too rapid passage of the gases, it is well to attach a second barium-hydroxide tube to retain any carbon dioxide that may pass the first.

3. For the most accurate work the Meyer tubes should be washed with dilute acid before beginning work each day. After a determination is finished the tube should be completely filled two or three times with tap water, then rinsed with distilled water, in order to remove the carbon dioxide liberated when dissolving the carbonate from the previous determination.

4. The flask containing the carbonate should be thoroughly agitated after adding the acid, since the carbonate sometimes dissolves rather slowly if this is not done; this is particularly the case if it has packed much during filtration.

Fig. 1.—Apparatus for Filtration in Determination of Carbon by the Direct-Combustion Method.

Apparatus and Procedure for Filtration.

The apparatus is shown to approximately one-tenth size in Fig. 1, which is self-explanatory. The stop-cock is a three-way cock connected to the suction pipe. The rubber tubing connected to the Meyer tube should be of best-grade black rubber, and the lengths used should be so chosen as to permit of easy manipulation of the tube. The Meyer tube is connected or disconnected by the rubber stoppers which are left always attached to the rubber tubes. The carbon tube C is fitted with a perforated porcelain plate sliding easily.
The funnel is prepared for filtration by making on the porcelain disk a felt of asbestos about $\frac{1}{16}$ to $\frac{1}{8}$ in. in thickness, using amphibole (not serpentine) asbestos which has been carefully digested with strong hydrochloric acid for several hours and washed with water until it gives no acid reaction. On top of the asbestos pad is placed a layer of similarly treated quartz, mixed with asbestos, of the height shown. A mixture of quartz grains of various sizes (approximately 50 per cent passing a 20-mesh sieve and 50 per cent passing a 10-mesh and remaining on a 20-mesh sieve) is suitable. The mixture of quartz and asbestos may be obtained by filling the funnel from a beaker (directing against it a stream from a wash-bottle) while maintaining a gentle suction. In this way the asbestos is properly mixed with the quartz. A little experience and attention to these details will enable one to prepare the quartz-bed in a manner that will greatly expedite filtration. The stopper is now inserted in the funnel, the Meyer tube connected as shown and the liquid and precipitate sucked into the funnel. Only a gentle suction should be used. When necessary $P_2$ is opened to admit air back of the column of liquid in the Meyer tube. When the contents of the Meyer tube have been transferred, the large bulb nearest $B$ is half filled with water by opening $P_1$; the stop-cock $S$ is operated during this and subsequent operations so as to maintain a gentle suction all the time. $M$ is now manipulated so as to bring the wash water in contact with all parts of the interior, after which the water is sucked through $C$; $P_2$ is left open during this and subsequent washings. After eight washings as directed, allowing the wash water to drain off thoroughly each time before adding more, $M$ may be detached, the stopper removed from the funnel and the washings completed by filling $C$ to the top with CO$_2$-free water, sucking off completely and repeating the operation once. With care the washing may be done with 150 cc. of water. Air is now admitted through the side opening of $S$, $C$ is removed and the porcelain disk carrying the asbestos, quartz and barium carbonate is thrust, by means of a long glass rod, into a flask, removing any adhering particles from the sides of $C$, by a stream of water from a wash bottle. An excess of the standard acid is now added from a burette or pipette, using a portion to
Methods for Analysis of Carbon Steel.

wash out $M$, and after the contents of the flask have been thoroughly agitated by shaking, the excess of acid is titrated against the standard alkali, using 3 drops of the methyl-orange indicator.

Notes.
The operation of filtering can be carried out very rapidly after a little practice.
Glass wool should on no account be used as a substitute for the quartz, on account of the probability of errors arising from its attack by the alkali or acid.
It is well to wash out the rubber tubes connected to the Meyer tube with a little water each day before beginning work.

DETERMINATION OF CARBON

BY THE

COLORIMETRIC METHOD.

(Routine.)

Solution Required.

**Nitric Acid.**—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Method.

In a small Erlenmeyer flask or test tube, dissolve 0.2 to 0.5 g. of steel, depending on the carbon content of the sample, in 5 to 20 cc. of the nitric acid. Boil gently until the solution is complete and the liquid is clear. Cool and compare with a solution of a standard steel treated under like conditions.

Note.
In order to obtain reliable results by this method the standard steel should be of the same kind, of approximately the same chemical composition, and in the same physical condition as the sample steel. The carbon content of the standard steel is determined by the direct combustion method.
SERIAL DESIGNATION: A 33 - 14.

DETERMINATION OF MANGANESE
BY THE
BISMUTHATE METHOD.

SOLUTIONS REQUIRED.

**Nitric Acid.**—Mix 500 cc. of nitric acid, sp. gr. 1.42, and 1500 cc. of distilled water.

**Nitric Acid for Washing.**—Mix 30 cc. of nitric acid, sp. gr. 1.42, and 970 cc. of distilled water.

**Stock Sodium Arsonite.**—To 15 g. of arsensious oxide (As₂O₃) in a 300-cc. Erlenmeyer flask, add 45 g. of sodium carbonate and 150 cc. of distilled water. Heat the flask and contents on a water bath until the arsensious oxide is dissolved, cool the solution and make up to 1000 cc. with distilled water.

**Standard Sodium Arsenite.**—Dilute 300 cc. of stock-sodium-arsenite solution to 1000 cc. with distilled water and titrate against potassium-permanganate solution (about N/10), which has been standardized by using Bureau of Standards sodium oxalate.¹ Titrate 10-cc. portions of the permanganate solution, to each of which have been added 50-cc. portions of the nitric acid. A clear green color free from brownish or purplish tints will be found a satisfactory and reproducible end-point. Adjust the solution so that 1 cc. is equivalent to 0.10 per cent of manganese, on the basis of a 1-g. sample.

The factor Na₂C₂O₄—> Mn = 0.16397 (using the 1913 atomic weights).

METHOD.

In a 300-cc. Erlenmeyer flask dissolve 1 g. of steel in 50 cc. of the nitric acid, and boil to expel the oxides of nitrogen. Cool, and add about ½ g. of sodium bismuthate and heat for a few minutes, or until the pink color has disappeared, with or without precipitation of manganese dioxide. Add small portions of ferrous sulfate (or any suitable reducing agent) in sufficient quantity to clear the solution, and boil to expel the oxides of nitrogen. Cool to 15° C., add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of 3-per-

cent nitric acid and filter through an alundum filter or asbestos pad, washing with 3-per-cent nitric acid. Titrate immediately with standard-sodium-arsenite solution to the disappearance of the pink color, each cubic centimeter required representing 0.10 per cent manganese.

Notes.

In the method, the preliminary treatment with sodium bismuthate has been found by a number of investigators to be apparently unnecessary; however, the available data to confirm this position are not considered sufficient to warrant its omission.

In making the asbestos filter pad it is advisable to have a thin bed, and as much surface as possible. This insures rapid filtration, and the filter may be used until it becomes clogged with bismuthate.

The filtrate must be perfectly clear, since the least particle of bismuthate carried through the filter will vitiate the results.

DETERMINATION OF MANGANESE
BY THE
PERSULFATE METHOD.
(Routine.)

Solutions Required.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Silver Nitrate.—Dissolve 1.33 g. of silver nitrate in 1000 cc. of distilled water.

Stock Sodium Arsenite.—To 15 g. of arsenious oxide (As₂O₃) in a 300-cc. Erlenmeyer flask, add 45 g. of sodium carbonate and 150 cc. of distilled water. Heat the flask and contents on a water bath until the arsenious oxide is dissolved, cool the solution and make up to 1000 cc. with distilled water.

Standard Sodium Arsenite.—Dilute a sufficient quantity of stock-sodium-arsenite solution with distilled water, and standardize against a steel of known manganese content, as determined by the bismuthate method. This solution should be of such strength that each cubic centimeter will be equivalent to 0.10 per cent of manganese on the basis of the weight of sample taken.
Method.

In a small Erlenmeyer flask or large test tube, dissolve 0.1 to 0.3 g. of steel, depending on the manganese content of the sample, in 15 cc. of the nitric acid. Boil gently until the solution is complete and the liquid is clear. Add 15 cc. silver-nitrate solution and 1 g. of ammonium persulfate, and continue heating the solution for \( \frac{1}{2} \) minute after the oxidation begins and bubbles rise freely. Cool in running water and complete the determination by either of the following procedures:

(a) Colorimetric.—Compare the color of the solution with that of a standard steel treated under like conditions.

(b) Titration.—Titrate with standard-sodium-arsenite solution to the disappearance of the pink color, each cubic centimeter required representing 0.10 per cent of manganese.

Notes.

In order to obtain reliable results by the colorimetric procedure, the standard should be of the same kind and of approximately the same chemical composition as the sample steel. The manganese content of the standard steel is determined by the bismuthate method.

The ammonium persulfate should be kept in moistened condition by small additions of distilled water at required intervals.

Determination of Phosphorus

By the

Molybdate-Magnesia Method.

Solutions Required.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Nitric Acid for Washing.—Mix 20 cc. nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water.

Potassium Permanganate.—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.
Ammonium Bisulfite.—Dissolve 30 g. of ammonium bisulfite in 1000 cc. of distilled water.

Ammonium Hydroxide, approximately 10-per-cent.—Mix 1000 cc. of ammonium hydroxide, sp. gr. 0.90, and 2000 cc. of distilled water.

Ammonium Molybdate.
Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr. 0.90, filter, and add 60 cc. of nitric acid, sp. gr. 1.42.

Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr. 1.42, and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water, and let stand at least 24 hours before using.

Magnesia Mixture.—Dissolve 50 g. of magnesium chloride and 125 g. of ammonium chloride in 750 cc. of distilled water, and then add 150 cc. of ammonium hydroxide, sp. gr. 0.90.

Method.

In a 300-cc. Erlenmeyer flask dissolve 5 g. of steel in 75 cc. of the nitric acid. Heat to boiling; while boiling add about 12 cc. of the potassium-permanganate solution, and continue boiling until manganese dioxide precipitates. Dissolve this precipitate by additions of the ammonium-bisulfite solution, boil until clear and free from brown fumes, cool to 35° C., add 100 cc. of the ammonium-molybdate solution at room temperature, let stand 1 minute, shake or agitate for 3 minutes, filter on a 9-cm. paper and wash the precipitate at least 3 times with the 2-per-cent nitric-acid solution to free it from iron.

Treat the precipitate on the filter with the 10-per-cent ammonium-hydroxide solution, letting the solution run into a 100-cc. beaker containing 10 cc. of hydrochloric acid, sp. gr. 1.20, and 0.5 g. of citric acid; add 30 cc. of ammonium hydroxide, sp. gr. 0.90, cool, and then add 10 cc. of the magnesia mixture very slowly, while stirring the solution vigorously. Set aside in a cool place for 2 hours, filter and wash with the 10-per-cent ammonium-hydroxide solution. Ignite and weigh. Dissolve
the precipitate of magnesium pyrophosphate with 5 cc. of nitric acid, sp. gr. 1.20, and 20 cc. of distilled water, filter and wash with hot water. Ignite and weigh. The difference in weights represents pure magnesium pyrophosphate containing 27.84 per cent of phosphorus.

Note.

The ammonium-molybdate solution should be kept in a cool place and should always be filtered before using.

DETERMINATION OF PHOSPHORUS
BY THE
ALKALIMETRIC METHOD.
(Routine.)

Solutions Required.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Nitric Acid for Washing.—Mix 20 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water.

Potassium Permanganate.—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.

Ammonium Bisulfite.—Dissolve 30 g. of ammonium bisulfite in 1000 cc. of distilled water.

Ammonium Molybdate.

Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr. 0.90, filter and add 60 cc. of nitric acid, sp. gr. 1.42.

Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr. 1.42, and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water and let stand at least 24 hours before using.
Potassium Nitrate, 1-per-cent.—Dissolve 10 g. of potassium nitrate in 1000 cc. of distilled water.

Phenolphthalein Indicator.—Dissolve 0.2 g. in 50 cc. of 95-per-cent ethyl alcohol and 50 cc. of distilled water.

Standard Sodium Hydroxide.—Dissolve 6.5 g. of purified sodium hydroxide in 1000 cc. of distilled water, add a slight excess of 1-per-cent solution of barium hydroxide, let stand for 24 hours, decant the liquid, and standardize it against a steel of known phosphorus content, as determined by the molybdate-magnesia method, so that 1 cc. will be equivalent to 0.01 per cent of phosphorus on the basis of a 2-g. sample (see notes). Protect the solution from carbon dioxide with a soda-lime tube.

Standard Nitric Acid.—Mix 10 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water. Titrate the solution against standardized sodium hydroxide, using phenolphthalein as indicator, and make it equivalent to the sodium hydroxide by adding distilled water.

Method.

In a 300-cc. Erlenmeyer flask dissolve 2 g. of steel in 50 cc. of the nitric acid. Heat the solution to boiling and while boiling add about 6 cc. of the potassium-permanganate solution and continue boiling until manganese dioxide precipitates. Dissolve this precipitate by additions of the ammonium-bisulfite solution, boil until clear and free from brown fumes, cool to 80° C., add 50 cc. of the ammonium-molybdate solution at room temperature, let stand 1 minute, shake or agitate for 3 minutes, and filter on a 9-cm. paper. Wash the precipitate three times with the 2-per-cent nitric-acid solution to free it from iron, and continue the washing with the 1-per-cent potassium-nitrate solution until the precipitate and flask are free from acid.

Transfer the paper and precipitate to a solution flask, add 20 cc. of distilled water, 5 drops of phenolphthalein solution as indicator, and an excess of standard-sodium-hydroxide solution. Insert a rubber stopper and shake vigorously until solution of the precipitate is complete. Wash off the stopper with distilled water and determine the excess of sodium-hydroxide solution by titrating with standard-nitric-acid solution. Each cubic centimeter of standard-sodium-hydroxide solution represents 0.01 per cent of phosphorus.
Notes.

The ammonium-molybdate solution should be kept in a cool place and should always be filtered before using.

All distilled water used in titration should be freed from carbon dioxide by boiling or otherwise.

Bureau of Standards Standard Steel No. 19(a) is recommended as a suitable steel for standardization of the sodium-hydroxide solution.

DETERMINATION OF SULFUR
BY THE
OXIDATION METHOD.

Solution Required.

Barium Chloride.—Dissolve 100 g. of barium chloride in 1000 cc. of distilled water.

Method.

In a 400-cc. beaker dissolve 5 g. of the steel in a mixture of 40 cc. of nitric acid, sp. gr. 1.42, and 5 cc. of hydrochloric acid, sp. gr. 1.20, add 0.5 g. of sodium carbonate and evaporate the solution to dryness. Add 40 cc. of hydrochloric acid, sp. gr. 1.20, evaporate to dryness and bake at a moderate heat. After solution of the residue in 30 cc. of hydrochloric acid, sp. gr. 1.20, and evaporation to sirupy consistency, add 2 to 4 cc. of hydrochloric acid, sp. gr. 1.20, and then 30 to 40 cc. of hot water. Filter and wash with cold water, the final volume not exceeding 100 cc. To the cold filtrate add 10 cc. of the barium-chloride solution. Let stand at least 24 hours, filter on a 9-cm. paper, wash the precipitate first with a hot solution containing 10 cc. of hydrochloric acid, sp. gr. 1.20, and 1 g. barium chloride to the liter, until free from iron; and then with hot water till free from chloride. Ignite and weigh as barium sulfate.

Keep the washings separate from the main filtrate and evaporate them to recover any dissolved barium sulfate.

Note.

A blank determination on all reagents used should be made and the results corrected accordingly.
DETERMINATION OF SULFUR
BY THE
EVOLUTION-TITRATION METHOD.
(Routine.)

APPARATUS.

Use a 480-cc. flask with a delivery tube and a 300-cc. tumbler of tall form (Fig. 2).

Fig. 2.—Apparatus for Determination of Sulfur by the Evolution Method.

SOLUTIONS REQUIRED.

* Dilute Hydrochloric Acid.*—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

* Ammoniacal Cadmium Chloride.*—Dissolve 10 g. of cadmium chloride in 400 cc. of distilled water and add 600 cc. of ammonium hydroxide, sp. gr. 0.90.
Potassium Iodate.—Dissolve 1.116 g. of potassium iodate and 12 g. of potassium iodide in 1000 cc. of distilled water. Standardize with a steel of known sulfur content. Each cubic centimeter should be equivalent to 0.01 per cent of sulfur, when a 5-g. sample is used (see notes).

Starch.—To 1000 cc. of boiling distilled water, add a cold suspension of 6 g. of starch in 100 cc. of distilled water; cool, add a solution of 6 g. of zinc chloride in 50 cc. of distilled water, and mix thoroughly.

Method.

Place 5 g. of steel in the flask and connect the latter as shown in Fig. 2. Place 10 cc. of the ammoniacal-cadmium-chloride solution and 150 cc. of distilled water in the tumbler. Add 80 cc. of the dilute hydrochloric acid to the flask through the thistle tube, heat the flask with its contents gently until the solution of the steel is complete, then boil the solution for % minute. Remove the tumbler which contains all the sulfur as cadmium sulfide, and to it add 5 cc. of starch solution and 40 cc. of the dilute hydrochloric acid, titrating immediately with potassium-iodate solution to a permanent blue color.

Notes.
Extremely slow or rapid evolution of hydrogen sulfide is to be avoided.
Bureau of Standards Standard Steel No. 8(a) is recommended for standardizing the potassium-iodate solution.

Determination of Silicon
By the
Nitro-Sulfuric Method.

Solutions Required.

Nitro-Sulfuric Acid.—Mix 1000 cc. of sulfuric acid, sp. gr. 1.84, 1500 cc. of nitric acid, sp. gr. 1.42, and 5500 cc. of distilled water.

Dilute Hydrochloric Acid.—Mix 100 cc. of hydrochloric acid, sp. gr. 1.20, and 900 cc. of distilled water.
Methods for Analysis of Carbon Steel.

Method.

Add cautiously 80 cc. of the nitro-sulfuric acid to 4.702 g of steel, in a platinum or porcelain dish of 300-cc. capacity, cover with a watch glass; heat until the steel is dissolved and evaporate slowly until copious fumes of sulfuric acid are evolved. Cool, add 125 cc. of distilled water, heat with frequent stirring until all salts are dissolved, add 5 cc. of hydrochloric acid, sp. gr. 1.20, heat for 2 minutes, and filter on a 9-cm. paper. Wash the precipitate several times with hot water, then with hot hydrochloric acid and hot water alternately to complete the removal of iron salts, and finally with hot water until free from acid. Transfer the filter to a platinum crucible, burn off the paper carefully with the crucible covered, finally igniting over a blast lamp or in a muffle furnace at 1000° C. for at least 20 minutes; cool in a desiccator and weigh. Add sufficient sulfuric acid, sp. gr. 1.84, to moisten the silica and then a small amount of hydrofluoric acid. Evaporate to dryness, ignite and weigh. The difference in weights in milligrams divided by 100 equals the percentage of silicon.

Note.

A blank determination on all reagents used should be made and the results corrected accordingly.

Determination of Silicon

By the

Sulfuric-Acid Method.

(Optional.)

Solution Required.

Dilute Hydrochloric Acid.—Mix 100 cc. of hydrochloric acid, sp. gr. 1.20, and 900 cc. of distilled water.

Method.

To 2.351 g. of steel, in a beaker of low form of 500-cc. capacity, add 60 cc. of distilled water, and then cautiously
15 cc. of sulfuric acid, sp. gr. 1.84. Cover with a watch glass, heat until the steel is dissolved and evaporate until copious fumes of sulfuric acid are evolved. Cool, add 100 cc. of distilled water and heat with frequent stirring until the salts are in solution. Filter on a 9-cm. paper, wash the precipitate several times with cold water, then with cold dilute hydrochloric acid until free from iron, and finally with cold water until free from acid. Ignite and weigh. Add sufficient sulfuric acid, sp. gr. 1.84, to moisten the silica and then a small amount of hydrofluoric acid. Evaporate to dryness, ignite and weigh. The difference in weights in milligrams divided by 50 equals the percentage of silicon.

**Note.**

A blank determination on all reagents used should be made and the results corrected accordingly.

**DETERMINATION OF COPPER**

**SOLUTIONS REQUIRED.**

*Sulfuric Acid.*—Mix 200 cc. of sulfuric acid sp. gr. × 1.84, and 800 cc. of distilled water.

*Potassium Ferrocyanide.*—Dissolve 10 g. of potassium ferrocyanide in 100 cc. of distilled water.

*Standard Copper Nitrate.*—Dissolve 2 g. of purest electrolytic copper in 20 cc. of nitric acid (1:1), and dilute to 1000 cc. with distilled water. Each cubic centimeter is equivalent to 0.02 per cent of copper on the basis of a 10-g. sample.

**METHOD.**

In a 300-cc. beaker dissolve 10 g. of the steel in 75 cc. of the sulfuric acid, and then add 150 cc. of distilled water. Heat the solution and saturate with hydrogen sulfide, filter and wash the precipitate free from iron with 1-per-cent sulfuric acid containing hydrogen sulfide. Incinerate the paper with its contents in a porcelain crucible and fuse with 0.5 g. of acid
Methods for Analysis of Carbon Steel.

Sodium sulfate. Extract with hot water, filter, and complete the determination colorimetrically as under 1 (a) or 1 (b), or electrolytically as under 2, as follows:

1. Evaporate the filtrate to about 25 cc., make faintly ammoniacal, filter into a 100-cc. Nessler tube and wash with hot water.

(a) If the solution is a strong blue, to another 100-cc. Nessler tube add 50 cc. of distilled water, 5 cc. of ammonium hydroxide, sp. gr. 0.90, and from a burette the standard-copper-nitrate solution until the blue colors match.

(b) If the solution is a faint blue, to the filtrate in a Nessler tube add the dilute sulfuric acid to faint acidity and then a few drops of the potassium-ferrocyanide solution. To another 100-cc. Nessler tube add 50-cc. of distilled water, a few drops of the potassium-ferrocyanide solution, and from a burette the standard-copper-nitrate solution until the reddish brown colors match.

2. Make the filtrate slightly acid with sulfuric acid, dilute with distilled water to a suitable volume, and determine the copper electrolytically.

DETERMINATION OF NICKEL
BY THE GRAVIMETRIC DIMETHYLGLYOXIME METHOD.

Solutions Required.

Hydrochloric Acid.—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

Dimethylglyoxime.—Dissolve 1 g. of dimethylglyoxime in 100 cc. of 95-per-cent ethyl alcohol.

Method.

In a 150-cc. beaker dissolve 1 g. of the steel in 20 cc. of the hydrochloric acid, and add about 2 cc. of nitric acid, sp. gr. 1.42, to oxidize the iron. Filter the solution and add to the filtrate
6 g. of tartaric acid, and water till the volume is 300 cc. Make the solution faintly ammoniacal, then faintly acid with the hydrochloric acid and heat nearly to boiling; add 20 cc. of the dimethylglyoxime solution and then ammonium hydroxide, sp. gr. 0.90, drop by drop till faintly alkaline, stirring vigorously. After standing one hour, filter on a weighed Gooch crucible, wash with hot water, dry at 110 to 120° C. and weigh. The precipitate contains 20.31 per cent of nickel.

Notes.

In making dimethylglyoxime solution, methyl alcohol may be substituted for ethyl alcohol.

The weight of sample taken should be varied according to the nickel content.

DETERMINATION OF NICKEL
BY THE
VOLUMETRIC DIMETHYLGLYOXIME METHOD.
(Routine.)

SOLUTIONS REQUIRED.

Hydrochloric Acid.—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

Dimethylglyoxime.—Dissolve 1 g. of dimethylglyoxime in 100 cc. of 95-per-cent ethyl alcohol.

Silver Nitrate.—Dissolve 0.5 g. of silver nitrate in 1000 cc. of distilled water.

Potassium Iodide.—Dissolve 20 g. of potassium iodide in 100 cc. of distilled water.

Standard Potassium Cyanide.—Dissolve 2.29 g. of potassium cyanide in 1000 cc. of distilled water. Standardize this solution by the procedure described below, against a steel of known nickel content as determined by the gravimetric dimethylglyoxime method, so that each cubic centimeter is equivalent to 0.05 per cent of nickel on the basis of a 1-g. sample (see notes).
Method.

In a 150-cc. beaker dissolve 1 g. of the steel in 20 cc. of the hydrochloric acid, and add about 2 cc. of nitric acid, sp. gr. 1.42, to oxidize the iron. Filter the solution and add to the filtrate 6 g. of tartaric acid, and water until the volume is 300 cc. Make the solution faintly ammoniacal, then faintly acid with the hydrochloric acid, and cool thoroughly. Add 20 cc. of the dimethylglyoxime solution and then ammonium hydroxide, sp. gr. 0.90, drop by drop, till faintly alkaline, stirring vigorously. After standing for a few minutes, filter on a Gooch crucible and wash with hot water. Dissolve the precipitate on the filter with 10 to 20 cc. of nitric acid (hot), sp. gr. 1.42, added drop by drop, and then wash 5 times with hot water, using suction. To the solution in a 500-cc. beaker add 3 g. of ammonium persulfate and boil for 5 minutes. Cool, make distinctly ammoniacal, add 10 cc. each of the silver-nitrate and potassium-iodide solutions, and titrate with the standard-potassium-cyanide solution to a faint turbidity.

Notes.

In making dimethylglyoxime solution, methyl alcohol may be substituted for ethyl alcohol.

Bureau of Standards Standard Steel No. 33 is recommended for standardizing the potassium-cyanide solution.

The weight of sample taken should be varied according to the nickel content.

DETERMINATION OF CHROMIUM.

Solutions Required.

Hydrochloric Acid.—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

Sodium Carbonate.—A saturated solution; approximately 60 g. of sodium carbonate and 100 cc. of distilled water.
Barium Carbonate.—Ten grams of finely divided barium carbonate suspended in 100 cc. of distilled water.

Standard Sodium Chromate.—Dissolve 2.6322 g. of sodium chromate in 1000 cc. of distilled water. Each cubic centimeter is equivalent to 0.02 per cent of chromium, when a 5-g. sample is used.

Standard Potassium Permanganate.—Dissolve 2 g. of potassium permanganate in 1000 cc. of distilled water. Standardize by using Bureau of Standards sodium oxalate, and dilute the solution with distilled water so that 1 cc. is equivalent to 0.02 per cent chromium, when a 5-g. sample is taken. The factor Na₂C₂O₄—> Cr = 0.2584 (using the 1913 atomic weights).

Ferrous Sulfate.—Dissolve 25 g. of ferrous ammonium sulfate in 900 cc. of distilled water and 100 cc. of sulfuric acid (1:1).

**METHOD.**

In a 300-cc. Erlenmeyer flask, covered, dissolve 5 g. of steel in 50 cc. of the hydrochloric acid. When completely dissolved, add gradually the saturated solution of sodium carbonate until practically all the free acid is neutralized; finish the neutralization with the barium-carbonate suspension, using an excess of about 1 g. of the carbonate. Boil the solution in the flask for 10 or 15 minutes, with the cover on. Filter the precipitate rapidly on paper and wash twice with hot water. Transfer the filter to a platinum crucible and after burning off the paper, fuse the residue for 10 minutes with a mixture of 5 g. of sodium carbonate and 0.25 g. of potassium nitrate. Dissolve the fusion in water, transfer to a beaker, add 2 cc. of 3-per-cent hydrogen peroxide, boil a few minutes and filter. Complete the determination of chromium in the filtrate by either of the following procedures:

1. If the solution is a strong yellow, add 10 cc. of sulfuric acid (1:1), and then the ferrous-sulfate solution in measured excess. Cool thoroughly and titrate with the standard-potassium-permanganate solution. The number of cubic centimeters of the potassium-permanganate solution obtained, subtracted from the number corresponding to the volume of the ferrous-sulfate

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solution used, will give the volume of the potassium-perman-
ganate solution equivalent to the chromium in the sample.

2. If the solution is a light yellow, cool the solution and
transfer to a 100-cc. Nessler tube. To another Nessler tube
add distilled water, and from a burette add the standard-
sodium-chromate solution until the yellow colors match.

Note.

If procedure No. 1 is used, all hydrogen peroxide must be destroyed by
boiling before acidifying, otherwise chromic acid will be reduced at this stage.
STANDARD METHODS

FOR

CHEMICAL ANALYSIS OF ALLOY STEELS.


These methods are issued under the fixed designation A 55; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

NIQUEL STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.1

DETERMINATION OF MANGANESE.

See the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.1

See the Determination of Manganese in Plain Carbon Steel by the Persulfate Method (Routine).1

1 Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
DETERMINATION OF PHOSPHORUS.

See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.¹

See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).¹

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.¹

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).¹

NOTES.

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten, or of copper or other metals precipitated by hydrogen sulfide from acid solutions.

The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.¹

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric-Acid Method (Optional).¹

DETERMINATION OF NICKEL.

See the Determination of Nickel in Plain Carbon Steel by the Gravimetric Dimethylgloxime Method.¹

See the Determination of Nickel in Plain Carbon Steel by the Volumetric Dimethylgloxime Method (Routine).¹

¹ Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
Determination of Nickel

By the Ether Extraction-Cyanide Titration Method.

(Optional Routine.)

Solutions Required.

Hydrochloric Acid.—Mix 600 cc. of hydrochloric acid, sp. gr. 1.20, and 400 cc. of distilled water.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Potassium Iodide.—Dissolve 20 g. of potassium iodide in 1000 cc. of distilled water.

Silver Nitrate.—Dissolve 0.5 g. of silver nitrate in 1000 cc. of distilled water.

Standard Potassium Cyanide.—Dissolve 4.589 g. of potassium cyanide in 1000 cc. of distilled water. Standardize the solution by the procedure described below, against a steel of known nickel content as determined by the gravimetric dimethylglyoxime method, so that 1 cc. is equivalent to 0.10 per cent nickel on the basis of a 1-g. sample (see note).

Method.

In a 150-cc. beaker dissolve 1 g. of the steel in 20 cc. of the hydrochloric acid, add about 2 cc. of nitric acid, sp. gr. 1.42, to oxidize the iron, and boil to expel the oxides of nitrogen. Cool, and transfer the solution into an 8-oz. separatory funnel, rinsing the beaker with small portions of the hydrochloric acid. Add 50 cc. of ether, shake for 5 minutes, let settle for 1 minute, and then draw off lower clear solution into another 8-oz. separatory funnel. Add 10 cc. of hydrochloric acid, sp. gr. 1.20, to the solution in the first separatory funnel, cool, shake thoroughly, allow to settle for 1 minute, and then draw off the lower clear solution into the second separatory funnel. To the combined solutions in the second separatory funnel add 50 cc. of ether, shake for 5 minutes, let settle for 1 minute, and then draw off the clear layer into a 150-cc. beaker. Heat the aqueous
solution gently to expel the ether, add 0.2 g. of potassium chlorate, boil until chlorate is decomposed, dilute to 100 cc. with hot water, make faintly ammoniacal, and boil for 5 minutes. Filter and wash with hot water. To the filtrate add 10 cc. of hydrochloric acid, sp. gr. 1.20, heat just short of boiling and precipitate the copper with hydrogen sulfide. Filter and wash with hot water. Boil the filtrate to expel hydrogen sulfide, reducing the volume by evaporation to approximately 100 cc., cool, and make solution distinctly ammoniacal, add 10 cc. each of the silver-nitrate and potassium-iodide solutions, and titrate with the standard-potassium-cyanide solution to a clear solution.

Note.

Bureau of Standards Standard Steel No. 33, is recommended for standardizing the potassium-cyanide solution.

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CHROME-NICKEL STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon by the Direct-Combustion Method.¹

DETERMINATION OF MANGANESE

BY THE

ZINC OXIDE-BISMUTHATE METHOD.

Solutions Required.

Sulfuric Acid.—Mix 200 cc. of sulfuric acid, sp. gr. 1.84, and 800 cc. of distilled water.

Nitric Acid.—Mix 500 cc. of nitric acid, sp. gr. 1.42, and 1500 cc. of distilled water.

¹Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
Nitric Acid for Washing.—Mix 30 cc. of nitric acid, sp. gr. 1.42, and 970 cc. of distilled water.

Sodium Carbonate.—A saturated solution; approximately 60 g. of sodium carbonate and 100 cc. of distilled water.

Zinc Oxide.—Twenty grams of zinc oxide (dry process) suspended in 100 cc. of distilled water (see notes)

Stock Sodium Arsenite.—To 15 g. of arsenious oxide (As₂O₃) in a 300-cc. Erlenmeyer flask, add 45 g. of sodium carbonate and 150 cc. of distilled water. Heat the flask and contents on a water bath until the arsenious oxide is dissolved, cool the solution and make up to 1000 cc. with distilled water.

Standard Sodium Arsenite.—Dilute 300 cc. of the stock-sodium-arsenite solution to 1000 cc. with distilled water and titrate against potassium-permanganate solution (about N/10) which has been standardized by using Bureau of Standards sodium oxalate.¹ Titrate 10-cc. portions of the permanganate solution, to each of which have been added 50-cc. portions of the nitric acid. A clear green color free from brownish or purplish tints will be found a satisfactory and reproducible end-point. Adjust the solution so that 1 cc. is equivalent to 0.10 per cent of manganese on the basis of a 1-g. sample.

The factor Na₂C₂O₄→Mn = 0.16397 (using the 1913 atomic weights).

Method.

In a platinum or porcelain dish of 300-cc. capacity, to 2.5 g. of the steel add 40 cc. of the sulfuric acid, cover with a watch glass, and heat until the steel is dissolved. Add about 4 cc. of nitric acid, sp. gr. 1.42, to oxidize the iron and evaporate slowly until copious fumes of sulfuric acid are evolved. Cool, add 100 cc. of hot water, heat with frequent stirring until all salts are dissolved, then transfer the solution into a volumetric 500-cc. flask. Add the sodium-carbonate solution until near neutrality, and the precipitate formed dissolves with difficulty, then add small portions of the zinc-oxide suspension, shaking vigorously after each addition, until after settling of the coagulated precipitate, the supernatant liquid is practically clear. Cool, and make up to the mark with water. Mix thoroughly by pouring the entire contents of the flask into a large, dry beaker,

¹ Circular No. 40, Bureau of Standards, Oct. 1, 1912
and back again to the flask, repeating several times. Allow
the precipitate to settle, filter off 200 cc. of the solution into
a 300-cc. Erlenmeyer flask, add 25 cc. of the nitric-acid solution,
and boil to expel the oxides of nitrogen. Cool, add 0.5 g.
of sodium bismuthate and heat for a few minutes, or until the
pink color has disappeared, with or without the precipitation of
manganese dioxide. Add small portions of ferrous sulfate (or
other suitable reducing agent) in sufficient quantity to clear
the solution, and boil to expel the oxides of nitrogen. Cool
to 15° C., add an excess of sodium bismuthate and agitate for a
few minutes. Let settle and filter through an alundum filter
or asbestos pad, washing with the 3-per-cent nitric acid. Titrate
immediately with the standard-sodium-arsenite solution to the
disappearance of the pink color.

Notes.
In the method, the preliminary treatment with sodium bismuthate has
been found by a number of investigators to be apparently unnecessary;
however the available data to confirm this position are not considered suf-
ficient to warrant its omission.
In making the asbestos filter pad it is advisable to have a thin bed and
as much surface as possible. This insures rapid filtration and the filter may
be used until it becomes clogged with bismuthate.
The filtrate must be perfectly clear since the least particle of bismuthate
carried through the filter will vitiate the results.
The zinc-oxide reagent should be free from manganese, or a correction
applied if it is present.

DETERMINATION OF MANGANESE

* BY THE

MODIFIED BISMUTHATE METHOD.

(Routine.)

Solutions Required.

Nitric Acid.—Mix 500 cc. of nitric acid, sp. gr. 1.42, and
1500 cc. of distilled water.

Nitric Acid for Washing.—Mix 30 cc. of nitric acid, sp. gr.
1.42, and 970 cc. of distilled water.

Stock Sodium Arsenite.—To 15 g. of arsenious oxide (As₂O₃)
in a 300-cc. Erlenmeyer flask, add 45 g. of sodium carbonate
and 150 cc. of distilled water. Heat the flask and contents on
Serial Designation: A 55 – 15. 279

a water bath until the arsenious oxide is dissolved, cool the solution and make up to 1000 cc. with distilled water.

Standard Sodium Arsenite.—Dilute 300 cc. of the stock-sodium-arsenite solution to 1000 cc. with distilled water and titrate against potassium-permanganate solution (about N/10) which has been standardized by using Bureau of Standards sodium oxalate.¹ Titrate 10-cc. portions of the permanganate solution, to each of which have been added 50-cc. portions of the nitric acid. A clear green color free from brownish or purplish tints will be found a satisfactory and reproducible end-point. Adjust the solution so that 1 cc. is equivalent to 0.10 per cent of manganese on the basis of a 1-g. sample.

The factor Na₂C₂O₄—>Mn = 0.16397 (using the 1913 atomic weights).

Method.

In a 300-cc. Erlenmeyer flask dissolve 1 g. of the steel in 50 cc. of the nitric acid, and boil to expel the oxides of nitrogen. Cool to 0-70° C., add about 0.5 g. of sodium bismuthate, and heat for a few minutes, or until the pink color has disappeared, with or without the precipitation of manganese dioxide. Add sufficient sulfurous acid or sodium sulfite to clear the solution and to reduce all of the chromic acid. Cool to approximately 0° C. in ice water, add an excess of sodium bismuthate and agitate. After 30 seconds standing, filter rapidly through an alundum filter or asbestos pad, washing with 3-per-cent nitric acid previously cooled in ice water to approximately 0° C. Titrate immediately with the standard-sodium-arsenite solution to the disappearance of the pink color.

Notes

In the method, the preliminary treatment with sodium bismuthate has been found by a number of investigators to be apparently unnecessary; however, the available data to confirm this position are not sufficient to warrant its omission.

In making the asbestos filter pad it is advisable to have a thin bed, and as much surface as possible. This insures rapid filtration, and the filter may be used until it becomes clogged with bismuthate.

The filtrate must be ice cold and perfectly clear, since any appreciable rise of temperature above 0° C., or the least particle of bismuthate carried through the filter will vitiate the results.

Methods for Analysis of Alloy Steels.

See the Determination of Manganese in Plain Carbon Steel by the Persulfate Method.¹

**NOTE.**

In making the titration special care should be given to standardizing the end-point reading, and the reading should be corrected by a blank, which varies with the amount of chromium present.

DETERMINATION OF PHOSPHORUS.

See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.¹

See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method.¹

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.¹

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).¹

**NOTES.**

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten, or of copper or other metals precipitated by hydrogen sulfide from acid solutions.

The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.¹

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric-Acid Method (Optional).¹

¹Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
Determination of Chromium by the Fusion Method.

Solutions Required.

Sulfuric Acid.—Mix 1000 cc. of sulfuric acid, sp. gr. 1.84, and 3000 cc. of distilled water.

Sodium Carbonate.—A saturated solution; approximately 60 g. of sodium carbonate and 100 cc. of distilled water.

Magnesium Carbonate.—Ten grams of finely divided magnesium carbonate suspended in 100 cc. of distilled water.

Barium Carbonate.—Ten grams of finely divided barium carbonate suspended in 100 cc. of distilled water.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Potassium-Ferricyanide Indicator.—Dissolve 0.1 g. of potassium ferricyanide in 50 cc. of distilled water (see notes).

Standard Potassium Bichromate.—Dissolve 5 g. of potassium bichromate in 1000 cc. of distilled water, standardize against pure ferrous ammonium sulfate, and adjust to tenth-normal.

Ferrous Sulfate.—Dissolve 25 g. of ferrous ammonium sulfate in 900 cc. of distilled water and 100 cc. of sulfuric acid (1:1).

Method.

In a 300-cc. Erlenmeyer flask, covered, dissolve 1 g. of the steel in 50 cc. of the sulfuric acid (see notes). When completely dissolved, add 50 to 75 cc. of hot water, then gradually the sodium-carbonate solution until near neutrality, then add an excess of the magnesium-carbonate suspension (see notes), and boil vigorously for 15 minutes, with the cover on, adding fresh portions of the carbonate suspension during this time, so that there is present in the solution at the end of the operation an excess of 2 to 3 g. of the carbonate. Let settle and pour the supernatant liquid on a rapid filter, washing by decantation twice with cold water, pouring the washings through the filter. Transfer the filter to a platinum crucible and after burning off
the paper, fuse the residue for 10 minutes with a mixture of 5 g. of sodium carbonate and 0.25 g. of potassium nitrate. Dissolve the fusion in water, transfer to a beaker, add 2 cc. of 3-per-cent hydrogen peroxide, boil a few minutes and filter. Add 20 cc. of the sulfuric acid, stir vigorously, cool and titrate against the standardized ferrous-sulfate solution, using the potassium-ferricyanide solution as outside indicator, or add at once a measured amount (in excess) of the ferrous-sulfate solution, and titrate back against the potassium-bichromate solution, using the same indicator.

Notes.

The solution of the steel may be in hydrochloric acid, sp. gr. 1.20 or any other desired strength, adjusting the amount of acid used to avoid a large excess being present.

Barium-carbonate suspension may be substituted for the magnesium carbonate suspension when hydrochloric acid is used as solvent.

All hydrogen peroxide must be destroyed by boiling before acidifying, otherwise chromic acid will be reduced at this stage.

The insoluble residue remaining after extraction of the fusion should be examined for chromium.

The potassium-ferricyanide indicator should be prepared fresh on the day it is used.

The ferrous-sulfate solution should be standardized on the day it is used.

In titrating with the ferrous-sulfate solution it is convenient to divide the solution, roughly titrate one portion, add the other and finish carefully.

DETERMINATION OF CHROMIUM
BY THE
CHLORATE METHOD.
(Routine.)

Solutions Required.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Potassium-Ferricyanide Indicator.—Dissolve 0.1 g. of potassium ferricyanide in 50 cc. of distilled water (see notes).
Standard Potassium Bichromate.—Dissolve 5 g. of potassium bichromate in 1000 cc. of distilled water, and standardize against pure ferrous ammonium sulfate, and adjust to tenth-normal.

Standard Potassium Permanganate.—Dissolve 2 g. of potassium permanganate in 1000 cc. of distilled water. Standardize by using Bureau of Standards sodium oxalate. Adjust the solution so that 1 cc. is equivalent to 0.10 per cent chromium on the basis of a 1-g. sample. The factor Na$_2$C$_2$O$_4$—>Cr = 0.2584 (using the 1913 atomic weights).

Ferrous Sulfate.—Dissolve 25 g. of ferrous ammonium sulfate in 900 cc. of distilled water and 100 cc. of sulfuric acid (1:1).

Method.

In a 300-cc. Erlenmeyer flask dissolve 1 g. of the steel in 30 cc. of the nitric acid, and evaporate rapidly to approximately one-half volume. Add 50 cc. of nitric acid, sp. gr. 1.42, and add 1 g. of sodium chlorate (see notes). Evaporate by boiling to approximately one-half volume and complete the determination by either of the following procedures:

1. Dilute the solution with 100 cc. of distilled water and filter off the manganese dioxide, using suction, washing with hot water. Cool the filtrate, dilute with cold water to 600-cc. volume, and titrate against the standard-ferrous-sulfate solution, using the potassium-ferricyanide solution as outside indicator, or add at once a measured amount (in excess) of the ferrous-sulfate solution and titrate back against the standard-potassium-bichromate solution, using the same indicator.

2. Add 10 cc. of hydrochloric acid (1:1) and boil until the solution is clear and all manganese dioxide dissolved. Cool, dilute the solution with water to 300-cc. volume, add the ferrous-sulfate solution in measured amount (in excess), and titrate back with the standard-potassium-permanganate solution to a permanent pink color.

1 Circular No. 45, Bureau of Standards, Oct. 1, 1912.
Notes.

The potassium-ferricyanide indicator should be prepared fresh on the day it is used.

The ferrous-sulfate solution should be compared on the day it is used, with the standard-potassium-permanganate or standard-potassium-bichromate solutions.

Potassium chlorate may be used as oxidizing agent in the place of sodium chlorate.

In titrating with the ferrous-sulfate solution it is convenient to divide the solution, roughly titrate one portion, add the other and finish carefully.

DETERMINATION OF CHROMIUM
BY THE
PERMANGANATE OXIDATION METHOD.
(OPTIONAL ROUTINE.)

Solutions Required.

*Sulfuric Acid.*—Mix 1000 cc. of sulfuric acid, sp. gr. 1.84, and 3000 cc. of distilled water.

*Nitric Acid.*—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

*Potassium Permanganate.*—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.

*Standard Potassium Permanganate.*—Dissolve 2 g. of potassium permanganate in 1000 cc. of distilled water. Standardize by using Bureau of Standards sodium oxalate.\(^1\) Adjust the solution so that 1 cc. is equivalent to 0.10 per cent chromium on the basis of a 1-g. sample.

The factor \( \text{Na}_2\text{C}_2\text{O}_4 \rightarrow \text{Cr} = 0.2584 \) (using the 1913 atomic weights).

*Ferrous Sulfate.*—Dissolve 25 g. of ferrous ammonium sulfate in 900 cc. of distilled water and 100 cc. of sulfuric acid (1:1).

\(^1\) Circular No. 40, Bureau of Standards, Oct. 1, 1912.
Method.

In a 300-cc. Erlenmeyer flask, dissolve 1.25 g. (procedure No. 1) or 1 g. (procedure No. 2) of the steel in 50 cc. of the sulfuric acid. When completely dissolved, add 5 cc. of the nitric acid, and boil until clear and free from oxides of nitrogen. Dilute with hot water to approximately 150-cc. volume, heat, and while boiling add the potassium-permanganate solution slowly until a permanent brown precipitate appears (see notes). Complete the determination by either of the following procedures:

1. Add 25 cc. of ammonium hydroxide, sp. gr. 0.90, shake well, place on the cooler part of the hot plate to avoid bumping. Shake occasionally and digest for about 15 minutes, or until the permanganate is all decomposed, then add cautiously 20 cc. of the sulfuric acid and bring gently to a boil. Cool the solution and pour into a volumetric 250-cc. flask. Make up to mark with cold water and mix thoroughly. Allow precipitate to settle, filter off 200 cc. of the clear solution (equal to 1 g.), add the ferrous-sulfate solution in measured amount (in excess) and titrate back with the standard-potassium-permanganate solution to a permanent pink color. The number of cubic centimeters of the standard-potassium-permanganate solution obtained, subtracted from the number corresponding to the volume of the ferrous-sulfate solution used, will give the volume of the standard-potassium-permanganate solution equivalent to the chromium in the sample.

2. Add 10 cc. of hydrochloric acid (1:1), and boil until the solution is clear and all manganese dioxide dissolved. Cool, dilute the solution with water to 300-cc. volume, add the ferrous-sulfate solution in measured amount (in excess), and titrate back with the standard-potassium-permanganate solution to a permanent pink color.

Notes.

In oxidizing with the potassium-permanganate solution care should be taken to avoid a large excess, since the manganese-dioxide precipitate tends to hold the chromic acid.

In the solution of the manganese dioxide under procedure No. 2, the boiling should be continued until all chlorine fumes are expelled.

The ferrous-sulfate solution should be compared on the day it is used with the standard-potassium-permanganate solution.
DETERMINATION OF NICKEL.

See the Determination of Nickel in Plain Carbon Steel by the Gravimetric Dimethylglyoxime Method.¹

See the Determination of Nickel in Plain Carbon Steel by the Volumetric Dimethylglyoxime Method (Routine).¹

VANADIUM STEEL.

DETERMINATION OF CARBON.

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.¹

DETERMINATION OF MANGANESE.

See the Determination of Manganese in Chrome-Nickel Steel by the Zinc Oxide-Bismuthate Method.²

For the Routine Determination of Manganese, see the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.¹

DETERMINATION OF PHOSPHORUS

BY THE

MODIFIED MOLYBDATE-MAGNESIA METHOD

SOLUTIONS REQUIRED.

*Nitric Acid.*—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

*Nitric Acid for Washing.*—Mix 20 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water.

¹ Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
² Page 276,
Potassium Permanganate.—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.

Sodium Bisulfite.—Dissolve 30 g. of sodium bisulfite in 1000 cc. of distilled water.

Ammonium Molybdate.—Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr. 0.90, filter, and add 60 cc. of nitric acid, sp. gr. 1.42.

Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr. 1.42, and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water, and let stand at least 24 hours before using.

Magnesia Mixture.—Dissolve 50 g. of magnesium chloride and 125 g. of ammonium chloride in 750 cc. of distilled water, and then add 150 cc. of ammonium hydroxide, sp. gr. 0.90.

Ammonium Hydroxide, Approximately 10-per-cent.—Mix 1000 cc. of ammonium hydroxide, sp. gr. 0.90, and 2000 cc. of distilled water.

Ferrous Sulfate.—A saturated solution; approximately 40 g. of ferrous sulfate and 100 cc. of distilled water.

Method.

In a 300-cc. Erlenmeyer flask dissolve 5 g. of steel in 75 cc. of the nitric acid. Heat, and while boiling add about 12 cc. of the potassium-permanganate solution, and continue boiling until manganese dioxide precipitates. Dissolve the precipitate by additions of the sodium-bisulfite solution, boil until clear and free from oxides of nitrogen. Cool to 15–20° C., add 5 cc. of the ferrous-sulfate solution, and 2 or 3 drops of concentrated sulfurous acid, and then 100 cc. of the ammonium-molybdate solution. Let stand 1 minute, shake or agitate thoroughly for 5 minutes, filter on a 9-cm. paper and wash at least 3 times with the 2-per-cent nitric-acid solution to free from iron.

Treat the precipitate on the filter with the 10-per-cent ammonium-hydroxide solution, letting the solution run into a 100-cc. beaker containing 10 cc. of hydrochloric acid, sp. gr.
Methods for Analysis of Alloy Steels.

1.20, and 0.5 g. of citric acid; add 30 cc. of ammonium hydroxide, sp. gr. 0.90, cool, and then add 10 cc. of the magnesia mixture very slowly, while stirring the solution vigorously. Set aside in a cool place for 2 hours, filter and wash with the 10-per cent ammonium-hydroxide solution. Ignite and weigh. Dissolve the precipitate of magnesium pyrophosphate with 5 cc. of nitric acid, sp. gr. 1.20, and 20 cc. of water, filter and wash with hot water. Ignite and weigh. The difference in weights represents pure magnesium pyrophosphate containing 27.84 per cent of phosphorus.

Note.
The ammonium-molybdate solution should be kept in a cool place and should always be filtered before using.

DETERMINATION OF PHOSPHORUS
by the
MODIFIED ALKALIMETRIC METHOD.
(Routine.)

Solutions Required.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.
Nitric Acid for Washing.—Mix 20 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water.
Potassium Permanganate.—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.
Sodium Bisulfite.—Dissolve 30 g. of sodium bisulfite in 1000 cc. of distilled water.

Ammonium Molybdate.—Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr. 0.90, filter, and add 60 cc. of nitric acid, sp. gr. 1.42.

Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr. 14.2, and 960 cc. of distilled water.
When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water, and let stand at least 24 hours before using.

_Ferrous Sulfate._—A saturated solution; approximately 40 g. of ferrous sulfate and 100 cc. of distilled water.

_Potassium Nitrate, 1-per-cent._—Dissolve 10 g. of potassium nitrate in 1000 cc. of distilled water.

_Phenolphthalein Indicator._—Dissolve 0.2 g. of phenolphthalein in 50 cc. of 95-per-cent ethyl alcohol and 50 cc. of distilled water.

_Standard Sodium Hydroxide._—Dissolve 6.5 g. of purified sodium hydroxide in 1000 cc. of distilled water, add a slight excess of 1-per-cent solution of barium hydroxide, let stand for 24 hours, decant the liquid, and standardize it against a steel of known phosphorus content, as determined by the molybdate-magnesia method, so that 1 cc. will be equivalent to 0.01 per cent of phosphorus on the basis of a 2-g. sample (see notes). Protect the solution from carbon dioxide with a soda-lime tube.

_Standard Nitric Acid._—Mix 10 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water. Titrate the solution against the standardized sodium hydroxide, using phenolphthalein as indicator, and make it equivalent to the sodium hydroxide by adding distilled water.

**Method.**

In a 300-cc. Erlenmeyer flask dissolve 2 g. of steel in 50 cc. of the nitric acid. Heat, and while boiling add 6 cc. of the potassium-permanganate solution and continue boiling until manganese dioxide precipitates. Dissolve this precipitate by additions of the sodium-bisulfite solution, boil until clear and free from oxides of nitrogen, cool to 15-20° C., add 5 cc. of the ferrous-sulfate solution and 2 or 3 drops of concentrated sulfuric acid, and then 50 cc. of the ammonium-molybdate solution. Let stand for 1 minute, shake or agitate for 5 minutes, filter on a 9-cm. paper, wash the precipitate three times with the 2-per-cent nitric-acid solution to free it from iron, and continue the washing with the 1-per-cent potassium-nitrate solution until the precipitate and flask are free from acid.
Transfer the paper and precipitate to the solution flask, add 20 cc. of distilled water (see notes), 5 drops of phenolphthalein solution as indicator, and an excess of the standard-sodium-hydroxide solution. Insert a rubber stopper and shake vigorously until solution of the precipitate is complete. Wash off the stopper with distilled water and determine the excess of standard-sodium-hydroxide solution by titrating with standard-nitric-acid solution. Each cubic centimeter of standard-sodium-hydroxide solution represents 0.01 per cent of phosphorus.

Notes.

The ammonium-molybdate solution should be kept in a cool place and should always be filtered before using.

All distilled water used in titration should be freed from carbon dioxide by boiling or otherwise.

Bureau of Standards Standard Steel No. 24 is recommended as a suitable steel for standardizing the sodium-hydroxide solution.

DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.¹

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).¹

Notes.

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten, or of copper or other metals precipitated by hydrogen sulfide from acid solutions.

The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.¹

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric-Acid Method (Optional).¹

¹Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
DETERMINATION OF VANADIUM
BY THE
PHOSPHOMOLYBDATE-PRECIPITATION METHOD.

SOLUTIONS REQUIRED.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Nitric Acid for Washing.—Mix 20 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water.

Potassium Permanganate.—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.

Sodium Bisulfite.—Dissolve 30 g. of sodium bisulfite in 1000 cc. of distilled water.

Ammonium Phosphate.—Dissolve 50 g. of ammonium phosphate in 1000 cc. of distilled water.

Ammonium Molybdate.—Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr. 0.90, filter, and add 60 cc. of nitric acid, sp. gr. 1.42.

Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr. 1.42, and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water, and let stand at least 24 hours before using.

Acid Ammonium Sulfate.—Mix 50 cc. of sulfuric acid, sp. gr. 1.84, and 950 cc. of distilled water, and when cold add 15 cc. of ammonium hydroxide, sp. gr. 0.90. Use at a temperature of 80° C.

Standard Potassium Permanganate.—Dissolve 0.35 g. of potassium permanganate in 1000 cc. of distilled water, and standardize by using Bureau of Standards sodium oxalate. Adjust the solution so that 1 cc. is equivalent to 0.02 per cent vanadium on the basis of a 2.5-g. sample.

The factor Na₂C₂O₄→V = 0.7612 (using the 1913 atomic weights).

¹ Circular No. 49, Bureau of Standards, Oct. 1, 1912.
Method.

In a 300-cc. Erlenmeyer flask dissolve 2.5 g. of steel in 50 cc. of the nitric acid. Heat, and while boiling add 6 cc. of the potassium-permanganate solution and continue boiling until manganese dioxide precipitates. Dissolve the precipitate by additions of the sodium-bisulphite solution and continue boiling until clear and free from oxides of nitrogen. Add 5 cc. of the ammonium-phosphate solution and 10 g. of ammonium nitrate, heat to boiling, remove from the plate and add immediately 50 cc. of the ammonium-molybdate solution. Let stand 1 minute, shake or agitate for 3 minutes, filter the supernatant liquid by suction through an asbestos filter, and wash three times with the hot acid ammonium-sulfate solution. The flask containing the bulk of the precipitate is then set under the funnel fitted into a bell-jar filter and the asbestos pad is treated with successive small portions of hot sulfuric acid, sp. gr. 1.84. The solution is then heated until the precipitate is completely dissolved, a few drops of the nitric acid added, and the heating continued until copious fumes of sulfuric acid are evolved. Cool the solution, add hydrogen peroxide in small quantities, with vigorous shaking after each addition, until the solution takes on a deep brown color. Replace flask on the hot plate, fume for 4 or 5 minutes, cover the flask, cool, add 100 cc. of distilled water, heat to 80° C. and titrate with the standard-potassium-permanganate solution to a permanent pink color.

Note.

If, after the addition of hydrogen peroxide and subsequent heating, the solution does not take on a clear green or blue color, it should be heated until fumes of sulfuric acid are evolved to rid of any traces of nitric acid which interferes with the reduction, then cooled and the treatment with hydrogen peroxide repeated.
Determination of Vanadium

by the
Ether Extraction-Hydrochloric Acid Reduction Method.

(Routine.)

Solutions Required.

Hydrochloric Acid.—Mix 600 cc. of hydrochloric acid, sp. gr. 1.20, and 400 cc. of distilled water.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

Sulfuric Acid.—Mix 500 cc. of sulfuric acid, sp. gr. 1.84, and 500 cc. of distilled water.

Potassium Permanganate.—Dissolve 25 g. of potassium permanganate in 1000 cc. of distilled water.

Standard Potassium Permanganate.—Dissolve 0.35 g. of potassium permanganate in 1000 cc. of distilled water, and standardize by using Bureau of Standards sodium oxalate.\(^1\)

Adjust the solution so that 1 cc. is equivalent to 0.02 per cent vanadium on the basis of a 2.5 g. sample.

The factor \(\text{Na}_2\text{C}_2\text{O}_4 > \text{V} = 0.7612\) (using the 1913 atomic weights).

Method.

In a 150-cc. beaker dissolve 2.5 g. of the steel in 50 cc. of the hydrochloric acid, add small portions of the nitric acid to oxidize the iron, and heat to expel the oxides of nitrogen. Cool, and transfer the solution into an 8-oz. separatory funnel, rinsing the beaker with small portions of the hydrochloric acid. Add 50 cc. of ether, shake for 5 minutes, let settle for 1 minute, and then draw off lower clear solution into another 8-oz. separatory funnel. Add 10 cc. of hydrochloric acid, sp. gr. 1.20, to the solution in the first separatory funnel, shake thoroughly, allow to settle for 1 minute, and then draw off the lower clear solution into the second separatory funnel. To the combined solutions in the second separatory funnel add 50 cc. of ether, shake for

\(^1\) Circular No. 40, Bureau of Standards, Oct. 1, 1912.
5 minutes, let settle for 1 minute, and then draw off the clear layer into a 150-cc. beaker. Heat the aqueous solution gently to expel the ether, add 25 cc. of the sulfuric acid, and heat until copious fumes are evolved. Cool, dilute with 25 cc. of water, add a slight excess of the potassium-permanganate solution, and boil. Add 15 cc. of hydrochloric acid, sp. gr. 1.20, and heat to fuming for 10 minutes. Cool, add 100 cc. of water, heat to 80° C., and titrate with the standard-potassium-permanganate solution to a permanent pink color.

Note.
In heating the solution to expel oxides of nitrogen care should be taken not to boil.

CHROME - VANADIUM STEEL.

DETERMINATION OF CARBON

See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.¹

DETERMINATION OF MANGANESE.

See the Determination of Manganese in Chrome-Nickel Steel by the Zinc Oxide-Bismuthate Method.²

See the Determination of Manganese in Chrome-Nickel Steel by the Modified Bismuthate Method.³

DETERMINATION OF PHOSPHORUS.

See the Determination of Phosphorus in Vanadium Steel by the Modified Molybdate-Magnesia Method.⁴

See the Determination of Phosphorus in Vanadium Steel by the Modified Alkalimetric Method (Routine).⁵

¹ Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249.
² Page 276.
³ Page 278.
⁴ Page 286.
⁵ Page 288.
DETERMINATION OF SULFUR.

See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.¹

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).¹

NOTES.

The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten, or of copper or other metals precipitated by hydrogen sulfide from acid solutions.

The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

DETERMINATION OF SILICON.

See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.¹

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric-Acid Method (Optional).¹

DETERMINATION OF CHROMIUM

BY THE

FUSION METHOD.

SOLUTIONS REQUIRED.

Sulfuric Acid.—Mix 1000 cc. of sulfuric acid, sp. gr. 1.84, and 3000 cc. of distilled water.

Sodium Carbonate.—A saturated solution; approximately 60 g. of sodium carbonate and 100 cc. of distilled water.

Magnesium Carbonate.—Ten grams of finely divided magnesium carbonate suspended in 100 cc. of distilled water.

Barium Carbonate.—Ten grams of finely divided barium carbonate suspended in 100 cc. of distilled water.

Nitric Acid.—Mix 1000 cc. of nitric acid, sp. gr. 1.42; and 1200 cc. of distilled water.

¹Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33), p. 249,
Methods for Analysis of Alloy Steels.

Potassium-Ferricyanide Indicator.—Dissolve 0.1 g. of potassium ferricyanide in 50 cc. of distilled water (see notes).

Standard Potassium Bichromate.—Dissolve 5 g. of potassium bichromate in 1000 cc. of distilled water, standardize against pure ferrous ammonium sulfate, and adjust to tenth-normal.

Ferrous Sulfate.—Dissolve 25 g. of ferrous ammonium sulfate in 900 cc. of distilled water and 100 cc. of sulfuric acid (1:1). The strength of this solution should be expressed in terms of chromium and vanadium.

Method.

In a 300-cc. Erlenmeyer flask, covered, dissolve 1 g. of the steel in 50 cc. of the sulfuric acid (see notes). When completely dissolved, add 50 to 75 cc. of hot water, then gradually the sodium-carbonate solution until near neutrality, and then add an excess of the magnesium-carbonate suspension (see notes), and boil vigorously for 15 minutes, with the cover on, adding fresh portions of the carbonate suspension during this time, so that there is present in the solution at the end of the operation an excess of 2 to 3 g. of the carbonate. Let settle and pour the supernatant liquid on a rapid filter, washing by decantation twice with cold water, pouring the washings through the filter. Transfer the filter to a platinum crucible and after burning off the paper, fuse the residue for 10 minutes with a mixture of 5 g. of sodium carbonate and 0.25 g. of potassium nitrate. Dissolve the fusion in water, transfer to a beaker, add 2 cc. of 3-per-cent hydrogen peroxide, boil a few minutes and filter. Add 20 cc. of the sulfuric acid, stir vigorously, cool and titrate against the standardized ferrous-sulfate solution, using the potassium ferricyanide as outside indicator, or add at once a measured amount (in excess) of the ferrous-sulfate solution and titrate back against the standard-potassium-bichromate solution, using the same indicator.

From the number of cubic centimeters of the standard-ferrous-sulfate solution required deduct the number of cubic centimeters of the standard-ferrous-sulfate solution equivalent to the vanadium in the steel, as determined by the Phosphomolybdate-
Precipitation Method for Vanadium Steel, and the result will be the number of cubic centimeters of the standard-ferrous-sulfate solution equivalent to the chromium in the steel.

**Notes.**

The solution of the steel may be in hydrochloric acid, sp. gr. 1.20 or any other desired strength, adjusting the amount of acid used to avoid a large excess being present.

Barium-carbonate suspension may be substituted for the magnesium-carbonate suspension when hydrochloric acid is used as solvent.

All hydrogen peroxide must be destroyed by boiling before acidifying, otherwise chromic acid will be reduced at this stage.

The insoluble residue remaining after extraction of the fusion should be examined for chromium.

The potassium-ferricyanide indicator should be prepared fresh on the day it is used.

The ferrous-sulfate solution should be standardized on the day it is used.

In titrating with the ferrous-sulfate solution it is convenient to divide the solution, roughly titrate one portion, add the other and finish carefully.

**DETERMINATION OF CHROMIUM**

**BY THE**

**CHLORATE METHOD.**

(Routine.)

**Solutions Required.**

*Nitric Acid.—* Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.

*Potassium Ferricyanide Indicator.—* Dissolve 0.1 g. of potassium ferricyanide in 50 cc. of distilled water (see notes).

*Standard Potassium Bichromate.—* Dissolve 5 g. of potassium bichromate in 1000 cc. of distilled water, standardize against pure ferrous ammonium sulfate, and adjust to tenth-normal.

*Standard Potassium Permanganate.—* Dissolve 0.5 g. of potassium permanganate in 1000 cc. of distilled water. Standardize
by using Bureau of Standards sodium oxalate. Adjust the solution so that 1 cc. is equivalent to 0.05 per cent vanadium on the basis of a 1-g. sample.

The factor \( \text{Na}_2\text{C}_2\text{O}_4 \rightarrow \text{V} = 0.7612 \) (using the 1913 atomic weights).

*Ferrous Sulfate.*—Dissolve 25 g. of ferrous ammonium sulfate in 900 cc. of distilled water and 100 cc. of sulfuric acid (1:1). The strength of this solution should be expressed in terms of chromium and vanadium.

**Method.**

In a 300-cc. Erlenmeyer flask dissolve 1 g. of the steel in 30 cc. of the nitric acid, and evaporate rapidly to approximately one-half volume. Add 50 cc. of nitric acid, sp. gr. 1.42, and 1 g. of sodium chlorate (see notes). Evaporate by boiling to one-half volume, dilute with 100 cc. of water and filter off the manganese dioxide, using suction, washing with hot water. Cool the solution to room temperature and complete the determination by either of the following procedures:

1. Titrate against the ferrous-sulfate solution, using the potassium-ferricyanide solution as outside indicator (see notes). From the number of cubic centimeters of the ferrous-sulfate solution required deduct the number of cubic centimeters of the ferrous-sulfate solution equivalent to the vanadium in the steel, as determined by the Phosphomolybdate-Precipitation Method for Vanadium Steel, and the result will be the number of cubic centimeters of the ferrous-sulfate solution equivalent to the chromium in the steel.

2. Titrate against the ferrous-sulfate solution, using the potassium-ferricyanide solution as outside indicator (see notes). Cool to 15° C. and titrate against the standard-potassium-permanganate solution to a pink color permanent for 10 seconds. Deduct the number of cubic centimeters of the standard-potassium-permanganate solution consumed, which gives a direct measure of the vanadium content of the steel, from the first titration; the remainder will represent the chromium content of the steel.

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1 *Circular No. 40, Bureau of Standards, Oct. 1, 1912.*
2 Page 291.
Notes.

The potassium-ferricyanide indicator should be prepared fresh on the day it is used.

The ferrous-sulfate solution should be compared on the day it is used with the standard-potassium-permanganate or potassium-bichromate solutions.

Potassium chlorate may be used as oxidizing agent in the place of sodium chlorate.

In titrating with the ferrous-sulfate solution it is convenient to divide the solution, roughly titrate one portion, add the other and finish carefully.

DETERMINATION OF VANADIUM.

See the Determination of Vanadium in Vanadium Steel by the Phosphomolybdate-Precipitation Method.¹

DETERMINATION OF VANADIUM

BY THE

ETHER EXTRACTION - HYDROCHLORIC - ACID REDUCTION

METHOD.

(Routine.)

Solutions Required.

Hydrochloric Acid.—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

Standard Potassium Permanganate.—Dissolve 2 g. of potassium permanganate in 1000 cc. of distilled water, and standardize by using Bureau of Standards sodium oxalate.² Adjust the solution so that 1 cc. is equivalent to 0.10 per cent vanadium on the basis of when a 5-g. sample.

The factor Na$_2$C$_2$O$_4$—$\textbf{V} = 0.7612$ (using the 1913 atomic weights).

Method.

In a 150-cc. beaker, dissolve 5 g. of the steel in 60 cc. of the hydrochloric acid, add small portions of nitric acid, sp. gr. 1.42, to oxidize the iron, avoiding an excess, and heat to expel

¹ Page 291.
the oxides of nitrogen. Cool, and transfer the solution into an 8-oz. separatory funnel, rinsing the beaker with small portions of the hydrochloric acid. Add 50 cc. of ether, shake for 5 minutes, let settle for 1 minute, and then draw off lower clear solution into another separatory funnel. Add 10 cc. of hydrochloric acid, sp. gr. 1.20, to the solution in the first separatory funnel, shake thoroughly, allow to settle for 1 minute, and then draw off the lower clear solution into the second separatory funnel. To the combined solution in the second separatory funnel add 50 cc. of ether, shake for 5 minutes, let settle for 1 minute, and then draw off the clear layer into a 150-cc. beaker. Heat the aqueous solution gently to expel the ether, evaporate to approximately one-fourth original volume, add 0.5 g. of potassium chlorate and boil down to a volume of 10 cc. Add 25 cc. of hydrochloric acid, sp. gr. 1.20, and again evaporate to 10 cc. Add 20 cc. of sulfuric acid, sp. gr. 1.84, and evaporate until copious fumes of sulfuric acid are evolved. Cool, dilute with water to 100-cc. volume, and titrate against the standard potassium permanganate to a pink color permanent for 10 seconds. Deduct the chromium blank and the remainder is equivalent to the vanadium content of the steel.

Note.

If much chromium relative to the vanadium is present the result will be high due to the oxidation of a portion of the chromium by the permanganate, and should be corrected by a blank which varies with the amount of the chromium present. This blank is conveniently made by putting a suitable amount of a chrome or chrome-nickel steel, free from vanadium, through the above process. By using varying amounts of this steel, so as to vary the chromium correspondingly, a curve may be constructed showing the relation between amount of chromium present and the amount of blank, and this curve can then be used in all subsequent work.
SILICO - MANGANESE STEEL.

DETERMINATION OF CARBON.
See the Determination of Carbon in Plain Carbon Steel by the Direct-Combustion Method.¹

DETERMINATION OF MANGANESE.
See the Determination of Manganese in Plain Carbon Steel by the Bismuthate Method.¹

See the Determination of Manganese in Plain Carbon Steel by the Persulfate Method (Routine).¹

DETERMINATION OF PHOSPHORUS.
See the Determination of Phosphorus in Plain Carbon Steel by the Molybdate-Magnesia Method.¹

See the Determination of Phosphorus in Plain Carbon Steel by the Alkalimetric Method (Routine).¹

DETERMINATION OF SULFUR.
See the Determination of Sulfur in Plain Carbon Steel by the Oxidation Method.¹

See the Determination of Sulfur in Plain Carbon Steel by the Evolution-Titration Method (Routine).¹

NOTES.
The Evolution-Titration Method should not be used with steels containing appreciable amounts of tungsten, or of copper or other metals precipitated by hydrogen sulfide from acid solutions.
The annealing of the steel drillings has been found by a number of investigators to increase the degree of refinement of the method.

DETERMINATION OF SILICON.
See the Determination of Silicon in Plain Carbon Steel by the Nitro-Sulfuric Method.¹

See the Determination of Silicon in Plain Carbon Steel by the Sulfuric-Acid Method (Optional).¹

¹ Standard Methods for Chemical Analysis of Plain Carbon Steel Serial Designation: A 33, p. 249.
RECOMMENDED PRACTICE
FOR
ANNEALING OF MISCELLANEOUS ROLLED AND
FORGED CARBON-STEEL OBJECTS.

Serial Designation: A 35–11.

This recommended practice is issued under the fixed designation A 35; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1911.

1. Purpose and General Procedure.—The usual purpose in annealing miscellaneous forged or rolled carbon-steel objects is to remove existing coarseness of grain. This removal is brought about by heating the object to an annealing temperature, which varies with the carbon content of the metal. But the rate at which the object cools from this annealing temperature influences its properties very profoundly. Hence this rate of cooling should be suited to the duties which the object has to perform in service, and hence to the properties which we seek to give it.

Therefore these specifications first consider the annealing temperature to which the piece must be heated in order to remove existing coarse grain, and then the rate of cooling from that temperature.

Under certain special conditions an annealing is required in order to remove, not coarseness of grain, but the effects of rolling or otherwise working the metal at a temperature so low as to set up serious internal stress. Appropriate treatment for these conditions is given in Section 14.
As these specifications are intended to apply to a great variety of miscellaneous objects, they are purposely made suggestive rather than mandatory in many respects, because no single set of rules can be applied rigorously to such widely varying classes of objects and purposes.

Annealing for Removing Existing Coarse Grain.

2. Method of Heating.—In the case of large objects, the heating of the interior of which lags behind that of the outside, though the early part of the heating may if desired be rapid, the final approach to the annealing temperature aimed at should be slow, so that the interior may be brought fully up to it without carrying the exterior far beyond it, because in general any needlessly high temperature is injurious, and tends to re-coarsen the grain. The temperature should be held long enough at the annealing point to insure that the whole of the interior reaches that point, and that the refining of the grain may become complete. An exposure of one hour should be long enough for pieces 12 in. thick. Thicker pieces need a longer heating.

3. Control of Temperature. Pyrometers.—For all important work in careful hands the use of some trustworthy pyrometer is strongly recommended. But most pyrometers should be checked frequently against some standard. For those who are unwilling to take this trouble it is safer to rely on a trained eye than on an unchecked pyrometer. The operator should have clearly before him the fact that no pyrometer indicates the temperature of the interior of the object heated, and that the temperature which most pyrometers indicate is one between the temperature of the outside of the object heated and the temperature of the flame which is supplying the heat. Wherever practicable the part of the pyrometer which is supposed to reach the temperature of the object heated should be in immediate contact with that object, and should be protected from the flame or other source of heat by a suitable insulation, as for instance by covering it with sand. In important cases the gas or other source of heat should be shut off for at least ten minutes before taking the observation.

4. Control Without the Use of a Pyrometer.—In working without a pyrometer and relying on the eye, the light surrounding the furnace should be dull, and should be kept as nearly constant as practicable, in order that the eye may not be misled
Recommended Practice for Annealing.

by the changing contrasts between the surrounding light and that of the object heated. In particular, direct sunlight should be excluded, and any arc or other strong lights should be so placed that neither they themselves nor any concentrated part of their light is in the field of the operator's sight when he is estimating by eye the temperature of the objects to be annealed. Allowance should be made for the brighter surroundings by day than at night, and on sunny than on dark days.

5. Magnetic Indications.—The annealing temperature for steels containing between 0.50 and 0.90 per cent of carbon is that at which the metal suddenly ceases to be magnetic. This fact may sometimes be used for the purpose of fixing or verifying the annealing temperature.

6. Annealing Temperature.—In general, the higher the carbon content the lower should be the annealing temperature. Hence different temperatures are given for different ranges of carbon content. Further, in order to bring the interior of large objects up to an effective annealing temperature, their outside may often be raised advantageously somewhat above that temperature. Hence for each range of carbon content a range of temperature is given. The upper limit of this range applied (1) to larger objects, and (2) to the lower part of the range of carbon content given.

The following ranges of temperature should be used for the several ranges of carbon content indicated. They refer to the usual moderate manganese content. For steels with a manganese content greater than 0.75 per cent slightly lower temperatures suffice.

<table>
<thead>
<tr>
<th>Range of Carbon Content</th>
<th>Range of Annealing Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.12 per cent</td>
<td>875 to 925° C. (1607–1697° F.)</td>
</tr>
<tr>
<td>0.12 to 0.29</td>
<td>840 ° 870 ° (1544–1598 °)</td>
</tr>
<tr>
<td>0.30 ° 0.49</td>
<td>815 ° 840 ° (1499–1544 °)</td>
</tr>
<tr>
<td>0.50 ° 1.00</td>
<td>790 ° 815 ° (1454–1499 °)</td>
</tr>
</tbody>
</table>

7. Care in Heating.—Care should be taken that all parts of the object reach the same temperature. To that end it may be necessary to mask from the heat, by means of bricks, the thinner part of objects of varying thickness. When the heating is nearly finished, these bricks may be removed. In particular the flame should never be allowed to touch any part of the object under treatment.

8. Cooling.—After the object has been held at the annealing temperature long enough to make its temperature nearly uniform throughout, and to complete the refining of the grain, it should
be cooled in a way suited to its carbon content and to giving it the specific properties needed. The general principles are: first, the higher the carbon the slower should be the cooling; and second, the slower the cooling the softer and more ductile the metal will be, and the lower will be its tensile strength, elastic limit, and yield point. The greatest softness and ductility are obtained at a certain sacrifice of strength and elasticity, and the greatest strength and elasticity at a certain sacrifice of softness and ductility.

For most purposes neither of these extremes is desired, and it is not only sufficient as regards quality but economical to remove the object from the furnace as soon as it has been thoroughly annealed, and to allow it to cool in air, always completely protected not only from rain and snow but from sharp drafts of air. Objects containing more than 0.50 per cent of carbon should cool more slowly till the color dies out, say at 500° C. (932° F.), as for instance by leaving them in the furnace. They may then be removed and cooled in air. Further, thin objects containing between 0.25 and 0.50 per cent of carbon should be treated like those of 0.50 per cent of carbon, unless they can be so massed together that their collective bulk will retard their cooling, so that they will collectively cool even in air with moderate slowness, like single large objects.

Special Annealing Methods.

9. The foregoing methods are economical because they release the furnaces early for further use. In case special qualities are desired the following methods may be used:

10. To Give the Greatest Softness and Ductility of which the metal is capable, even at a certain sacrifice of strength and elastic limit, for instance for ease of machining or to resist a small number of severe distortions, the metal should be cooled slowly, either within the furnace, or in the case of large objects, under a cover of lime, clay, or other slow conductor of heat. The slower the cooling and the lower the temperature to which slow cooling is carried, the softer and weaker will be the steel. But for most cases for which even unusual softness and ductility are required, it suffices to remove the object from the furnace when it has become dead black, and to cool it thenceforth in air.

11. To Give Great Tensile Strength and High Elastic Limit even at a certain sacrifice of ductility, the cooling should be
more rapid, the rapidity to be governed by the thickness and carbon content of the object. Thin objects and those with high carbon content cannot stand so rapid a cooling as thick and low-carbon ones, lest their ductility be too far sacrificed. For instance, thick objects with less than 0.50 per cent of carbon may be cooled completely in air, of course protected from rain or snow. Objects with 0.50 per cent of carbon or more, and thin objects with from 0.30 to 0.50 per cent of carbon, may be cooled in air if their cooling is somewhat retarded, as for instance by massing them together, as happens in the case of rails.

12. To Give an Unusually High Combination of Ductility with Tensile Strength and Elastic Limit. Water or Oil Quenching and Annealing.—This process needs great care and intelligence, and should in general be used only by those familiar with high-grade steels. After holding at the annealing temperature suited to the particular steel, as indicated in Section 6, the object is quenched in oil, which should be kept in circulation. It may be quenched in water if its carbon content is so low and its shape so simple that it is not in danger of cracking or receiving permanently harmful stress. In any event the danger of such cracking and stress is lessened by removing the object from the oil or water before it has cooled completely, say when its temperature has fallen to 160° C. (320° F.). It should if possible not cool below 100° C. (212° F.) and certainly not below 20° C. (68° F.). The annealing should begin within a very few hours after the quenching and if possible without ever allowing the piece to cool below 100° C. (212° F.) and certainly not below 20° C. (68° F.).

The steel thus hardened should next be annealed by heating to a temperature suited for giving the properties needed. In general the higher this annealing goes, the more ductile will the steel become, and the lower will be its strength and elastic limit.

For very high elastic limit and tensile strength, anneal at 500 to 650° C. (932 to 1202° F.). In this case the ductility will be low. Some steels, such as watch-springs and shafting, are annealed at 350° C. Little commercial annealing is done below 500° C.

For intermediate tensile strength, elastic limit, and ductility, best suited to the majority of cases, anneal at 600 to 650° C. (1112 to 1202° F.).
For the greatest ductility, with good strength and elastic limit, anneal at from 725 to 750° C. (1337 to 1382° F.).

The object should be held at this second annealing temperature long enough not only to allow its interior to reach it, but also to relieve the stress given in the water or oil quenching. For pieces of moderate thickness a 4-hour exposure should suffice.

13. To Give a Moderate Increase of Strength and Elastic Limit above that Given by a Simple Slow Cooling, without the Full Sacrifice of Ductility which a Simple Air Cooling would Cause.—After holding at the annealing temperature suited to the carbon content, as indicated in Section 6, hasten the cooling till the object is at a dull red, say 650° C. (1202° F.), and henceforth cool slowly. The hastening of the cooling may be brought about in the case of thin objects in relatively shallow furnaces by opening the furnace door till the temperature falls to dull redness; or by running the objects out into the air on a movable car-bottom, and returning them to the furnace when they have cooled to dull redness; or even, in the case of objects with not over 0.30 per cent carbon and not too thin, by a temporary immersion in oil or even water, followed by a return to the furnace. In cases in which such operations are to be performed frequently, special unfired chambers may be used for the final slow cooling, thus leaving the annealing furnaces proper available for their regular work. The results obtained in this way are not as good as those obtained with the method described in Section 11.

14. Special Annealing to Remove the Effects of Rolling or Otherwise Working the Object in the Cold or at any Unduly Low Temperature.—The object should be heated to about 775° C. (1427° F.) and cooled with a slowness which should increase with the thickness, that is, the least dimension of the piece. In the case of thin plates a mere heating to 725° C. (1337° F.), followed immediately by slow cooling, should suffice. In the case of thick forgings, in which much time may be needed to allow severe stress to relieve itself, the sojourn at 775° C. (1427° F.) may be prolonged for several hours, though always at the cost of superficial decarburizing.

Such annealing for steel containing less than 0.15 per cent carbon should be at 900° C. (1652° F.). Great brittleness may be caused by annealing very low carbon steel in the neighborhood of 700° C. (1292° F.), after cold working.
RECOMMENDED PRACTICE
FOR
ANNEALING OF CARBON-STEEL CASTINGS.


This recommended practice is issued under the fixed designation A 36; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1914.

1. The castings should preferably be sufficiently cleaned of adhering sand before annealing to ensure thorough and uniform heating.

2. The castings should be heated slowly and uniformly to temperatures varying with the carbon content of the steel, approximately as follows:

<table>
<thead>
<tr>
<th>Carbon, per cent.</th>
<th>Temperature, deg. Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 0.16</td>
<td>925</td>
</tr>
<tr>
<td>0.16 to 0.34</td>
<td>875</td>
</tr>
<tr>
<td>0.35 to 0.54</td>
<td>850</td>
</tr>
<tr>
<td>0.55 to 0.79</td>
<td>830</td>
</tr>
</tbody>
</table>

Nothing in these recommendations shall operate against the temperatures aimed at being 50 and, in special cases, 100° C. higher than those given in the table, when necessary to attain the desired result.

3. The castings should be kept at the maximum temperature a sufficient length of time to ensure the refining of the grain.
In general, the heavier the sections of the casting, the longer must be the time of exposure to the maximum temperature.

4. (a) The castings should be cooled slowly and uniformly in the furnace, when it is desired that the steel shall possess the maximum softness.

(b) The castings may be cooled at an accelerated rate, when it is desired that the steel possess rather higher tensile strength and elastic limit than can be procured by very slow cooling. This cooling must be so conducted as to leave the steel reasonably free from cooling stresses.

The manner of carrying out this accelerated cooling should be such as will attain the desired result. For instance, the castings may be withdrawn from the furnace and buried in a bed of material that is a poor conductor of heat; or the annealing furnace may be so thrown open that it will cool more rapidly than if left closed. Should the castings be of such uneven section that they cool at unequal rates at various points when the furnace is opened, especially if the carbon of the steel is high, the furnace should be closed after the castings have become black, and their further cooling so retarded that the stresses set up by the unequal rates of cooling are relieved.
RECOMMENDED PRACTICE
FOR
HEAT TREATMENT OF CASE-HARDENED
CARBON-STEEL OBJECTS.


This recommended practice is issued under the fixed designation A 37; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1914.

It is recommended that the following treatments be applied to case-hardened carbon-steel objects according to requirements:

1. When hardness of case only is desired and lack of toughness or even brittleness unimportant, the carburized objects may be quenched from the carburizing temperature, as for instance, by emptying the contents of the boxes in cold water or in oil. Both the core and the case are then coarsely crystalline.

2. In order to reduce the hardening stresses and to decrease the danger of distortion and cracking in the quenching bath, the objects may be removed from the box and allowed to cool before quenching to a temperature slightly exceeding the critical range of the case, namely, 800 to 825°C. Both the core and case remain coarsely crystalline.

3. To refine the case and increase its toughness, the carburized objects should be allowed to cool slowly in the carburizing box within the furnace or outside to 650°C. or below, and should then be reheated to a temperature slightly exceeding the
lower critical point of the case (in the majority of instances a temperature varying in accordance with the carbon content and thickness of the case between 775 and 825° C. will be suitable), and quenched in water, or, for greater toughness but less hardness, in oil. The objects should be removed from the quenching bath before their temperature has fallen below 100° C. This treatment is more especially to be recommended when the carburizing temperature has not exceeded 900° C. It refines the case but not the core.

4. To refine both the core and the case and to increase their toughness, the objects should be allowed to cool slowly from the carburizing temperature to 650° C. or below and should then be (a) reheated to a temperature exceeding the critical point of the core, which will generally be from 900 to 950° C., followed by quenching in water or in oil; and (b) before they have cooled below 100° C., they should be reheated to a temperature slightly exceeding the lower critical point of the case (in the majority of instances a temperature varying in accordance with the carbon content and thickness of the case between 775 and 825° C. will be suitable), and again quenched in water or oil.

5. In order to reduce the hardening stresses created by quenching, the objects, as a final treatment, may be tempered by reheating them to a temperature not exceeding 200° C.

1 The objects should be removed from the quenching bath before they have cooled below 100° C. in order to lessen the danger of cracking, and they should be placed in the reheating furnace while still at a temperature of at least 100° C. likewise to lessen the danger of cracking, it being inadvisable (a) to allow steel to cool completely in the quenching bath and (b) to place hardened steel in a hot furnace. Obviously, if the furnace is cold the hardened steel may likewise be cold when placed in it for reheating.
STANDARD SPECIFICATIONS
FOR
LAP-WELDED CHARCOAL-IRON BOILER TUBES,
BOILER FLUES, SAFE ENDS, AND ARCH
TUBES FOR LOCOMOTIVES.

Serial Designation: A 38–16.

The specifications for this material are issued under the fixed designation A 38; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912; REVISED, 1916.

I. MANUFACTURE.

1. The tubes shall be made from knobbled, hammered charcoal iron.

II. PHYSICAL PROPERTIES AND TESTS.

Bend Tests. 2. (a) Quench-bend Tests.—Strips $\frac{1}{2}$ in. in width by 6 in. in length, planed lengthwise from tubes, when heated to a cherry red and quenched at once in water the temperature of which is 80° F., shall bend in opposite directions at each end, as shown in Fig. 1, without showing cracks or flaws.

(b) Nick-bend Tests.—Strips $\frac{1}{2}$ in. in width by 6 in. in length, planed lengthwise from tubes, when nicked and broken by light blows, shall show a wholly fibrous fracture.
3. A test specimen 12 in. in length shall be heated for a length of 5 in. to a bright cherry red (1200-1400° F.), placed in a vertical position, and a smooth tapered steel pin at blue heat (600-800° F.) forced into the end of the tube by pressure or by light blows of a 10-lb. hammer. Under this test the tube shall expand to $1\frac{1}{8}$ times its original diameter without splitting or cracking. The pin shall be of tool steel and shall have a taper of $1\frac{1}{8}$ in. per foot of length.

4. A test specimen 2\frac{1}{2} in. in length shall stand crushing longitudinally to a height of $1\frac{1}{8}$ in. without splitting in either direction and without cracking or opening at the weld.

5. Each tube shall stand an internal hydraulic pressure of between 500 and 750 lb. per sq. in.

6. In case of doubt as to the quality of material, the following test shall be made to detect the presence of steel. A cross-section of tube shall be turned or ground to a perfectly true surface, polished free from dirt or cracks, and etched until the soft parts are sufficiently dissolved for the iron tube to show a decided ridged surface, with the weld very distinct, while a steel tube would show a homogeneous surface.

7. Test specimens shall consist of sections cut from a tube. They shall be smooth on the ends and free from burrs.

8. One tube from each lot of 250 or fraction thereof shall be tested as specified in Sections 2, 3, and 4. Each tube shall be tested as specified in Section 5.

9. If the results of the tests do not conform to the requirements specified in Sections 2, 3, or 4, retests of two additional tubes from the same lot shall be made and each of these shall conform to the requirements specified.

III. STANDARD MINIMUM WEIGHTS.

10. The standard minimum weights for tubes of various outside diameters and thicknesses, are as indicated in Table I.

IV. WORKMANSHIP AND FINISH.

11. (a) The finished tubes shall be circular within 0.02 in., and the mean diameter shall not vary more than 0.015 in. from

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*A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.*
Specifications for Lap-Welded Iron Boiler Tubes.

the size ordered. They shall not be shorter than the length ordered, but may exceed it by 0.125 in.

(b) The thickness at any point shall not vary more than 0.01 in. from that specified, except at the weld, where an additional thickness of 0.015 in. shall be allowed.

12. The finished tubes shall have a smooth surface, free from laminations, cracks, blisters, pits, and imperfect welds, and shall have a workmanlike finish. They shall be free from kinks, bends and buckles, and evidences of unequal contraction in cooling or injury in manipulation.

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Weight, lb. per ft. of Length.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearest B. w. g.</td>
<td>Outside Diameter, in.</td>
</tr>
<tr>
<td>0.095 12</td>
<td>1.65 1.00 2.14 2.39</td>
</tr>
<tr>
<td>0.100 12</td>
<td>1.69 2.18 2.46 2.75</td>
</tr>
<tr>
<td>0.125 11</td>
<td>2.13 2.45 2.78 3.11</td>
</tr>
<tr>
<td>0.150 10</td>
<td>2.28 2.64 2.99 3.34</td>
</tr>
<tr>
<td>0.165 9</td>
<td>2.51 2.90 3.29 3.68</td>
</tr>
<tr>
<td>0.180 7</td>
<td>... 4.00 4.90 5.26 6.05 6.83 7.61 8.01 8.20 8.40 8.98 9.00 9.21 9.67 9.79 9.90 9.97</td>
</tr>
</tbody>
</table>

V. MARKING.

13. "Knobbled charcoal, tested to 500 lb. pressure," shall be legibly marked at the middle of the length of each tube.

VI. INSPECTION AND REJECTION.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment.

Rejection. 15. Tubes when inserted in the boiler shall stand expanding and beading without splitting or breaking. Tubes which fail in this manner will be rejected, and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
STAYBOLT IRON.


The specifications for this material are issued under the fixed designation A 39; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1910; REVISED, 1912, 1914.

I. MANUFACTURE.

1. The iron shall be rolled from a bloom or boxpile, made wholly from puddled iron or knobbled charcoal iron. The puddle mixture and the component parts of the bloom or boxpile shall be free from any admixture of iron scrap or steel.

2. (a) Bloom.—A bloom is a solid mass of iron that has been hammered into a convenient size for rolling.

   (b) Boxpile.—A boxpile is a pile, the sides, top and bottom of which are formed by four flat bars and the interior of which consists of a number of small bars the full length of the pile.

   (c) Iron Scrap.—This term applies only to foreign or bought scrap and does not include local mill products free from foreign or bought scrap.

II. PHYSICAL PROPERTIES AND TESTS.1

3. (a) The iron shall conform to the following requirements as to tensile properties:

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1 Committee A-2 on Wrought Iron, which prepared these specifications for presentation to the Society, desires to call attention to the fact that the vibration test has been omitted from the specifications. While recognizing its importance, the committee feels that the variations in the results obtained by this test are so great that it is not advisable to include such a requirement in the specifications until it has been carefully standardized. The committee means to institute further inquiries with the hope of reaching a sound basis for this test in the measurably near future.
Tensile strength, lb. per sq. in. .................................. 49,000 - 53,000
Yield point, min., " " ........................................ 0.6 tens. str.
Elongation in 8 in., min., per cent ......................... 30
Reduction of area, " " ...................................... 48

(b) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed 1 1/2 in. per minute.

4. (a) Cold-bend Tests.—The test specimen shall bend cold through 180 deg. flat on itself in both directions without fracture on the outside of the bent portion.

(b) Quench-bend Tests.—The test specimen, when heated to a yellow heat and quenched at once in water the temperature of which is between 80° and 90° F., shall bend through 180 deg. flat on itself without fracture on the outside of the bent portion.

(c) Nick-bend Tests.—The test specimen, when nicked 25 per cent around with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter of the specimen, and broken, shall show a clean fiber entirely free from crystallization.

(d) Bend tests may be made by pressure or by blows.

5. The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to have been rolled from a bloom or a boxpile, and to be free from steel.

6. All test specimens shall be of the full section of material as rolled.

7. (a) Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Sections 3 and 4; but only one of these bars shall be tested as specified in Section 5.

(b) If any test specimen from either of the bars originally selected to represent a lot of material, contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, one retest from a different bar will be allowed.

(c) When retests as specified in Paragraph (b) are not permitted, a reduction of 2 per cent in elongation and 3 per cent in

Etch Tests.¹

Test Specimens.

Number of Tests.

¹ A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.

reduction of area from that specified in Section 3 (a) shall be allowed.

III. PERMISSIBLE VARIATIONS IN GAGE.

8. The bars shall be truly round within 0.01 in., and shall not vary more than 0.005 in. above nor more than 0.01 in. below the specified size.

IV. FINISH.

9. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends, and evidences of being burnt.

V. MARKING.

10. The bars shall be stamped or marked as designated by the purchaser.

VI. INSPECTION AND REJECTION.

11. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

12. (a) If either of the test bars selected to represent a lot does not conform to the requirements specified in Sections 3, 4, 5, and 6, the lot will be rejected.

(b) Bars which will not take a clean, sharp thread with dies in fair condition, or which develop defects in forging or machining, will be rejected, and the manufacturer shall be notified.
STANDARD SPECIFICATIONS
FOR
ENGINE-BOLT IRON.


The specifications for this material are issued under the fixed designation A 40; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912; REVISED, 1913.

I. MANUFACTURE

1. The iron shall be made wholly from puddled iron and shall be free from any admixture of iron scrap or steel.

2. Iron Scrap.—This term applies only to foreign or bought scrap and does not include local mill products free from foreign or bought scrap.

II. PHYSICAL PROPERTIES AND TESTS.

3. (a) The iron shall conform to the following requirements as to tensile properties:

- Tensile strength, lb. per sq. in. ............... 50 000 – 54 000
- Yield point, min., lb. per sq. in. ............... 0.6 tens. str.
- Elongation in 8 in., min., per cent ............. 25
- Reduction of area, “ .......................... 40

(b) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed 1 1/2 in. per minute.

(318)
4. For material over 14 sq. in. in section, a deduction of 2000 lb. per sq. in. from the tensile strength specified in Section 3 shall be made.

5. (a) Cold-bend Tests.—The test specimen shall bend cold through 180 deg. around a pin the diameter of which is equal to the diameter of the specimen, without fracture on the outside of the bent portion.

(b) Hot-bend Tests.—The test specimen, when heated to a bright cherry red, shall bend through 180 deg. flat on itself without fracture on the outside of the bent portion.

(c) Nick-bend Tests.—The test specimen, when nicked 25 per cent around with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter of the specimen, and broken, shall show a wholly fibrous fracture.

(d) Bend tests may be made by pressure or by blows.

6. The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to be free from steel.

7. (a) Tension test specimens shall be of the full section of material as rolled, if possible. Otherwise, the specimens shall be taken from the material as rolled; for bars 2½ in. or less in diameter, the axis of the specimen shall coincide with the axis of the bar; for bars over 2½ in. in diameter, the axis of the specimen shall be located at any point one-half the distance from the center to the surface and shall be parallel to the axis of the bar; and the specimens shall be turned to a diameter of 1 in. for a length of at least 9 in., with enlarged ends.

(b) Bend and etch test specimens shall be of the full section of material as rolled; except that for bars over 1¼ in. in diameter, the cold-bend test specimen may be machined to not less than 1 sq. in. in section.

8. (a) Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Sections 3 and 5; but only one of these bars shall be tested as specified in Section 6.

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A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.
(b) If any test specimen from either of the bars originally selected to represent a lot of material, contain surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, one retest from a different bar will be allowed.

III. PERMISSIBLE VARIATIONS IN GAGE.

9. The bars shall conform to the standard limit gages adopted by the Master Car Builders’ Association, as given in Table I.¹

<table>
<thead>
<tr>
<th>Nominal Diameter of Bars, in.</th>
<th>Large Size, + End, in.</th>
<th>Small Size, - End, in.</th>
<th>Total Variation, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16</td>
<td>0.2550</td>
<td>0.2450</td>
<td>0.010</td>
</tr>
<tr>
<td>1/8</td>
<td>0.3180</td>
<td>0.3070</td>
<td>0.011</td>
</tr>
<tr>
<td>3/8</td>
<td>0.3810</td>
<td>0.3690</td>
<td>0.012</td>
</tr>
<tr>
<td>7/16</td>
<td>0.4440</td>
<td>0.4310</td>
<td>0.013</td>
</tr>
<tr>
<td>1/2</td>
<td>0.5070</td>
<td>0.4930</td>
<td>0.014</td>
</tr>
<tr>
<td>9/16</td>
<td>0.5700</td>
<td>0.5550</td>
<td>0.015</td>
</tr>
<tr>
<td>5/8</td>
<td>0.6330</td>
<td>0.6170</td>
<td>0.016</td>
</tr>
<tr>
<td>1/4</td>
<td>0.7585</td>
<td>0.7415</td>
<td>0.017</td>
</tr>
<tr>
<td>7/8</td>
<td>0.8840</td>
<td>0.8660</td>
<td>0.018</td>
</tr>
<tr>
<td>1</td>
<td>1.0095</td>
<td>0.9905</td>
<td>0.019</td>
</tr>
<tr>
<td>5/16</td>
<td>1.1350</td>
<td>1.1150</td>
<td>0.020</td>
</tr>
<tr>
<td>3/4</td>
<td>1.2605</td>
<td>1.2395</td>
<td>0.021</td>
</tr>
<tr>
<td>13/8</td>
<td>1.3860</td>
<td>1.3640</td>
<td>0.022</td>
</tr>
<tr>
<td>1/2</td>
<td>1.5115</td>
<td>1.4885</td>
<td>0.023</td>
</tr>
<tr>
<td>5/12</td>
<td>1.6370</td>
<td>1.6130</td>
<td>0.024</td>
</tr>
<tr>
<td>3/4</td>
<td>1.7625</td>
<td>1.7375</td>
<td>0.025</td>
</tr>
<tr>
<td>13/8</td>
<td>1.8880</td>
<td>1.8620</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Round bars 2 in. in diameter and over shall be rolled to nominal diameter.

IV. FINISH.

10. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends, and evidences of being burnt.

¹ Adopted by the Master Car Builders’ Association in 1883 and revised in 1911. See Proceedings, Master Car Builders’ Assoc., Vol. 49, Part 2, pp. 956-957 (1915).
V. MARKING.

11. The bars shall be stamped or marked as designated by Marking. the purchaser.

VI. INSPECTION AND REJECTION.

12. (a) The inspector representing the purchaser shall have Inspection. free entry, at all times while work on the contract of the pur- chaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the ac- ceptance or rejection of material in his own laboratory or else- where. Such tests, however, shall be made at the expense of the purchaser.

13. (a) If either of the test bars selected to represent a lot Rejection. does not conform to the requirements specified in Sections 3, 4, 5, and 6, the lot will be rejected.

(b) Bars which develop defects in forging or machining will be rejected, and the manufacturer shall be notified.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS
FOR
REFINED WROUGHT-IRON BARS.


The specifications for this material are issued under the fixed designation A 41; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912; REvised, 1913.

I. MANUFACTURE.

1. Refined wrought-iron bars shall be made wholly from puddled iron, and may consist either of new muck-bar iron or a mixture of muck-bar iron and scrap, but shall be free from any admixture of steel.

II. PHYSICAL PROPERTIES AND TESTS.

2. (a) The iron shall conform to the following minimum requirements as to tensile properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, lb. per sq. in.</td>
<td>48 000</td>
</tr>
<tr>
<td>(See Sections 3 and 4)</td>
<td></td>
</tr>
<tr>
<td>Yield point, lb. per sq. in.</td>
<td>25 000</td>
</tr>
<tr>
<td>(See Section 5)</td>
<td></td>
</tr>
<tr>
<td>Elongation in 8 in., per cent.</td>
<td>22</td>
</tr>
</tbody>
</table>

(b) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed 11/2 in. per minute.

3. Twenty per cent of the test specimens representing one size may show tensile strengths 1000 lb. per sq. in. under or (322)
5000 lb. per sq. in. over that specified in Section 2; but no specimen shall show a tensile strength under 45,000 lb. per sq. in.

4. For flat bars which have to be reduced in width, a deduction of 1000 lb. per sq. in. from the tensile strength specified in Sections 2 and 3 shall be made.

5. Twenty per cent of the test specimens representing one size may show the following percentages of elongation in 8 in.:

**Round Bars.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ in. or over, tested as rolled</td>
<td>20 per cent</td>
</tr>
<tr>
<td>Under ½ in.,</td>
<td>16 &quot;</td>
</tr>
<tr>
<td>Reduced by machining</td>
<td>18 &quot;</td>
</tr>
</tbody>
</table>

**Flat Bars.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ in. or over, tested as rolled</td>
<td>18 per cent</td>
</tr>
<tr>
<td>Under ½ in.,</td>
<td>16 &quot;</td>
</tr>
<tr>
<td>Reduced by machining</td>
<td>16 &quot;</td>
</tr>
</tbody>
</table>

6. (a) **Cold-bend Tests.**—Cold-bend tests will be made only on bars having a nominal area of 4 sq. in. or under, in which case the test specimen shall bend cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to twice the diameter or thickness of the specimen.

(b) **Hot-bend Tests.**—The test specimen, when heated to a temperature between 1700° and 1800° F., shall bend through 180 deg. without fracture on the outside of the bent portion, as follows: For round bars under 2 sq. in. in section, flat on itself; for round bars 2 sq. in. or over in section and for all flat bars, around a pin the diameter of which is equal to the diameter or thickness of the specimen.

(c) **Nick-bend Tests.**—The test specimen, when nicked 25 per cent around for round bars, and along one side for flat bars, with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter or thickness of the specimen, and broken, shall not show more than 10 per cent of the fractured surface to be crystallin.

(d) Bend tests may be made by pressure or by blows.
7. The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to be free from steel.

8. (a) Tension and bend test specimens shall be of the full section of material as rolled, if possible. Otherwise, the speci-

Table I.—Standard Limit Gages.

<table>
<thead>
<tr>
<th>Nominal Diameter of Bars, in.</th>
<th>Large Size, +End, in.</th>
<th>Small Size, −End, in.</th>
<th>Total Variation, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8</td>
<td>0.2550</td>
<td>0.2450</td>
<td>0.010</td>
</tr>
<tr>
<td>5/32</td>
<td>0.3150</td>
<td>0.3070</td>
<td>0.011</td>
</tr>
<tr>
<td>3/16</td>
<td>0.3810</td>
<td>0.3690</td>
<td>0.012</td>
</tr>
<tr>
<td>7/32</td>
<td>0.4440</td>
<td>0.4310</td>
<td>0.013</td>
</tr>
<tr>
<td>1/4</td>
<td>0.5070</td>
<td>0.4930</td>
<td>0.014</td>
</tr>
<tr>
<td>9/32</td>
<td>0.5700</td>
<td>0.5550</td>
<td>0.015</td>
</tr>
<tr>
<td>5/16</td>
<td>0.6330</td>
<td>0.6170</td>
<td>0.016</td>
</tr>
<tr>
<td>3/8</td>
<td>0.7385</td>
<td>0.7415</td>
<td>0.017</td>
</tr>
<tr>
<td>7/32</td>
<td>0.8840</td>
<td>0.8660</td>
<td>0.018</td>
</tr>
<tr>
<td>1/2</td>
<td>1.0065</td>
<td>0.9905</td>
<td>0.019</td>
</tr>
<tr>
<td>11/2</td>
<td>1.1350</td>
<td>1.1150</td>
<td>0.020</td>
</tr>
<tr>
<td>11/4</td>
<td>1.2935</td>
<td>1.2395</td>
<td>0.021</td>
</tr>
<tr>
<td>13/8</td>
<td>1.3800</td>
<td>1.3640</td>
<td>0.022</td>
</tr>
<tr>
<td>13/4</td>
<td>1.5115</td>
<td>1.4885</td>
<td>0.023</td>
</tr>
<tr>
<td>17/8</td>
<td>1.6370</td>
<td>1.6130</td>
<td>0.024</td>
</tr>
<tr>
<td>15/4</td>
<td>1.7625</td>
<td>1.7375</td>
<td>0.025</td>
</tr>
<tr>
<td>17/8</td>
<td>1.8880</td>
<td>1.8620</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Round bars 2 in. in diameter and over shall be rolled to nominal diameter.

9. (a) All bars of one size shall be piled separately. One

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1 A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.
bar from each 100 or fraction thereof will be selected at random and tested as specified.

(b) If any test specimen from the bar originally selected to represent a lot of material, contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, one retest from a different bar will be allowed.

III. PERMISSIBLE VARIATIONS IN GAGE.

10. (a) Round bars shall conform to the standard limit gages adopted by the Master Car Builders’ Association, as given in Table I.¹

(b) The width or thickness of flat bars shall not vary more than 2 per cent from that specified.

IV. FINISH.

11. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends, and evidences of being burnt.

V. INSPECTION AND REJECTION.

12. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

13. All bars of one size will be rejected if the test specimens representing that size do not conform to the requirements specified.

¹ Adopted by the Master Car Builders’ Association in 1883 and revised in 1911. See Proceedings, Master Car Builders’ Assoc., Vol. 49, Part 2, pp. 956-957 (1915).
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STANDARD SPECIFICATIONS
FOR
WROUGHT-IRON PLATES.

The specifications for this material are issued under the fixed designation A 42; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913.

Classes.

1. These specifications cover two classes of wrought-iron plates, namely:
   Class A, as defined in Section 2 (b);
   Class B, as defined in Section 2 (c).

I. MANUFACTURE.

Process.

2. (a) All plates shall be rolled from piles entirely free from any admixture of steel.
   (b) Piles for Class A plates shall be made from puddle bars made wholly from pig iron and such scrap as emanates from rolling the plates.
   (c) Piles for Class B plates shall be made from puddle bars made wholly from pig iron or from a mixture of pig iron and cast-iron scrap, together with wrought-iron scrap.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

3. (a) The plates shall conform to the following minimum requirements as to tensile properties:

(326)
(b) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed $1\frac{1}{2}$ in. per minute.

4. For plates under $\frac{7}{16}$ in. in thickness, a deduction of 1 from the percentages of elongation specified in Section 3 shall be made for each decrease of $\frac{1}{16}$ in. in thickness below $\frac{7}{16}$ in.

5. (a) Cold-bend Tests.—The test specimen shall bend cold through 90 deg. without fracture on the outside of the bent portion, as follows: For Class A plates, around a pin the diameter of which is equal to $1\frac{1}{2}$ times the thickness of the specimen; and for Class B plates, around a pin the diameter of which is equal to 3 times the thickness of the specimen.

(b) Nick-bend Tests.—The test specimen, when nicked on one side and broken, shall show for Class A plates a wholly fibrous fracture, and for Class B plates, not more than 10 per cent of the fractured surface to be crystallin.

6. Tension and bend test specimens shall be taken from the finished plates and shall be of the full thickness of plates as rolled. The longitudinal axis of the specimen shall be parallel to the direction in which the plates are rolled.

7. (a) One tension, one cold-bend and one nick-bend test shall be made for each variation in thickness of $\frac{3}{8}$ in. and not less than one test for every ten plates as rolled.

(b) If any test specimen fails to conform to the requirements specified through an apparent local defect, a retest shall be taken; and should the retest fail, the plates represented by such test shall be rejected.

III. FINISH.

8. The plates shall be straight, smooth and free from cinder spots and holes, and free from injurious flaws, buckles, blisters, seams and laminations.
IV. INSPECTION.

9. (a) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the plates are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of plates at his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.
STANDARD SPECIFICATIONS
FOR
IRON AND STEEL CHAIN.


The specifications for this material are issued under the fixed designation A 56; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

1. (a) These specifications cover two classes of iron and one class of steel chain.

Class A, wrought-iron chain, is of the quality generally sold under the trade designation of “Crane Chain”;

Class B, wrought-iron or steel chain, is of the quality generally sold under the trade designation of “Ordinary Coil Chain.”

(b) The purposes for which these classes are generally used are as follows:

Class A, for slings, railway cranes, hoists and other places where a failure would imperil human life;

Class B, for ordinary service.

I. MATERIAL AND MANUFACTURE.

2. (a) Class A, Iron Chain, shall be manufactured from wrought iron which has been made wholly from puddled iron, free from any admixture of steel or scrap containing steel.
(b) Class B, Iron Chain, shall be manufactured from a grade of wrought iron conforming to the requirements of the Standard Specifications for Refined Wrought-Iron Bars (Serial Designation: A 41), of the American Society for Testing Materials.

(c) Class B, Steel Chain, shall be manufactured from steel made by the open-earth process, which shall be ductile and of satisfactory welding quality.

II. CHEMICAL PROPERTIES AND TESTS.

3. The wrought iron and steel used in the manufacture of chain of the respective classes referred to in this paragraph shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Chemical Composition</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese, not over</td>
<td></td>
<td>not over 0.05 per cent</td>
</tr>
<tr>
<td>Phosphorus.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur.</td>
<td></td>
<td>“ 0.05 “</td>
</tr>
</tbody>
</table>

4. (a) Analyses may be made by the purchaser from finished chain, which shall conform to the requirements specified in Section 3.

(b) Drillings for analysis shall be taken with a drill the diameter of which is approximately one-half the diameter of the bar from which drillings are being taken, and the cuttings shall be taken through the bar from surface to surface.

III. PHYSICAL PROPERTIES AND TESTS.

5. (a) All chain shall be proof-tested by subjecting it to the loads shown in Table I, and when so tested it shall stand these loads without showing any defects.

(b) When requested, the manufacturer shall furnish a certificate of proof-test to the purchaser or his representative.

6. Samples from finished chain shall conform to the minimum requirements as to tensile properties specified in Table II, the elongation being determined in a gage length of from 12 to 18 in., to the nearest link.
7. Tension test specimens shall consist of a length not less than 2 ft. cut from the finished chain.

8. One tension test shall be made to represent each 200 ft. Number of Tests, or fraction thereof ordered.

<table>
<thead>
<tr>
<th>Diameter of Bar, in.</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>1550</td>
<td>1500</td>
</tr>
<tr>
<td>5/16</td>
<td>2900</td>
<td>2400</td>
</tr>
<tr>
<td>3/8</td>
<td>4100</td>
<td>3400</td>
</tr>
<tr>
<td>7/16</td>
<td>5600</td>
<td>4700</td>
</tr>
<tr>
<td>1/2</td>
<td>7300</td>
<td>6100</td>
</tr>
<tr>
<td>9/16</td>
<td>9200</td>
<td>7800</td>
</tr>
<tr>
<td>5/8</td>
<td>11500</td>
<td>9600</td>
</tr>
<tr>
<td>11/16</td>
<td>13400</td>
<td>11600</td>
</tr>
<tr>
<td>3/4</td>
<td>16500</td>
<td>13800</td>
</tr>
<tr>
<td>13/16</td>
<td>19400</td>
<td>15800</td>
</tr>
<tr>
<td>7/8</td>
<td>22500</td>
<td>18800</td>
</tr>
<tr>
<td>15/16</td>
<td>25800</td>
<td>21200</td>
</tr>
<tr>
<td>1</td>
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<td>24500</td>
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<tr>
<td>11/16</td>
<td>33200</td>
<td>27600</td>
</tr>
<tr>
<td>13/16</td>
<td>37200</td>
<td>31000</td>
</tr>
<tr>
<td>1/4</td>
<td>46000</td>
<td>38300</td>
</tr>
<tr>
<td>3/8</td>
<td>56000</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>66200</td>
<td></td>
</tr>
<tr>
<td>5/8</td>
<td>69100</td>
<td></td>
</tr>
<tr>
<td>13/32</td>
<td>82500</td>
<td></td>
</tr>
<tr>
<td>7/16</td>
<td>95000</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>108000</td>
<td></td>
</tr>
</tbody>
</table>

9. If the tension test fails to conform to the requirements specified in Section 6, two additional tension tests may be made, each of which shall meet the requirements of Section 6.
IV. STANDARD WEIGHTS AND DIMENSIONS.

10. (a) The nominal weights and maximum lengths of 100 links for chain of various sizes are given in Table III.

(b) The weight of the chain shall not vary more than 3 per cent over nor more than 5 per cent under the nominal weight specified in Table III. Excess weight over the permissible variation of 3 per cent will not be paid for.

<table>
<thead>
<tr>
<th>Diameter of Bar, in.</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>3700</td>
<td>15</td>
</tr>
<tr>
<td>5/16</td>
<td>5800</td>
<td>15</td>
</tr>
<tr>
<td>7/32</td>
<td>8200</td>
<td>15</td>
</tr>
<tr>
<td>1/4</td>
<td>11200</td>
<td>15</td>
</tr>
<tr>
<td>3/6</td>
<td>14600</td>
<td>15</td>
</tr>
<tr>
<td>1/2</td>
<td>18400</td>
<td>15</td>
</tr>
<tr>
<td>11/6</td>
<td>23000</td>
<td>15</td>
</tr>
<tr>
<td>5/8</td>
<td>26800</td>
<td>15</td>
</tr>
<tr>
<td>3/4</td>
<td>33000</td>
<td>15</td>
</tr>
<tr>
<td>13/6</td>
<td>38800</td>
<td>15</td>
</tr>
<tr>
<td>7/8</td>
<td>45000</td>
<td>15</td>
</tr>
<tr>
<td>15/16</td>
<td>51600</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>58800</td>
<td>15</td>
</tr>
<tr>
<td>11/6</td>
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<td>15</td>
</tr>
<tr>
<td>11/8</td>
<td>74400</td>
<td>15</td>
</tr>
<tr>
<td>11/4</td>
<td>92000</td>
<td>15</td>
</tr>
<tr>
<td>13/8</td>
<td>112000</td>
<td>15</td>
</tr>
<tr>
<td>13/6</td>
<td>132400</td>
<td>15</td>
</tr>
<tr>
<td>15/8</td>
<td>138200</td>
<td>15</td>
</tr>
<tr>
<td>15/4</td>
<td>165000</td>
<td>15</td>
</tr>
<tr>
<td>17/8</td>
<td>180000</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>216000</td>
<td>15</td>
</tr>
</tbody>
</table>
(c) The length shall be measured after the chain has been proof-tested, and shall be measured to the inside of the end links.

(d) In determining the length of the chain, a load not exceeding 10 per cent of the proof load specified in Table I shall be applied to take up the slack.

**Table III.**

<table>
<thead>
<tr>
<th>Diameter of Bar, in.</th>
<th>Class A</th>
<th>Class B</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>88</td>
<td>102</td>
<td>83</td>
<td>75</td>
</tr>
<tr>
<td>5/16</td>
<td>100</td>
<td>114.7</td>
<td>125</td>
<td>110</td>
</tr>
<tr>
<td>3/8</td>
<td>113</td>
<td>125</td>
<td>175</td>
<td>165</td>
</tr>
<tr>
<td>7/16</td>
<td>125</td>
<td>137.5</td>
<td>220</td>
<td>205</td>
</tr>
<tr>
<td>1/2</td>
<td>140</td>
<td>150</td>
<td>280</td>
<td>265</td>
</tr>
<tr>
<td>1/8</td>
<td>150</td>
<td>166</td>
<td>360</td>
<td>325</td>
</tr>
<tr>
<td>1/16</td>
<td>170</td>
<td>176</td>
<td>450</td>
<td>425</td>
</tr>
<tr>
<td>1/4</td>
<td>185</td>
<td>195</td>
<td>540</td>
<td>520</td>
</tr>
<tr>
<td>5/8</td>
<td>200</td>
<td>213</td>
<td>625</td>
<td>610</td>
</tr>
<tr>
<td>1/8</td>
<td>213</td>
<td>225</td>
<td>745</td>
<td>725</td>
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<tr>
<td>1/4</td>
<td>225</td>
<td>238</td>
<td>850</td>
<td>810</td>
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<td>238</td>
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<td>960</td>
<td>925</td>
</tr>
<tr>
<td>1/4</td>
<td>250</td>
<td>263</td>
<td>1075</td>
<td>1025</td>
</tr>
<tr>
<td>1/2</td>
<td>265</td>
<td>295</td>
<td>1340</td>
<td>1225</td>
</tr>
<tr>
<td>5/8</td>
<td>290</td>
<td>325</td>
<td>1410</td>
<td>1350</td>
</tr>
<tr>
<td>3/4</td>
<td>315</td>
<td>353.5</td>
<td>1750</td>
<td>1650</td>
</tr>
<tr>
<td>1/2</td>
<td>355</td>
<td></td>
<td>2100</td>
<td></td>
</tr>
<tr>
<td>7/8</td>
<td>390</td>
<td></td>
<td>2450</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>425</td>
<td></td>
<td>2875</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>475</td>
<td></td>
<td>3200</td>
<td></td>
</tr>
<tr>
<td>7/8</td>
<td>525</td>
<td></td>
<td>3640</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>575</td>
<td></td>
<td>4200</td>
<td></td>
</tr>
</tbody>
</table>

**V. WORKMANSHIP AND FINISH.**

11. (a) The chain shall be free from injurious defects and shall have a workmanlike finish. The diameter at the welds shall not be perceptibly less than the diameter of the bar and,
Specifications for Iron and Steel Chain.

unless otherwise specified, shall not exceed the diameter of the bar by more than 25 per cent.

(b) Prior to testing and inspection the chain shall be free from paint or any other coating which would tend to conceal defects.

VI. INSPECTION AND REJECTION.

12. (a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

(b) The purchaser may make the tests to govern the acceptance of the material at his own laboratory, or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

13. Unless otherwise specified, any rejection based on tests made in accordance with Section 12 (b) shall be reported within five working days from receipt of samples.
STANDARD SPECIFICATIONS
FOR
FOUNDRY PIG IRON.¹

Serial Designation: A 43-09.

The specifications for this material are issued under the fixed designation A 43; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1904; REVISED, 1909.

PERCENTAGES AND VARIATIONS.

In order that there may be uniformity in grading, the following percentages and variations shall be used.²

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.04</td>
<td>Sa</td>
</tr>
<tr>
<td>1.50</td>
<td>0.05</td>
<td>Se</td>
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<td>0.06</td>
<td>Si</td>
</tr>
<tr>
<td>2.50</td>
<td>0.07</td>
<td>So</td>
</tr>
<tr>
<td>3.00</td>
<td>0.08</td>
<td>Su</td>
</tr>
<tr>
<td>3.50</td>
<td>0.09</td>
<td>Sy</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>Sh</td>
</tr>
</tbody>
</table>

(0.25 allowed either way.) (Maximum.) (Minimum.)

¹ It is recommended that foundry pig iron be bought by analysis, and that when so bought these Standard Specifications be used.

² These specifications do not advise that all five elements be specified in all contracts for pig iron, but do recommend that when these elements are specified, the given percentages shall be used.
Specifications for Foundry Pig Iron.

**Manganese.**

<table>
<thead>
<tr>
<th>Per cent.</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20</td>
<td>Ma</td>
</tr>
<tr>
<td>0.40</td>
<td>Me</td>
</tr>
<tr>
<td>0.60</td>
<td>Mi</td>
</tr>
<tr>
<td>0.80</td>
<td>Mo</td>
</tr>
<tr>
<td>1.00</td>
<td>Mu</td>
</tr>
<tr>
<td>1.25</td>
<td>My</td>
</tr>
<tr>
<td>1.50</td>
<td>Mh</td>
</tr>
</tbody>
</table>

**Phosphorus.**

<table>
<thead>
<tr>
<th>Per cent.</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20</td>
<td>Pa</td>
</tr>
<tr>
<td>0.40</td>
<td>Pe</td>
</tr>
<tr>
<td>0.60</td>
<td>Pi</td>
</tr>
<tr>
<td>0.80</td>
<td>Po</td>
</tr>
<tr>
<td>1.00</td>
<td>Pu</td>
</tr>
<tr>
<td>1.25</td>
<td>Py</td>
</tr>
<tr>
<td>1.50</td>
<td>Ph</td>
</tr>
</tbody>
</table>

(0.20 allowed either way.)  (0.15 allowed either way.)

Illustration of the use of above coding: The word Li-se-ca-mo-pi indicates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>0.05</td>
<td>3.00</td>
<td>0.80</td>
<td>0.60</td>
</tr>
</tbody>
</table>

with variations as allowed.

Percentages of any element specified half way between the above shall be designated by the addition of the letter X to the next lower symbol.

Example.—PeX indicates Phosphorus 0.50 with "allowed" variations (0.15) up and down.

In the case of phosphorus and manganese, the percentages may be used as maximum or minimum figures, but unless so specified they will be considered to include the variations above given.

**Sampling and Analysis.**

Each car load, or its equivalent, shall be considered as a unit in sampling.

One sample shall be taken to every four tons in the car, and shall be so chosen from different parts of the car as to represent as nearly as possible the average quality of the iron.

Drillings shall be taken so as to fairly represent the composition of the pig as cast.

An equal weight of the drillings from each pig shall be thoroughly mixed to make up the sample for analysis.

In case of dispute, the sampling and analysis shall be made by an independent chemist, mutually agreed upon, if practicable, at the time the contract is made.

It is recommended that the standard methods of the American Foundrymen's Association be used for analysis.
Gravimetric methods shall be used for the analysis of sulfur, unless otherwise specified in the contract.

The cost of re-sampling and re-analysis shall be borne by the party in error.

**Base or Quoting Price.**

For market quotations, an iron of 2.00 per cent in silicon (with variations of 0.25 either way) and 0.05 per cent in sulfur (maximum) shall be taken as the base.

**The American Foundrymen's Association Suggests the Following Clauses, for the Purpose of Adjusting Disputes Between Buyer and Seller.**

*Base Table.*—The following table may be filled out, and may become a part of the contract. "B," or Base, represents the price agreed upon for a pig iron running 2.00 per cent in silicon (with allowed variation of 0.25 either way) and under 0.05 per cent in sulfur; "C" is a constant differential to be determined at the time the contract is made.

This table is for settling any differences which may arise in filling a contract, as explained under penalties and allowances, and may be used to regulate the price of a grade of pig iron which the purchaser desires, and the seller agrees, to substitute for the one originally specified.

Silicon percentages allow 0.25 variation either way. Sulfur percentages are maximum.

**Sulfur, per cent.**

<table>
<thead>
<tr>
<th>Sulfur, per cent.</th>
<th>Silicon, per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.25</td>
</tr>
<tr>
<td>0.04   °C</td>
<td>B+6C</td>
</tr>
<tr>
<td>0.05   °C</td>
<td>B+5C</td>
</tr>
<tr>
<td>0.06   °C</td>
<td>B+4C</td>
</tr>
<tr>
<td>0.07   °C</td>
<td>B+3C</td>
</tr>
<tr>
<td>0.08   °C</td>
<td>B+2C</td>
</tr>
<tr>
<td>0.09   °C</td>
<td>B+1C</td>
</tr>
<tr>
<td>0.10   °C</td>
<td>B</td>
</tr>
</tbody>
</table>

**Penalties.—** In case the iron, when delivered, does not conform to the specifications, the buyer shall have the option of either refusing the iron, or accepting it on the basis shown in the
above table, which must be filled out at the time the contract is made.

*Allowances.*—In case the furnace cannot, for any good reason, deliver the iron as specified at the time delivery is due, the purchaser may at his option accept any other analysis which the furnace can deliver, the price to be determined by the base table above, which must be filled out at the time the contract is made.
STANDARD SPECIFICATIONS
FOR
CAST-IRON PIPE AND SPECIAL CASTINGS.

Serial Designation: A 44–04.

The specifications for this material are issued under the fixed designation A 44: the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1904.

DESCRIPTION OF PIPES.

SECTION 1. The pipes shall be made with hub and spigot joints, and shall accurately conform to the dimensions given in Tables I and II. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 ft. in length, exclusive of socket. For pipes of each size from 4 in. to 24 in., inclusive, there shall be two standards of outside diameter, and for pipes from 30 in. to 60 in., inclusive, there shall be four standards of outside diameter, as shown by Table II.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of about 6 in. from each end of the pipe so as to obtain the required standard thickness and weight for each size and class of pipe.

Pipes whose standard thickness and weight are intermediate
### Table I.—General Dimensions of Pipes.

<table>
<thead>
<tr>
<th>Nominal Diam., in.</th>
<th>Classes</th>
<th>Actual Outside Diam., in.</th>
<th>Diam. of Sockets, Pipe, in.</th>
<th>Special Castings, Pipe, in.</th>
<th>Depth of Sockets, Special Castings, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Special Castings</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>A—B</td>
<td>4.80</td>
<td>5.60</td>
<td>3.70</td>
<td>3.50</td>
</tr>
<tr>
<td>5</td>
<td>C—D</td>
<td>5.00</td>
<td>5.80</td>
<td>5.70</td>
<td>3.50</td>
</tr>
<tr>
<td>6</td>
<td>A—B</td>
<td>6.90</td>
<td>7.70</td>
<td>7.80</td>
<td>3.50</td>
</tr>
<tr>
<td>6</td>
<td>C—D</td>
<td>7.10</td>
<td>7.90</td>
<td>7.80</td>
<td>3.50</td>
</tr>
<tr>
<td>8</td>
<td>A—B</td>
<td>9.05</td>
<td>9.85</td>
<td>10.00</td>
<td>4.00</td>
</tr>
<tr>
<td>8</td>
<td>C—D</td>
<td>9.30</td>
<td>10.10</td>
<td>10.00</td>
<td>4.00</td>
</tr>
<tr>
<td>10</td>
<td>A—B</td>
<td>11.10</td>
<td>11.90</td>
<td>12.10</td>
<td>4.00</td>
</tr>
<tr>
<td>10</td>
<td>C—D</td>
<td>11.40</td>
<td>12.20</td>
<td>12.10</td>
<td>4.00</td>
</tr>
<tr>
<td>12</td>
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<td>14.00</td>
<td>14.20</td>
<td>4.00</td>
</tr>
<tr>
<td>12</td>
<td>C—D</td>
<td>13.50</td>
<td>14.30</td>
<td>14.20</td>
<td>4.00</td>
</tr>
<tr>
<td>14</td>
<td>A—B</td>
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<td>16.10</td>
<td>16.10</td>
<td>4.00</td>
</tr>
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<td>16.45</td>
<td>4.00</td>
</tr>
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<td>16</td>
<td>A—B</td>
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<td>18.40</td>
<td>18.40</td>
<td>4.00</td>
</tr>
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<td>16</td>
<td>C—D</td>
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<td>18.80</td>
<td>18.80</td>
<td>4.00</td>
</tr>
<tr>
<td>18</td>
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<td>20.50</td>
<td>20.50</td>
<td>4.00</td>
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<td>20.92</td>
<td>20.92</td>
<td>4.00</td>
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<tr>
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<td>A—B</td>
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<td>22.60</td>
<td>22.60</td>
<td>4.00</td>
</tr>
<tr>
<td>20</td>
<td>C—D</td>
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<td>23.06</td>
<td>23.06</td>
<td>4.00</td>
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<td>24</td>
<td>A—B</td>
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<td>26.80</td>
<td>26.80</td>
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<td>24</td>
<td>C—D</td>
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<td>27.32</td>
<td>27.32</td>
<td>4.00</td>
</tr>
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<td>32.74</td>
<td>32.74</td>
<td>4.50</td>
</tr>
<tr>
<td>30</td>
<td>B</td>
<td>32.00</td>
<td>33.00</td>
<td>33.00</td>
<td>4.50</td>
</tr>
<tr>
<td>30</td>
<td>C</td>
<td>32.40</td>
<td>33.40</td>
<td>33.40</td>
<td>4.50</td>
</tr>
<tr>
<td>30</td>
<td>D</td>
<td>32.74</td>
<td>33.74</td>
<td>33.74</td>
<td>4.50</td>
</tr>
<tr>
<td>36</td>
<td>A</td>
<td>37.96</td>
<td>38.96</td>
<td>38.96</td>
<td>4.50</td>
</tr>
<tr>
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<td>39.30</td>
<td>39.30</td>
<td>4.50</td>
</tr>
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<td>C</td>
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<td>39.70</td>
<td>39.70</td>
<td>4.50</td>
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<td>40.16</td>
<td>40.16</td>
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<td>42</td>
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<td>45.20</td>
<td>45.20</td>
<td>5.00</td>
</tr>
<tr>
<td>42</td>
<td>B</td>
<td>44.55</td>
<td>45.50</td>
<td>45.50</td>
<td>5.00</td>
</tr>
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<td>C</td>
<td>45.10</td>
<td>46.10</td>
<td>46.10</td>
<td>5.00</td>
</tr>
<tr>
<td>42</td>
<td>D</td>
<td>45.58</td>
<td>46.58</td>
<td>46.58</td>
<td>5.00</td>
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<tr>
<td>48</td>
<td>A</td>
<td>50.50</td>
<td>51.50</td>
<td>51.50</td>
<td>5.00</td>
</tr>
</tbody>
</table>
between the classes in Table II shall be made of the same outside diameter as the next heavier class. Pipes whose standard thickness and weight are less than shown by Table II shall be made of the same outside diameter as the Class A pipes, and pipes whose thickness and weight are more than shown by Table II shall be made of the same outside diameter as the Class D pipes.

For pipes 4 in. to 12 in., inclusive, one class of special castings shall be furnished, made from Class D pattern. Those having spigot ends shall have outside diameters of spigot ends midway between the two standards of outside diameter as shown by Table II, and shall be tapered back for a distance of 6 in. For pipes from 14 in. to 24 in., inclusive, two classes of special castings shall be furnished, Class B special castings with Classes A and B pipes, and Class D special castings with Classes C and D pipes, the former to be stamped “AB” and the latter to be stamped “CD.” For pipes 30 in. to 60 in., inclusive, four classes of special castings shall be furnished, one for each class of pipe, and shall be stamped with the letter of the class to which they belong.

**Allowable Variation in Diameter of Pipes and Sockets.**

**Section 2.** Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in
<table>
<thead>
<tr>
<th>Nominal Inside Diameter, in.</th>
<th>Thickness, in.</th>
<th>Weight per Foot</th>
<th>Length</th>
<th>Thickness, in.</th>
<th>Weight per Foot</th>
<th>Length</th>
<th>Thickness, in.</th>
<th>Weight per Foot</th>
<th>Length</th>
<th>Thickness, in.</th>
<th>Weight per Foot</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A, 100 FT. HEAD, 43 LB. PRESSURE</td>
<td></td>
<td></td>
<td></td>
<td>Class B, 200 FT. HEAD, 86 LB. PRESSURE</td>
<td></td>
<td></td>
<td></td>
<td>Class C, 300 FT. HEAD, 130 LB. PRESSURE</td>
<td></td>
<td></td>
<td></td>
<td>Class D, 400 FT. HEAD, 173 LB. PRESSURE</td>
</tr>
<tr>
<td>Nominal Inside Diameter, in.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.42</td>
<td>20.0</td>
<td>240</td>
<td>0.45</td>
<td>21.7</td>
<td>260</td>
<td>0.48</td>
<td>23.3</td>
<td>250</td>
<td>0.52</td>
<td>25.0</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>0.44</td>
<td>20.8</td>
<td>270</td>
<td>0.48</td>
<td>33.3</td>
<td>400</td>
<td>0.51</td>
<td>35.8</td>
<td>430</td>
<td>0.55</td>
<td>38.3</td>
<td>460</td>
</tr>
<tr>
<td>8</td>
<td>0.46</td>
<td>42.9</td>
<td>515</td>
<td>0.51</td>
<td>47.5</td>
<td>570</td>
<td>0.56</td>
<td>52.1</td>
<td>625</td>
<td>0.60</td>
<td>55.8</td>
<td>670</td>
</tr>
<tr>
<td>10</td>
<td>0.50</td>
<td>47.1</td>
<td>685</td>
<td>0.57</td>
<td>63.8</td>
<td>765</td>
<td>0.62</td>
<td>70.8</td>
<td>830</td>
<td>0.68</td>
<td>76.7</td>
<td>920</td>
</tr>
<tr>
<td>12</td>
<td>0.54</td>
<td>72.5</td>
<td>870</td>
<td>0.62</td>
<td>82.1</td>
<td>955</td>
<td>0.68</td>
<td>91.7</td>
<td>1100</td>
<td>0.75</td>
<td>100.0</td>
<td>1200</td>
</tr>
<tr>
<td>14</td>
<td>0.57</td>
<td>89.6</td>
<td>1075</td>
<td>0.66</td>
<td>102.5</td>
<td>1230</td>
<td>0.74</td>
<td>116.7</td>
<td>1400</td>
<td>0.82</td>
<td>129.2</td>
<td>1550</td>
</tr>
<tr>
<td>16</td>
<td>0.60</td>
<td>108.3</td>
<td>1300</td>
<td>0.70</td>
<td>125.0</td>
<td>1500</td>
<td>0.80</td>
<td>143.8</td>
<td>1725</td>
<td>0.89</td>
<td>158.3</td>
<td>1900</td>
</tr>
<tr>
<td>18</td>
<td>0.64</td>
<td>129.2</td>
<td>1550</td>
<td>0.75</td>
<td>150.0</td>
<td>1800</td>
<td>0.87</td>
<td>173.0</td>
<td>2100</td>
<td>0.96</td>
<td>191.7</td>
<td>2300</td>
</tr>
<tr>
<td>20</td>
<td>0.67</td>
<td>150.0</td>
<td>1800</td>
<td>0.80</td>
<td>175.0</td>
<td>2100</td>
<td>0.92</td>
<td>208.3</td>
<td>2500</td>
<td>1.03</td>
<td>229.2</td>
<td>2750</td>
</tr>
<tr>
<td>24</td>
<td>0.76</td>
<td>204.2</td>
<td>2450</td>
<td>0.89</td>
<td>233.5</td>
<td>2800</td>
<td>1.04</td>
<td>279.2</td>
<td>3350</td>
<td>1.16</td>
<td>306.7</td>
<td>3680</td>
</tr>
<tr>
<td>30</td>
<td>0.88</td>
<td>291.7</td>
<td>3500</td>
<td>1.03</td>
<td>333.3</td>
<td>4000</td>
<td>1.20</td>
<td>400.0</td>
<td>4500</td>
<td>1.37</td>
<td>450.0</td>
<td>5400</td>
</tr>
<tr>
<td>36</td>
<td>0.99</td>
<td>391.7</td>
<td>4700</td>
<td>1.15</td>
<td>454.2</td>
<td>5450</td>
<td>1.36</td>
<td>545.8</td>
<td>6550</td>
<td>1.58</td>
<td>625.0</td>
<td>7500</td>
</tr>
<tr>
<td>42</td>
<td>1.10</td>
<td>512.5</td>
<td>6150</td>
<td>1.28</td>
<td>591.7</td>
<td>7100</td>
<td>1.54</td>
<td>716.7</td>
<td>8600</td>
<td>1.78</td>
<td>825.0</td>
<td>9900</td>
</tr>
<tr>
<td>48</td>
<td>1.26</td>
<td>666.7</td>
<td>8000</td>
<td>1.42</td>
<td>750.0</td>
<td>9000</td>
<td>1.71</td>
<td>908.3</td>
<td>10900</td>
<td>1.96</td>
<td>1050.0</td>
<td>12600</td>
</tr>
<tr>
<td>54</td>
<td>1.55</td>
<td>800.0</td>
<td>9600</td>
<td>1.55</td>
<td>933.3</td>
<td>11200</td>
<td>1.90</td>
<td>1141.7</td>
<td>13700</td>
<td>2.23</td>
<td>1341.7</td>
<td>16100</td>
</tr>
<tr>
<td>60</td>
<td>1.39</td>
<td>916.7</td>
<td>11000</td>
<td>1.67</td>
<td>1104.2</td>
<td>13250</td>
<td>2.00</td>
<td>1341.7</td>
<td>16100</td>
<td>2.38</td>
<td>1583.3</td>
<td>19000</td>
</tr>
</tbody>
</table>

The above weights are for 12 ft. laying lengths and standard sockets; proportionate allowance to be made for any variation therefrom.
Serial Designation: A 44 - 04.

joint room from any cause. The diameters of the sockets and the outside diameters of the bead ends of the pipes shall not vary from the standard dimensions by more than 0.06 in. for pipes 16 in. or less in diameter; 0.08 in. for 18-in., 20-in. and 24-in. pipes; 0.10 in. for 30-in., 36-in. and 42-in. pipes; 0.12 in. for 48-in. pipes; and 0.15 in. for 54-in. and 60-in. pipes.

Allowable Variation in Thickness.

Section 3. For pipes whose standard thickness is less than 1 in., the thickness of metal in the body of the pipe shall not be more than 0.08 in. less than the standard thickness; and for pipes whose standard thickness is 1 in. or more, the variation shall not exceed 0.10 in., except that for spaces not exceeding 8 in. in length in any direction, variations from the standard thickness of 0.02 in. in excess of the allowance above given shall be permitted.

For special castings of standard patterns a variation of 50 per cent greater than allowed for straight pipe shall be permitted.

Defective Spigots May be Cut.

Section 4. Defective spigot ends on pipes 12 in. or more in diameter may be cut off in a lathe, and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 ft. in length, exclusive of the socket.

In case the length of a pipe differs from 12 ft., the standard weight of the pipe given in Table II shall be modified in accordance therewith.

Special Castings.

Section 5. All special castings shall be made in accordance with the cuts and the dimensions given in the table forming a part of these specifications.

The diameters of the sockets and the external diameters of the bead ends of the special castings shall not vary from the standard dimensions by more than 0.12 in. for castings 16 in. or less in diameter; 0.15 in. for 18-in., 20-in. and 24-in. pipes; 0.20 in. for 30-in., 36-in. and 42-in. pipes; and 0.24 in. for 48-in.,
54-in. and 60-in. pipes. These variations apply only to special castings made from standard patterns.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The manufacturer shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans and made of the best quality of mild steel, with hexagonal heads and nuts and sound, well-fitting threads.

**Marking.**

**Section 6.** Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe and special casting larger than 4 in. may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

<table>
<thead>
<tr>
<th>1901</th>
<th>1901</th>
<th>1901</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall be not less than 2 in. in length and \( \frac{1}{8} \) in. in relief for pipes 8 in. in diameter and larger. For smaller sizes of pipes the letters may be 1 in. in length. The weight and the class letter shall be conspicuously painted in white on the inside of each pipe and special casting after the coating has become hard.

**Allowable Percentage of Variation in Weight.**

**Section 7.** No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipes 16 in. or less in diameter, and 4 per cent for pipes more than 16 in. in diameter; and no excess above the standard weight of more than the given percentages for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent.
No special casting shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent for pipes 12 in. or less in diameter, and 8 per cent for larger sizes, except that curves, Y-pieces and breeches pipe may be 12 per cent below the standard weight, and no excess above the standard weight of more than the above percentages for the several sizes will be paid for. These variations apply only to castings made from the standard patterns.

Quality of Iron.

Section 8. All pipes and special castings shall be made of cast iron of good quality, and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

Tests of Materials.

Section 9. Specimen bars of the metal used, each being 26 in. long by 2 in. wide and 1 in. thick, shall be made without charge as often as the engineer may direct, and, in default of definite instructions, the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flat-wise upon supports 24 in. apart and loaded in the center, shall, for pipes 12 in. or less in diameter, support a load of 1900 lb. and show a deflection of not less than 0.30 in. before breaking; and for pipes of sizes larger than 12 in., they shall support a load of 2000 lb. and show a deflection of not less than 0.32 in. The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

Casting of Pipes.

Section 10. The straight pipes shall be cast in dry sand molds in a vertical position. Pipes 16 in. or less in diameter
shall be cast with the hub end up or down, as specified in the proposal. Pipes 18 in. or more in diameter shall be cast with the hub end down.

The pipes shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

**Quality of Castings.**

**Section 11.** The pipes and special castings shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

**Cleaning and Inspection.**

**Section 12.** All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

**Coating.**

**Section 13.** Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300° F. immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300° F. (or less if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when
deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be re-coated shall first be thoroughly scraped and cleaned.

**HYDROSTATIC TEST.**

**SECTION 14.** When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressure to which the different sizes and classes of pipes shall be subjected are as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>20-In. Diameter Less than 20-In. Diameter, lb. per sq. in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A pipe</td>
<td>150</td>
</tr>
<tr>
<td>Class B pipe</td>
<td>200</td>
</tr>
<tr>
<td>Class C pipe</td>
<td>250</td>
</tr>
<tr>
<td>Class D pipe</td>
<td>300</td>
</tr>
</tbody>
</table>

**WEIGHING.**

**SECTION 15.** The pipes and special castings shall be weighed for payment under the supervision of the engineer after the application of the coal-tar pitch varnish. If desired by the engineer the pipes and special castings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made up on the basis of a ton of 2000 lb.

**CONTRACTOR TO FURNISH MEN AND MATERIALS.**

**SECTION 16.** The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipes and special castings; and, should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made
as specified, this statement to contain the results of the tests upon the test bars.

**Power of Engineer to Inspect.**

Section 17. The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting and coating of the pipes and special castings. The forms, sizes, uniformity and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipes or other castings which are not in conformity with the specifications or drawings.

**Inspector to Report.**

Section 18. The inspector at the foundry shall report daily to the foundry office all pipes and special castings rejected, with the causes for rejection.

**Castings to be Delivered Sound and Perfect.**

Section 19. All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other castings which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered until the final completion and adjustment of the contract, provided, however, that the contractor shall not be held liable for pipes or special castings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they receive the coating.

**Definition of the Word “Engineer.”**

Section 20. Wherever the word “engineer” is used herein, it shall be understood to refer to the engineer or inspector acting for the purchaser and to his properly authorized agents, limited by the particular duties intrusted to them.
STANDARD SPECIFICATIONS
FOR
CAST-IRON LOCOMOTIVE CYLINDERS.


The specifications for this material are issued under the fixed designation A 45; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1904; REVISED, 1911, 1914.

I. MANUFACTURE.
1. Locomotive cylinders shall be made from good quality, Process. close-grained gray iron cast in a dry mold.

II. CHEMICAL PROPERTIES AND TESTS.
2. Drilling taken from the fractured end of the transverse Chemical test bars shall conform to the following limits in chemical Composition:

   Phosphorus ..................... not over 0.90 per cent
   Sulfur ........................... " 0.12 "

3. A check analysis of drillings taken from the transverse Check test bar may be made by the purchaser, and shall conform to the requirements specified in Section 2.

III. PHYSICAL PROPERTIES AND TESTS.
4. When placed horizontally upon supports 12 in. apart Transverse and tested under a centrally applied load, the arbitration test Tests.
bars, specified in Section 6 (a), shall show an average transverse strength of not less than 3200 lb. and an average deflection of not less than 0.09 in.

**Chill Test.**

5. Before pouring, a sample of the iron shall be taken and chilled in a cast-iron mold, as specified in Section 6 (b). The sample shall be allowed to cool in the mold until it is dark red or almost black, when it may be knocked out and quenched in water. The sample, on being broken, shall show a close-grained gray iron, with a well-defined border of white iron at the bottom of the fracture. The depth of the white iron shall not be less than $\frac{3}{15}$ in. as measured at the center line.
6. (a) Arbitration Bar.—The mold for the bars is shown in Fig. 1. The bottom of the bar is $\frac{1}{8}$ in. smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask shall be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

(b) Chill Test.—The form and dimensions of the mold shall be in accordance with Fig. 2.

7. (a) Two arbitration test bars, cast as specified in Section 6 (a), shall be poured from each ladle of metal used for one or more cylinders.

(b) One chill test, cast as specified in Section 6 (b), shall be poured from each ladle of metal used for one or more cylin-
Character of Castings.

Character of Castings.

8. Cylinders shall be smooth, well-cleaned, free from shrinkage cracks and from other defects sufficiently extensive to impair the value of the castings, and shall finish to blue-print size.

V. MARKING.

Marking.

9. Each cylinder shall have cast on it, in raised letters, marks designating the maker, the date of casting, the serial and pattern numbers and other marks specified by the purchaser.

VI. INSPECTION AND REJECTION.

Inspection.

10. (a) The purchaser or his inspector shall be given a reasonable opportunity to enable him to witness the pouring of the cylinders and test specimens, as well as to be present when physical tests are made.

(b) In case the inspector is not present to witness the pouring of the castings and test specimens, the manufacturer will make all tests required by these specifications, and, upon demand, will furnish the purchaser with a copy of the results of his tests, and will hold the transverse and chill test specimens subject to examination by the inspector. The tests made by the manufacturer shall be considered final.

(c) All physical tests and inspection shall be made at the place of manufacture.

Rejection.

11. Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five working days from the receipt of samples.
STANDARD SPECIFICATIONS
FOR
CAST-IRON CAR WHEELS.

Serial Designation: A 46 – 05.

The specifications for this material are issued under the fixed designation A 46; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1905.

The wheels furnished under this specification must be made from the best materials, and in accordance with the best foundry methods. The following pattern analysis is given for information, as representing the chemical properties of a good cast-iron wheel. Successful wheels, varying in some of the constituents quite considerably from the figures given, may be made:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Carbon</td>
<td>3.50 per cent</td>
</tr>
<tr>
<td>Graphitic Carbon</td>
<td>2.90 &quot;</td>
</tr>
<tr>
<td>Combined Carbon</td>
<td>0.60 &quot;</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.70 &quot;</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.40 &quot;</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.50 &quot;</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.08 &quot;</td>
</tr>
</tbody>
</table>

1. Wheels will be inspected and tested at the place of manufacture.

2. All wheels must conform in general design and in measurements to drawings, which will be furnished, and any departure from the standard drawing must be by special permission in writing, and manufacturers wishing to deviate from the stand-
 Specifications for Car Wheels.

ard dimensions must submit duplicate drawings showing the proposed changes, which must be approved.

Drop Tests.

3. The following table gives data as to weight and tests of various kinds of wheels for different kinds of cars and service:

<table>
<thead>
<tr>
<th>Wheel Diameter</th>
<th>33-in. diameter Freight and Passenger cars.</th>
<th>36-in. diameter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kind of service</td>
<td>60,000 lb. capacity and less</td>
<td>70,000 lb. capacity.</td>
</tr>
<tr>
<td>Number............</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Desired...........</td>
<td>600</td>
<td>650</td>
</tr>
<tr>
<td>Weight Variation...</td>
<td>Two per cent either way.</td>
<td></td>
</tr>
<tr>
<td>Height of drop, ft</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Number of blows....</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Marking.

4. Each wheel must have plainly cast on the outside plate the name of the maker and place of manufacture. Each wheel must also have cast on the inside double plate the date of casting and a serial foundry number. The manufacturer must also provide for the guarantee mark, if so required by the contract. No wheel bearing a duplicate number, or a number which has once been passed upon, will be considered. Numbers of wheels once rejected will remain unfilled. No wheel bearing an indistinct number or date, or any evidence of an altered or defaced number will be considered.

Measures.

5. All wheels offered for inspection must have been measured with a standard tape measure and must have the shrinkage number stenciled in plain figures on the inside of the wheel. The standard tape measure must correspond in form and construction to the "Wheel Circumference Measure" established by the Master Car Builders' Association in 1900. The nomenclature of that measure need not, however, be followed, it being sufficient if the graduating marks indicating tape sizes are \( \frac{3}{8} \) in. apart. Any convenient method of showing the shrinkage or stencil number may be employed. Experience shows that standard tape measures elongate a little with use, and it is essential to have them frequently compared and rectified. When
ready for inspection, the wheels must be arranged in rows according to shrinkage numbers, all wheels of the same date being grouped together. Wheels bearing dates more than thirty days prior to the date of inspection will not be accepted for test, except by permission. For any single inspection and test only wheels having three consecutive shrinkage or stencil numbers will be considered. The manufacturer will, of course, decide what three shrinkage or stencil numbers he will submit in any given lot of 103 wheels offered, and the same three shrinkage or stencil numbers need not be offered each time.

6. The body of the wheels must be smooth and free from slag and blowholes, and the hubs must be solid. Wheels will not be rejected because of drawing around the center core. The tread and throat of the wheels must be smooth, free from deep and irregular wrinkles, slag, sand wash, chill cracks or swollen rims, and be free from any evidence of hollow rims, and the throat and tread must be practically free from sweat.

7. Wheels tested must show soft, clean, gray iron, free from defects, such as holes containing slag or dirt more than \( \frac{1}{4} \) in. in diameter, or clusters of such holes, honeycombing of iron in the hub, white iron in the plates or hub, or clear white iron around the anchors of chaplets at a greater distance than \( \frac{1}{2} \) in. in any direction. The depth of the clear white iron must not exceed \( \frac{7}{8} \) in. at the throat and 1 in. at the middle of the tread, nor must it be less than \( \frac{3}{8} \) in. at the throat or any part of the tread. The blending of the white iron with the gray iron behind must be without any distinct line of demarcation, and the iron must not have a mottled appearance in any part of the wheel at a greater distance than 1\( \frac{5}{8} \) in. from the tread or throat. The depth of chill will be determined by inspection of the three test wheels described below, all test wheels being broken for this purpose, if necessary. If one only of the three test wheels fails in limits of chill, all the lot under test of the same shrinkage or stencil number will be rejected and the test will be regarded as finished so far as this lot of 103 wheels is concerned. The manufacturer may, however, offer the wheels of the other two shrinkage or stencil numbers, provided they are acceptable in other respects as constituents of another 103 wheels for a subsequent test. If two of the three test wheels fail in limits of chill, the wheels in the
lot of 103 of the same shrinkage or stencil number as these two wheels will be rejected, and, as before, the test will be regarded as finished so far as this lot of 103 wheels is concerned. The manufacturer may, however, offer the wheels of the third shrinkage or stencil number, provided they are acceptable in other respects, as constituents of another 103 wheels for a subsequent test. If all three test wheels fail in limits of chill, of course the whole hundred will be rejected.

8. The manufacturer must notify when he is ready to ship not less than 100 wheels; must await the arrival of the inspector; must have a car, or cars, ready to be loaded with the wheels, and must furnish facilities and labor to enable the inspector to inspect, test, load and ship the wheels promptly. Wheels offered for inspection must not be covered with any substance which will hide defects.

9. A hundred or more wheels being ready for test, the inspector will make a list of the wheel numbers, at the same time examining each wheel for defects. Any wheels which fail to conform to specifications by reason of defects must be laid aside, and such wheels will not be accepted for shipment. As individual wheels are rejected, others of the proper shrinkage, or stencil number, may be offered to keep the number good.

10. The inspector will retape not less than 10 per cent of the wheels offered for test, and if he finds any showing wrong tape-marking, he will tape the whole lot and require them to be restenciled, at the same time having the old stencil marks obliterated. He will weigh and make check measurements of at least 10 per cent of the wheels offered for test, and if any of these wheels fail to conform to the specification, he will weigh and measure the whole lot, refusing to accept for shipment any wheels which fail in these respects.

11. Experience indicates that wheels with higher shrinkage or lower stencil numbers are more apt to fail on thermal test; more apt to fail on drop test, and more apt to exceed the maximum allowable chill than those with higher stencil or lower shrinkage numbers; while, on the other hand, wheels with higher stencil or lower shrinkage numbers are more apt to be deficient in chill. For each 103 wheels apparently acceptable, the inspector will select three wheels for test—one from each of the three shrinkage
or stencil numbers offered. One of these wheels chosen for this purpose by the inspector must be tested by drop test as follows: The wheel must be placed flange downward in an anvil block weighing not less than 1700 lb., set on rubble masonry 2 ft. deep and having three supports not more than 5 in. wide for the flange of the wheel to rest on. It must be struck centrally upon the hub by a weight of 200 lb., falling from a height as shown in the table in Section 3. The end of the falling weight must be flat, so as to strike fairly on the hub, and when by wear the bottom of the weight assumes a round or conical form, it must be replaced. The machine for making this test is shown on drawings which will be furnished. Should the wheel stand without breaking in two or more pieces, the number of blows, shown in the above table, the 100 wheels represented by it will be considered satisfactory as to this test. Should it fail, the whole hundred will be rejected.

12. The other two test wheels must be tested as follows: **Thermal Test.**
The wheels must be laid flange down in the sand, and a channel-way 1 1/2 in. in width at the center of the tread and 4 in. deep must be molded with green sand around the wheel. The clean tread of the wheel must form one side of this channelway, and the clean flange must form as much of the bottom as its width will cover. The channelway must then be filled to the top from one ladle with molten cast iron, which must be poured directly into the channelway without previous cooling or stirring, and this iron must be so hot, when poured, that the ring which is formed when the metal is cold shall be solid or free from wrinkles or layers. Iron at this temperature will usually cut a hole at the point of impact with the flange. In order to avoid spitting during the pouring, the tread and inside of the flange during the thermal test should be covered with a coat of shellac; wheels which are wet or which have been exposed to snow or frost may be warmed sufficiently to dry them or remove the frost before testing, but under no circumstances must the thermal test be applied to a wheel that in any part feels warm to the hand. The time when pouring ceases must be noted, and two minutes later an examination of the wheel under test must be made. If the wheel is found broken in pieces, or if any crack in the plates extends through or into the tread, the test wheel will be regarded as having failed.
If both wheels stand, the whole hundred will be accepted as to this test. If both fail, the whole hundred will be rejected. If one only of the thermal test wheels fails, all of the lot under test of the same shrinkage or stencil number will be rejected, and the test will be regarded as finished, so far as this lot of wheels is concerned. The manufacturer may, however, offer the wheels of the other two shrinkage or stencil numbers, provided they are acceptable in other respects, as constituents of another 103 wheels for a subsequent test.

13. All wheels which pass inspection and test will be regarded as accepted, and may be either shipped or stored for future shipment, as arranged. It is desired that shipments should be, as far as possible, in lots of 100 wheels. In all cases the inspector must witness the shipment, and he must give, in his report the numbers of all wheels inspected and the disposition made of them.

14. Individual wheels will be considered to have failed and will not be accepted or further considered, which,
   First.—Do not conform to standard design and measurement.
   Second.—Are under or over weight.
   Third.—Have the physical defects described in Section 6.

15. Each 103 wheels submitted for test will be considered to have failed and will not be accepted or considered further, if,
   First.—The test wheels do not conform to Section 7, especially as to limits of white iron in the throat and tread and around chaplets.
   Second.—One of the test wheels does not stand the drop test as described in Section 11.
   Third.—Both of the two test wheels do not stand the thermal test as described in Section 12.
STANDARD SPECIFICATIONS
FOR
MALLEABLE-IRON CASTINGS.¹


The specifications for this material are issued under the fixed designation A 47; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1904; Revised, 1915.

I. MANUFACTURE.

1. The castings shall be made from iron melted in either Process. an air furnace, open-hearth furnace or electric furnace.

II. PHYSICAL PROPERTIES AND TESTS.

2. Tension test specimens specified in Section 5 shall con- form to the following minimum requirements as to tensile properties:

   Tensile strength, lb. per sq. in. .................... 38 000
   Elongation in 2 in., per cent. ....................... 5

3. Transverse test specimens specified in Section 5, tested with the cope side up on supports 12 in. apart, pressure being

¹ These specifications are intended for general use, and in particular for railroad malleable iron castings, for which purpose they will be designated when additional specifications for other classes of malleable iron castings shall be adopted.
applied at the center, shall conform to the following requirements as to transverse properties:

<table>
<thead>
<tr>
<th>Thickness of Specimen, in.</th>
<th>Minimum Load Applied at Center, lb.</th>
<th>Minimum Deflection at Center, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>900</td>
<td>1.25</td>
</tr>
<tr>
<td>5/8</td>
<td>1400</td>
<td>1.00</td>
</tr>
<tr>
<td>3/4</td>
<td>2700C</td>
<td>0.75</td>
</tr>
</tbody>
</table>

4. In addition to the tension and transverse tests, the inspector representing the purchaser may satisfy himself of the suitability of the iron used for the castings by breaking a reasonable number of castings before annealing to examine for excessive mottling or graphite spots. In the case of castings of special design or importance, he may also require test lugs of a size proportional to the thickness of the casting, but not exceeding 5/8 by 3/4 in. in section. At least one of these lugs shall be left on the casting for final inspection.

5. (a) Tension test specimens shall be of the form and dimensions shown in Fig. 1. Transverse test specimens shall be 14 in. in length by 1 in. in width and either 1/2, 5/8 or 3/4 in. in thickness. The thickness of the specimen selected shall be in proportion to the thickness of the casting which it represents.

(b) Two tension and two transverse test specimens shall be cast in each mold with risers of sufficient height at each end to secure sound bars. All specimens shall be cast without chills, and with ends perfectly free in the mold.

(c) Four molds shall be poured to represent each melt. When the entire melt is used for castings which are subject to these specifications, two molds shall be poured within five minutes after tapping into the first ladle, and two molds from
the last iron of the melt. When only part of the melt is required for such castings, two molds shall be poured from the first ladle of iron used and two molds after the required iron has been tapped.

(d) The molds shall be suitably stamped to identify the specimens.

The test specimens from one mold from the first and one mold from the last of the melt shall be annealed in the hottest part of the annealing oven, and the remaining specimens shall be annealed in the coldest part.

6. One tension and one transverse test specimen from each of the four molds representing a melt shall be selected for test. The remaining specimens shall be reserved, and shall be tested in case of failure to conform to the requirements specified.

7. If more than one tension or transverse test specimen from each of the two molds annealed in the two points in the oven specified in Section 5 (d) fails to meet the requirements as to tensile or transverse properties specified in Sections 2 and 3, the castings from that melt will be rejected.

III. WORKMANSHIP AND FINISH.

8. The castings shall substantially conform to the sizes and shapes of the patterns, and shall be made in a workman-like manner. A variation of $\frac{3}{16}$ in. per ft. will be permitted.

9. The castings shall be free from blemishes, scale and shrinkage cracks.

IV. INSPECTION.

10. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.
STANDARD SPECIFICATIONS
FOR
GRAY-IRON CASTINGS.

Serial Designation: A 48-05.

The specifications for this material are issued under the fixed designation A 48; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

A DoPT, 1905.

1. Unless furnace iron is specified, all gray castings are understood to be made by the cupola process.

2. The sulfur contents shall be as follows:
   - Light castings: not over 0.08 per cent.
   - Medium castings: 0.10
   - Heavy castings: 0.12

3. In dividing castings into light, medium and heavy classes, the following standards have been adopted:
   - Castings having any section less than ½ in. thick shall be known as light castings.
   - Castings in which no section is less than 2 in. thick shall be known as heavy castings.
   - Medium castings are those not included in the above classification.

4. Transverse Test.—The minimum breaking strength of the “Arbitration Bar” under transverse load shall be not under:
   - Light castings: 2,500 lb.
   - Medium castings: 2,900
   - Heavy castings: 3,300

In no case shall the deflection be under 0.10 in.

(362)
**Serial Designation:** A 48-05.

*Tension Test.*—Where specified, this shall not run less than:

- Light castings: 18,000 lb. per sq. in.
- Medium castings: 21,000 lb. per sq. in.
- Heavy castings: 24,000 lb. per sq. in.

5. The quality of the iron going into castings under specification shall be determined by means of the "Arbitration Bar." This is a bar 1\(\frac{1}{4}\) in. in diameter and 15 in. long. It shall be prepared as stated further on and tested transversely. The tension test is not recommended, but in case it is called for, the bar as shown in Fig. 1, and turned up from any of the broken pieces of the transverse test shall, be used. The expense of the tension test shall fall on the purchaser.

![Arbitration Bar Diagram](image)

Fig. 1.—Tension Test Specimen.

6. Two sets of two bars shall be cast from each heat, one set from the first and the other set from the last iron going into the castings. Where the heat exceeds 20 tons, an additional set of two bars shall be cast for each 20 tons or fraction thereof above this amount. In case of a change of mixture during the heat, one set of two bars shall also be cast for every mixture other than the regular one. Each set of two bars is to go into a single mold. The bars shall not be rumbled or otherwise treated, being simply brushed off before testing.

7. The transverse test shall be made on all the bars cast, with supports 12 in. apart, load applied at the middle, and the deflection at rupture noted. One bar of every two of each set made must fulfil the requirements to permit acceptance of the castings represented.
8. The mold for the bars is shown in Fig. 2. The bottom of the bar is $\frac{1}{16}$ in. smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of one to twelve bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled.

9. The rate of application of the load shall be from 20 to 40 seconds for a deflection of 0.10 in.
10. Borings from the broken pieces of the "Arbitration Bar" samples shall be used for the sulfur determinations. One determination for each mold made shall be required. In case of dispute, the standards of the American Foundrymen's Association shall be used for comparison.

11. Castings shall be true to pattern, free from cracks, flaws and excessive shrinkage. In other respects they shall conform to whatever points may be specially agreed upon.

12. The inspector shall have reasonable facilities afforded him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications. All tests and inspections shall, as far as possible, be made at the place of manufacture prior to shipment.
STANDARD METHODS
FOR
SAMPLING AND ANALYSIS OF PIG AND
CAST IRON.

Serial Designation: A 64–16.

These methods are issued under the fixed designation A 64; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

SAMPLING.

Pig Iron.—One pig shall be selected at random from each four tons of iron and ten such pigs (representing 40 tons of iron) shall constitute a unit for sampling. The surface of each pig shall be cleansed with a stiff wire brush or in any manner that will remove all loose sand without introducing deleterious matter.

The skin, down to clean metal, shall then be removed with an emery wheel at the center of the upper face of each pig and the surface carefully brushed off.

Drillings shall be taken with a ¼-in. twist drill, from top to bottom of each pig, starting from the center of the cleared space and stopping when the point of the drill appears below. One hole only shall be bored in each pig.

Suitable precautions shall be taken to prevent the escape of fine particles during the drilling. To this end a disk of clean sheet metal shall be clamped upon the pig after the skin has been removed. This disk shall have a hole in its center just large
enough to receive the drill. Most of the drillings will then accumulate on top of the disk and can be brushed off after the drill is withdrawn. The pig shall then be turned bottom side up over any suitable receptacle for collecting what may have remained in the drill hole.

**Castings.**—In accordance with the Standard Specifications for Gray-Iron Castings (Serial Designation: A 48) of the American Society for Testing Materials, three test bars, 1.2 in. in diameter, shall be cast in sand from each heat at the beginning and again at the end of the pouring. One bar from each set having been broken, one end of each next the fracture shall be thoroughly cleaned and the outer skin removed for a sufficient distance from the fracture and down to clean metal. Chips shall then be taken by means of a lathe or milling machine across the whole face of the bar and until not less than 100 g. weight has been collected. The same amount shall be taken from each bar. The bar shall be so clamped as to permit the attachment or use of any suitable device for collecting every part of the sample and the machine shall be run slowly enough to reduce to a minimum the danger of loss of fine particles.

**Subsequent Treatment of Sample from both Pig and Castings.**—In the determination of total and graphitic carbon, and in the case of check analyses on the other constituents, the following precautions shall be taken: The entire unit shall be weighed and then sifted on tight-fitting sieves (with cover) having 80 (and if need be 120) meshes to the linear inch (approximately 900 and 2500 per square centimeter). The finer sieve need be used only in case the particles passing the coarser sieve are not sufficiently uniform in size and shape to meet the requirements of the treatment that follows.

The two (or three) portions so obtained shall be separately weighed. Each one shall then be thoroughly mixed without any loss of material and divided by weight into two (or three) exactly equal portions, each of which shall be placed in a clean, glass-stoppered bottle or other receptacle of suitable material and appropriately labeled. Of the three sets of the subdivided samples, one shall be retained by the works, one sent to the purchaser’s chemist and the third reserved.
Before weighing out for analysis, the contents of each bottle shall be thoroughly mixed and each portion used for analysis shall be made up of the two (or three) partial samples in the same proportion which they bear to the gross sample. Thus, if the gross sample, weighing, say, 500 g., has been separated into portions weighing 400, 80, and 20 g., the amounts of each that must be weighed to yield a 2-g. portion for analysis are 1.6 g., 0.32 g., and 0.08 g., respectively.

METHODS OF ANALYSIS.

DETERMINATION OF SILICON
BY THE
NITRO-SULFURIC (DROWN) METHOD.

SOLUTIONS REQUIRED.

*Nitro-Sulfuric Acid.*—Mix 1000 cc. of sulfuric acid, sp. gr. 1.84, 1500 cc. of nitric acid, sp. gr. 1.42, and 5500 cc. of distilled water.

*Dilute Hydrochloric Acid.*—Mix 100 cc. of hydrochloric acid, sp. gr. 1.20, and 900 cc. of distilled water.

METHOD.

Add cautiously 30 cc. of the nitro-sulfuric acid to 1 g. of iron in a platinum or porcelain dish of 300-cc. capacity, cover with a clock glass, heat until the metal is dissolved, and evaporate slowly until copious fumes of sulfuric acid are evolved. Cool, add 125 cc. of distilled water, heat with frequent stirring until all salts are dissolved, add 5 cc. of hydrochloric acid, sp. gr. 1.20, heat for 2 minutes, and filter on a 9-cm. paper. Wash the precipitate several times with hot water, then with hot hydrochloric acid and hot water alternately to complete the removal of iron salts, and finally with hot water until free from acid. Transfer the filter to a platinum crucible, burn off the paper carefully with the crucible covered, finally igniting over a blast
lamp or in a muffle furnace at 1000° C. for at least 20 minutes; cool in a desiccator and weigh. Add sufficient sulfuric acid, sp. gr. 1.84, to moisten the silica and then a small amount of hydrofluoric acid. Evaporate to dryness, ignite and weigh. The difference in weights represents silica from which the percentage of silicon may be calculated.

Run a blank determination on all reagents.

**DETERMINATION OF SILICON**

**BY THE HYDROCHLORIC-ACID METHOD.**

**SOLUTIONS REQUIRED.**

*Hydrochloric Acid.*—Mix equal volumes of hydrochloric acid, sp. gr. 1.20, and distilled water.

**METHOD.**

Place 1 or 2 g. of the metal in a casserole or 400-cc. beaker and add 30 to 40 cc. of the hydrochloric acid. When action has ceased, evaporate to dryness and bake in an air bath or on a hot plate until all acid is removed. Cool, add 15 cc. of concentrated hydrochloric acid and heat until all iron salts are in solution. Dilute with four or five times the volume of water, filter, wash, ignite and treat the precipitate as described under the Nitro-Sulfuric Method.

**DETERMINATION OF SULFUR.**

**SOLUTIONS REQUIRED.**

*Barium Chloride.*—Dissolve 100 g. of barium chloride (BaCl₂·2H₂O) in 1000 cc. of distilled water.

**METHOD.**

Dissolve 5 g. of iron in a 400-cc. beaker, using a mixture of 40 cc. of nitric acid, sp. gr. 1.42, and 5 cc. of hydrochloric acid, sp. gr. 1.20. Add 0.5 g. of sodium carbonate, evaporate the
solution to dryness and bake the residue on the hot plate until fumes are no longer given off. Treat the residue in 30 cc. of strong hydrochloric acid, dilute and filter. (See subsequent paragraph in this section for treatment of this residue for extraction of its possible sulfur content.) Cool the filtrate and add ammonia until a permanent cloudiness appears, then add 5 cc. of strong hydrochloric acid so as to obtain a perfectly clear liquid. Precipitate the sulfur in the cold filtrate (about 100 cc.) with 10 cc. of the barium-chloride solution. After 24 to 48 hours collect the precipitate on a filter paper, wash first with hot water (containing 10 cc. of concentrated hydrochloric acid and 1 g. of barium chloride to the liter) until free from iron, and then with hot water till free from chloride; or, first with cold water, then with 25 cc. of water containing 2 cc. of concentrated hydrochloric acid to the liter. Keep the washings separate from the main filtrate and evaporate them to recover any dissolved barium sulfate.

Place the insoluble residue, containing silica, graphite, etc., in a platinum crucible, cover with sodium carbonate (free from sulfur) and char the paper (use an alcohol lamp for this and subsequent heating operations) without allowing the carbonate to melt; the crucible should be covered during this operation. Then thoroughly mix in 0.2 g. of sodium nitrate and fuse the mass with the cover removed. Dissolve the contents of the crucible in water, filter and evaporate the filtrate with hydrochloric acid in excess, using a porcelain container; repeat the evaporation with water and hydrochloric acid to insure removal of nitrates. Extract the residue with a few drops of hydrochloric acid and water, filter off the insoluble matter and add barium chloride to the filtrate. Add the barium sulfate obtained to the main portion.

Run a blank with all reagents.

DETERMINATION OF PHOSPHORUS.

Solutions Required.

_Nitric Acid for Dissolving._—Mix 1000 cc. of nitric acid, sp. gr. 1.42, and 1200 cc. of distilled water.
Nitric Acid for Washing.—Mix 20 cc. of nitric acid, sp. gr. 1.42, and 1000 cc. of distilled water.

Ammonium-Molybdate Solution for Precipitating.
Solution No. 1.—Place in a beaker 100 g. of 85-per-cent molybdic acid, mix it thoroughly with 240 cc. of distilled water, add 140 cc. of ammonium hydroxide, sp. gr., 0.90, filter and add 60 cc. of nitric acid, sp. gr. 1.42.
Solution No. 2.—Mix 400 cc. of nitric acid, sp. gr., 1.42, and 960 cc. of distilled water.

When the solutions are cold, add solution No. 1 to solution No. 2, stirring constantly; then add 0.1 g. of ammonium phosphate dissolved in 10 cc. of distilled water; agitate thoroughly, let stand at least 24 hours and filter before using.

Ammonium-Molybdate Solution for Washing.—Mix equal volumes of the above compounded molybdate solution and of water.

Potassium-Nitrate Solution.—Dissolve 10 g. of potassium-nitrate in 1000 cc. of distilled water.

Phenolphthalein Solution.—Dissolve 0.2 g. of phenolphthalein in 50 cc. of 95-per-cent ethyl alcohol and 50 cc. of distilled water.

Standard Sodium-Hydroxide Solution.—To 100 g. of pure sodium hydroxide add an amount of distilled water just insufficient to completely dissolve it. Pour into a tall cylinder, close the cylinder and allow the insoluble matter to settle. Dilute in the proportion of 30 cc. to 2000 cc. of distilled water.

Standard Nitric Acid.—Measure 2000 cc. of distilled water into a glass-stoppered bottle, add 20 cc. of nitric acid, sp. gr. 1.42, and mix thoroughly. Measure accurately 10 cc. of the “standard sodium-hydroxide solution.” Place this in a small flask, add 40 cc. of distilled water and 3 drops of “phenolphthalein solution.” Drop “standard nitric acid” from a carefully calibrated burette into the flask until the pink color just disappears. If the solutions are not of the same strength, dilute the stronger with water until they agree.

The solutions being of equal strength, standardize them as follows: Titrate the ammonium phosphomolybdate from an iron in which the phosphorus has been accurately determined, and divide the percentage of phosphorus by the number of
Methods for Analysis of Pig and Cast Iron.

cubic centimeters of the "standard sodium-hydroxide solution" required to neutralize it. The result is the value of the "standard sodium-hydroxide solution." The solution should preferably be of such strength that 1 cc. = 0.0002 g. of phosphorus. Protect the solution from carbon dioxide by a soda-lime tube.

Magnesia Mixture.—Dissolve 110 g. of crystallized magnesium chloride (MgCl₂·6H₂O) or 50 g. of the anhydrous salt in distilled water, and filter. Dissolve 28 g. of ammonium chloride in distilled water, add a little bromine water and a slight excess of ammonia and filter. Add this solution to the solution of magnesium chloride, add enough ammonia to make the solution smell decidedly of ammonia, dilute to about 2 liters, transfer to a bottle, shake vigorously from time to time, allow it to stand for several days, and filter into a small bottle as required for use. Ten cubic centimeters of this solution will precipitate about 0.15 g. of P₂O₅.

Ammonia Wash Water, Approximately 10 per cent.—Mix 1000 cc. of ammonia water, sp. gr. 0.90, and 2000 cc. of distilled water in which has been dissolved 25 g. of ammonium nitrate.

Methods.

A. Molybdate Method for Non-titaniferous Irons.

Procedure for Obtaining Phosphomolybdate.—In a 400 cc. beaker dissolve 1 g. of metal (2 g. for irons low in phosphorus), using 25 (or 50) cc. of "nitric acid for dissolving." Evaporate to dryness and heat on the hot plate or in the air bath at approximately 200° C. for about an hour. Allow the beaker to cool, dissolve the residue in 15 cc. of concentrated hydrochloric acid and evaporate to dryness to render the silica insoluble. Redissolve in 15 cc. of concentrated hydrochloric acid, dilute with water, filter off insoluble and wash. (Burn off the filter paper and graphite; expel silica with a few drops of hydrofluoric acid and a drop or two of sulfuric acid, taking care not to drive off all of the last-named acid. Take up the residue with concentrated hydrochloric acid, dilute, and filter if need be into the main solution). Evaporate to a small volume until salts just begin to separate. Add 10 cc. of concentrated nitric acid and evaporate until salts again begin to separate; add 15 cc. more of
concentrated nitric acid and evaporate to a small volume. The solution being in an Erlenmeyer flask and the initial volume not over 25 cc. and its temperature that of the room, add 25 to 100 cc. of the molybdate reagent, according to the phosphorus content of the iron, shake for 4 or 5 minutes and let stand for 30 minutes to 3 or 4 hours at room temperature.

Then (a): Filter on a Gooch crucible, wash with the solution of "ammonium-molybdate solution for washing" and then with water containing 1 per cent of nitric acid, dry at 120° C. and weigh as ammonium phosphomolybdate containing 1.63 per cent of phosphorus.

Or, (b): Filter on a 9-cm. paper and wash, first with the "nitric acid for washing," and then with "potassium-nitrate solution," until the washings are no longer acid. Place filter and precipitate in the precipitating vessel and run in from a pipette 10 cc. of the "standard sodium-hydroxide solution." If, after agitation, this is insufficient to dissolve the precipitate, add 10 cc. more, and if necessary continue the additions until the precipitate is dissolved. Dilute to 50 cc., add 3 drops of "phenolphthalein solution," and add from a burette "standard nitric acid" until the pink color disappears; subtract the number of cubic centimeters of "standard nitric acid" used from the number of cubic centimeters of "standard sodium-hydroxide solution" taken to dissolve the precipitate, and the remainder will be the number of cubic centimeters of the "standard sodium-hydroxide solution" required to neutralize the ammonium phosphomolybdate. From this calculate the amount of phosphorus.

Or, (c): Filter on a small filter and wash with the "ammonium-molybdate solution for washing" until a drop of the filtrate gives no reaction for iron with potassium ferrocyanide. Dissolve the precipitate in 2 or 3 cc. of strong ammonia and filter through the paper that held the precipitate into a small beaker of about 100-cc. capacity, washing with ammoniacal water. With large precipitates more ammonia may be needed, but always the amounts of ammonia and wash water used should be as small as is consistent with perfect solution of the precipitate and thorough washing. When the precipitate is small the filtrate and washings should amount to about 25 cc.
Neutralize the solution with strong hydrochloric acid; if the yellow precipitate forms, add ammonia until it redissolves.

To the cold alkaline liquid add very slowly 10 cc. of "magnesia mixture," stirring constantly, add a little more ammonia and again stir vigorously. It is well to stand the beaker in cold water and stir the solution several times after the precipitate has begun to form. After 4 hours, filter on a small filter and wash with the "ammonia wash water." Dry, ignite in a crucible very carefully to burn off the carbonaceous matter, and finally heat for 10 minutes over the blast lamp. (The heat should not be so high as to cause partial fusion of the pyrophosphate.) Fill the crucible half full of hot water, add from 5 to 20 drops of hydrochloric acid, and heat for a few minutes to dissolve the magnesium pyrophosphate. If a residue remains, filter, wash, ignite in the crucible used for the pyrophosphate, weigh it, and deduct its weight from that of the unpurified salt. Calculate the phosphorus on the basis of 27.84 per cent in $\text{Mg}_2\text{P}_2\text{O}_7$.

B. Molybdate Method for Irons Containing Titanium.

Proceed as under method A until the solution resulting from treatment of the insoluble residue has been combined with the main solution. Then proceed according to Blair \(^1\) up to a certain point, as follows:

Heat the solution nearly to boiling, remove from the flame and add gradually from a small beaker a mixture of 2 cc. of acid ammonium sulfite \(^3\) and 10 cc. of ammonia, stirring constantly. The precipitate, which forms at first, redissolves, and when all but a little of the reagent has been added, replace the beaker over the flame. If, at any time while adding the sulfite solution, the precipitate formed will not redissolve, even after vigorous stirring, add a few drops of hydrochloric acid, and when the solution clears, continue the addition, very slowly, of

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\(^1\) If a flocculent white precipitate now shows, filter it off, dry and ignite it in a platinum crucible, fuse the residue with a very little sodium carbonate, extract the melt with hot water, filter, acidify the filtrate with nitric acid, add some ammonium nitrate and molybdate reagent and if phosphorus is indicated by the formation of a yellow precipitate, filter, wash and dissolve this in ammonia and add to the main solution.


\(^3\) Made by saturating strong ammonia water with sulfur-dioxide gas. Eighteen cubic centimeters of such a solution will deoxidize a solution of 10 g. of iron.
the acid ammonium sulfite. After replacing the beaker over the
flame, add to the solution (which should smell quite strongly
of sulfurous anhydride) ammonia, drop by drop, until the solu-
tion is quite decolorized, and finally until a slight greenish
precipitate remains undissolved even after vigorous stirring.
Now add the remainder of the sulfite solution, which should
throw down a white precipitate, which usually redissolves,
leaving the solution quite clear and almost perfectly decol-
orized. Should any precipitate remain undissolved, however,
add hydrochloric acid, drop by drop, until the solution clears,
when it should smell perceptibly of sulfurous anhydride. If the
reagents are used exactly in the proportions indicated, the
reactions will take place as described, and the operations will be
readily and quickly carried out. If the solution of acid
ammonium sulfite is weaker than it should be, of course the
ferric chloride will not be reduced, and the solution, at the end
of the operation described above, will not be decolorized and
will not smell of sulfurous anhydride. In this case add more
acid ammonium sulfite (without the addition of ammonia)
until the solution smells strongly of sulfurous anhydride, then
add ammonia until the slight permanent precipitate appears,
and redissolve it in as few drops of hydrochloric acid as possible.
The solution being now very nearly neutral, the iron in the
ferrous condition, and an excess of sulfurous acid present, add
to the solution 5 cc. of hydrochloric acid to make it decidedly
acid and to insure the complete decomposition of any excess of
the acid ammonium sulfite that may be present. Boil the
solution while a stream of carbon dioxide passes through it,
until every trace of sulfurous anhydride is expelled. Add a
few drops of bromine water or of a solution of ferric chloride,
and cool the solution by placing the beaker in cold water. To
the cold solution add ammonia from a small beaker very slowly,
and finally, drop by drop, with constant stirring. The green
precipitate of ferrous hydroxide which forms at first is dissolved
by stirring, leaving the solution perfectly clear, but subse-
quently, although the green precipitate dissolves, a whitish one
remains, and the next drop of ammonia increases the whitish

1 If arsenic is present pass a current of hydrogen-sulfide gas through the solution for 15
minutes, filter, and expel excess of the precipitant by a current of carbon dioxide.
precipitate or gives it a reddish tint, and finally the greenish precipitate remains undissolved even after vigorous stirring, and another drop of ammonia makes the whole precipitate appear green. If, before this occurs the precipitate does not appear decidedly red in color, dissolve the green precipitate, by a drop or two of hydrochloric acid, and add a little bromine water or ferric-chloride solution (1 or 2 cc.), then add ammonia as before, and repeat this until the reddish precipitate is obtained, and then the green coloration as described above. Dissolve the green precipitate in a very few drops of acetic acid (sp. gr. 1.04), when the precipitate remaining will be quite red in color, then add about 1 cc. of acetic acid, and dilute the solution with boiling water, so that the beaker may be about four-fifths full. Heat to boiling, and when the solution has boiled one minute, lower the flame, filter as rapidly as possible through a 14-cm. filter, and wash once with hot water. The filtrate should run through clear, but in a few minutes it will appear cloudy by the precipitation of ferric hydroxide. The points to be observed are the red color of the precipitate and the clearness of the solution when it first runs through.

Dry the filter and precipitate without scorching the paper. Remove with filter paper any precipitate adhering to the beaker and dry the paper. Transfer the main portion of the precipitate (all that can be removed) to a small porcelain mortar. Burn carefully the filter and the wipings of the beaker and transfer the ash to the mortar. Grind the contents of the mortar with 3 g. of sodium carbonate and a little nitrate and transfer the mixture to a platinum crucible, cleaning pestle and mortar with a little sodium carbonate. Fuse the whole for half an hour or more, cool, dissolve the fused mass in hot water, filter,\(^1\) and wash with hot water.

Acidify the alkaline solution with nitric acid, evaporate in a small casserole nearly to dryness, transfer to a small Erlenmeyer flask, so that the final volume shall not exceed 25 cc., add at room temperature 25 to 100 cc. of the molybdate reagent and shake for 4 or 5 minutes. Let stand for 30 minutes to 3 or 4 hours. From this point the procedure is exactly as described for non-titaniferous irons under method A.

\(^1\) The residue on the filter contains the whole of the titanium.
DETERMINATION OF MANGANESE
BY THE
BISMUTHATE METHOD.

SOLUTIONS REQUIRED.

* Nitric Acid for Solution.—Mix 500 cc. of nitric acid, sp. gr. 1.42, and 1500 cc. of distilled water.

* Nitric Acid for Washing.—Mix 30 cc. of nitric acid, sp. gr. 1.42, and 970 cc. of distilled water.

* Stock Sodium Arsenite.—To 15 g. of arsenious oxide (As₂O₃) in a 300-cc. Erlenmeyer flask, add 45 g. of sodium carbonate and 150 cc. of distilled water. Heat the flask and contents in a water bath until the oxide is dissolved, cool the solution and make up to 1000 cc. with distilled water.

* Standard Sodium Arsenite.—Dilute 300 cc. of “stock sodium arsenite” solution to 1000 cc. with distilled water and titrate against potassium-permanganate solution (about N/10), which has been standardized by using Bureau of Standards Sodium Oxalate.¹

Adjust the solution so that 1 cc. is equivalent to 0.10 per cent of manganese, when a 1-g. sample is taken.

The factor Na₂C₂O₄—→Mn = 0.16397 (using the 1913 atomic weights).

METHOD.

In a 300-cc. Erlenmeyer flask dissolve 1 g. of iron in 50 cc. of the “nitric acid for solution” and boil to expel the oxides of nitrogen, cool, filter,² add about 0.5 g. of sodium bismuthate, and heat for a few minutes or until the pink color has disappeared, with or without precipitation of manganese dioxide. Add small portions of ferrous sulfate (or any suitable reducing agent) in sufficient quantity to clear the solution and boil to expel the oxides of nitrogen. Cool to about 15° C., add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of the “nitric acid for washing” and filter through an

¹ *Circular No. 40, Bureau of Standards, Oct. 1, 1912.*
² The insoluble residue should be examined for manganese.
alundum filter or asbestos pad,\textsuperscript{1} washing with the same nitric acid. Titrate immediately with “standard sodium arsenite” solution to the disappearance of the pink color, each cubic centimeter required representing 0.10 per cent manganese.

DETERMINATION OF MANGANESE
BY THE
FORD-WILLIAMS METHOD.

**Solutions Required.**

*Nitric Acid for Solution.*—Mix equal volumes of nitric acid, sp. gr. 1.42, and distilled water.

*Standard Ferrous-Sulfate Solution.*—Dissolve 10 g. of pure crystallized Fe$_2$SO$_4\cdot$7H$_2$O in 900 cc. of distilled water and 100 cc. of sulfuric acid, sp. gr. 1.84.

*Standard Permanganate Solution,* about N/10.—Dissolve 3.735 g. of potassium permanganate in 1000 cc. of distilled water. After aging, standardize this solution by means of sodium oxalate of ascertained purity (Sörensen’s as furnished by the Bureau of Standards for a fee of $2.00 for 120 g. or $3.00 for 200 g.).

**Method.**

Dissolve 3 g. of iron in 40 cc. of “nitric acid for solution,” dilute, filter,\textsuperscript{2} and evaporate almost to a syrupy consistency. Add 40 cc. of nitric acid, sp. gr. 1.42, and 3 g. of potassium chlorate. Boil the solution for 15 minutes. Remove from the source of heat and add 15 cc. of nitric acid, sp. gr. 1.42, and 3 g. of potassium chlorate. Boil again until yellow fumes cease to come off. Cool quickly and filter on an asbestos pad in a carbon funnel. Wash with cold nitric acid, sp. gr. 1.42 (free from oxides of nitrogen) until the iron is removed and then with water.

\textsuperscript{1} In making the asbestos pad it is advisable to have a thin bed and as much surface as possible. This insures rapid filtration, and the filter may be used until it becomes clogged with bismuthate. The filtrate must be perfectly clear, since the least particle of bismuthate carried through the filter will vitiate the results.

\textsuperscript{2} The insoluble residue should be examined for manganese.

\textsuperscript{3} It is very important to use nitric acid free from oxides of nitrogen, since these dissolve the precipitated manganese dioxide.
until the nitric acid is removed. Transfer the filter to the beaker in which precipitation was made, add a measured amount of the "standard ferrous-sulfate solution," so that there shall be an excess, and titrate the excess with the "standard permanganate solution."

In another operation titrate the same amount of "standard ferrous-sulfate solution" directly against the permanganate. The difference between the two amounts of permanganate used gives the measure of the manganese present in the iron. The comparison of the ferrous sulfate and permanganate solutions should be made each day they are used.

DETERMINATION OF CARBON
BY THE
DIRECT-COMBUSTION METHOD.

The method of direct combustion of the metal in oxygen is recommended, the carbon dioxide obtained being absorbed in barium-hydroxide solution, the precipitated barium carbonate filtered off, washed, dissolved in a measured excess of hydrochloric acid and the excess titrated against standard alkali.

The use of potassium-hydroxide solution or soda lime for the absorption of carbon dioxide, with suitable purifying train between absorption tube and furnace, is recognized as being capable of very satisfactory refinement and as possessing merit where the time element is of prime significance.

Owing to the diversity of apparatus by which correct results may be obtained in the determination of carbon, the recommendations are intended more to indicate what is acceptable than to prescribe definitely what shall be used.

Apparatus.

Purifying Train.—The method employed eliminates the necessity of a purifying train following the furnace, inasmuch as no precautions are necessary to prevent access of water vapor, or sulfur trioxide—the impurities usually guarded against—from the absorbing apparatus. All that is needed is a
calcium-chloride tower filled with stick sodium hydroxide placed before the furnace, or between the furnace and catalyzer, if, as recommended, the latter is used for the purpose of oxidizing organic matter in the oxygen.

**Material for Lining Boats.**—Alundum, "RR Alundum, alkali-free, specially prepared for carbon determination," as supplied by dealers is suitable, and is recommended. The 90-mesh or finer grades are used. Chromite, properly sized and freed from materials causing a blank, may also be employed. No substance containing alkali or alkaline earth metals, or carbon as carbonates or in other form, should be used as a lining material. Quartz sand, owing to its liability to fuse or to slag with the oxides of iron, causing bubbles of gas to be enclosed, is objectionable. Aluminum oxide, made by calcining alum or otherwise, often contains sulfate not easily destroyed, or may contain objectionable substances of an alkaline nature.

**Catalyzers.**—Suitable catalyzers are copper oxide, platinized quartz or asbestos, or platinum gauze. One of these should be used in the forward part of the combustion apparatus, as well as in the purifying train preceding the combustion tube (see above). Platinized materials sometimes give off volatile substances on heating, and whatever material is used should not be subject to this defect.

**Combustion Apparatus.**—Any apparatus heated by gas or electricity which will bring the sample to a temperature of 950 to 1100° C. may be used. Combustion tubes may be porcelain, glazed on one or both sides, quartz or platinum. Quartz is liable to devitrification when used continuously at temperatures above 1000° C., and may then become porous. Combustion crucibles of platinum may be heated by blast or by Meker burners.

**Boats or Other Containers of Samples being Burned.**—These may be of porcelain, quartz, alundum, clay, platinum, or nickel, and should always receive a lining of granular alundum.

**Purifying Train before Combustion Apparatus.**—This consists of a tower filled with stick sodium hydroxide, preceded by a catalyzer.

**The Train after the Combustion Apparatus.**—This consists merely of the Meyer tube for absorption of the carbon dioxide,
protected by a soda-lime tube at the far end. Meyer tubes with 7 to 10 bulbs of 10 to 15-cc. capacity each, and large bulbs at the ends, having volumes equal to the combined capacity of the small bulbs, have been used and found satisfactory.

Filtering Apparatus.—In filtration for accurate work, care should be taken to protect the solution from access of extraneous carbon dioxide. This is accomplished in the apparatus shown in Fig. 1. For work requiring less accuracy, the barium carbonate may be filtered off on a filter made by fitting a carbon funnel with a perforated porcelain disk and filtering by suction. The precipitate is then washed with distilled water from which the carbon dioxide has been removed by boiling.

Reagents.

Oxygen.—Oxygen of not less than 97-per-cent purity is recommended. Endeavor should be made to obtain oxygen which gives no blank, since the correction for or elimination of this is troublesome and uncertain. For the most accurate work the blank should be completely eliminated by the use of a catalyzer before the furnace, with a carbon-dioxide absorbent interposed between furnace and catalyzer.

Tenth-normal Hydrochloric Acid.—This may be standardized by any of the accepted methods, or as follows: Twenty cubic centimeters of the approximately N/10 acid is measured out with a pipette, and the silver chloride precipitated by an excess of silver-nitrate solution in a volume of 50 to 60 cc. After digesting at 70 to 80° C., until the supernatant liquid is clear, the chloride is filtered off on a tared Gooch filter and washed with water containing 2 cc. of nitric acid per 100 cc. of water, until freed from silver nitrate. After drying to constant weight at 130° C., the increase of weight over the original tare is noted, and from this weight, corresponding to the silver chloride, the strength of the hydrochloric acid is calculated, after which it is adjusted to the strength prescribed. The standardization should be based upon several concordant determinations, using varying amounts of acid.

1 cc. N/10 HCl = 0.0006 g. carbon.
Methods for Analysis of Pig and Cast Iron.

**Methyl Orange.**—Dissolve 0.02 g. in 100 cc. of hot distilled water and filter.

**Tenth-normal Sodium-Hydroxide Solution.**—This is standardized against the hydrochloric acid. Methyl orange is used as the indicator. The sodium-hydroxide solution should be stored in a large bottle from which it may be driven out by air pressure, protecting against carbon dioxide by soda-lime tubes.

**Barium-Hydroxide Solution.**—A saturated solution is filtered and stored in a large reservoir from which it is delivered by air pressure, protecting from carbon dioxide by a soda-lime tube. Use enough of this solution to fill all the small bulbs of the Meyer tube when the latter is properly set up for absorption.

**Factors Influencing Rapid Combustion.**

**Manner of Distributing Sample in Boat.**—This is of considerable importance. With all samples, close packing in a small space is conducive to rapid combustion. In the case of samples which burn too vigorously, a satisfactory regulation may sometimes be attained by spreading the sample loosely over the lining in the boat.

**Rate of Admitting Oxygen.**—The rate at which oxygen is admitted is also a factor in the velocity of combustion; a moderate rate of burning is to be sought. This is desirable from the standpoint of the complete absorption of the carbon dioxide by the barium-hydroxide solution. The above-mentioned factors can be governed so as to burn successfully irons of a very wide range of compositions, in either fine or coarse particles.

**Method.**

After having properly set up and tested the apparatus, place 1 g. of iron in a moderately packed condition on the bed material and introduce the boat into the combustion apparatus, already heated to the proper temperature. After about a minute (to allow the sample and container to reach the temperature of the furnace), admit oxygen somewhat more rapidly than it is consumed, as shown by the rate of bubbling in the
Meyer tube. The sample burns completely in 1 or 2 minutes, and all that is now necessary is to sweep all the carbon dioxide into the absorption apparatus. This can be accomplished in 6 to 8 minutes by passing about 1 or 2 liters of oxygen. Detach the Meyer tube and filter and wash the barium carbonate, using the special filtering apparatus shown. After solution in a measured excess of hydrochloric acid (the Meyer tube being washed out with a portion of the acid, to remove adhering barium carbonate), titrate the excess of acid against alkali and from the data thus obtained calculate the percentage of carbon.

APPARATUS AND PROCEDURE FOR FILTRATION.

The apparatus is shown to approximately one-tenth size in Fig. 1, which is self-explanatory. The stop-cock is a three-way cock connected to the suction pipe. The rubber tubing connected to the Meyer tube should be of best grade black rubber and the lengths should be so chosen as to permit of easy manipulation of the tube. The Meyer tube is connected or disconnected by the rubber stoppers which are left always attached to the rubber tubes. The carbon tube C is fitted with a perforated porcelain plate sliding easily.

The funnel is prepared for filtration by making on the porcelain disk a felt of asbestos about 1/16 to 3/8 in. in thickness, using amphibole (not serpentine) asbestos which has been carefully digested with strong hydrochloric acid for several hours and washed with water until it gives no acid reaction. On top of the asbestos pad is placed a layer of similarly treated quartz mixed with asbestos, of the height shown. A mixture of quartz grains of various sizes (approximately 50 per cent passing a

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1 As a precaution against error resulting from too rapid passage of the gases, it is well to attach a second barium-hydroxide tube to retain any carbon dioxide that may pass the first.

For the most accurate work the Meyer tubes should be washed with dilute acid before beginning work each day. After a determination is finished the tube should be completely filled two or three times with tap water, then rinsed with distilled water, in order to remove the carbon dioxide liberated when dissolving the carbonate from the previous determination.

The flask containing the carbonate should be thoroughly agitated after adding the acid, since the carbonate sometimes dissolves rather slowly if this is not done; this is particularly the case if it has packed much during filtration.

2 It is well to wash out the rubber tubes connected to the Meyer tube with a little water each day before beginning work.
20-mesh sieve and 50 per cent passing a 10-mesh and remaining on a 20-mesh sieve) is suitable. The mixture of quartz and asbestos may be obtained by filling the funnel from a beaker (directing against it a stream from a wash-bottle) while maintaining a gentle suction. In this way the asbestos is properly mixed with the quartz. A little experience and attention to these details will enable one to prepare the quartz-bed in a manner that will greatly expedite filtration. The stopper is now inserted in the funnel, the Meyer tube connected as shown and the liquid and precipitate sucked into the funnel. Only a gentle suction should be used. When necessary \( P_3 \) is opened to admit air back of the column of liquid in the Meyer tube. When the contents of the Meyer tube have been transferred, the large bulb nearest \( B \) is half filled with water by opening \( P_1 \); the stop-cock \( S \) is operated during this and subsequent operations so as to maintain a gentle suction all the time. \( M \) is now manipulated so as to bring the wash water in contact with all parts of the interior, after which the water is sucked through \( C \); \( P_3 \) is left open during this and subsequent washings.

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1 Glass wool should on no account be used as a substitute for the quartz, on account of the probability of errors arising from its attack by the alkali or acid.

2 The operation of filtering can be carried out very rapidly after a little practice.
eight washings as directed, allowing the wash water to drain off thoroughly each time before adding more, $M$ may be detached, the stopper removed from the funnel and the washing completed by filling $C$ to the top with CO$_2$-free water, sucking off completely and repeating the operation once. With care the washing may be done with 150 cc. of water. Air is now admitted through the side opening of $S$, $C$ is removed and the porcelain disk carrying the asbestos, quartz and barium carbonate is thrust, by means of a long glass rod, into a flask, removing any adhering particles from the sides of $C$, by a stream of water from a wash bottle. An excess of the standard acid is now added from a burette or pipette, using a portion to wash out $M$, and after the contents of the flask have been thoroughly agitated by shaking, the excess of acid is titrated against the standard alkali, using 3 drops of the methyl-orange indicator.
AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS

FOR

HARD-DRAWN COPPER WIRE.


The specifications for this material are issued under the fixed designation B 1; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1909; REVISED, 1911, 1913, 1915.

Material. 1. The material shall be copper of such quality and purity that, when drawn hard, it shall have the properties and characteristics herein required.

Shapes. 2. These specifications cover hard-drawn round wire, grooved trolley wire, and figure-eight trolley wire, as hereinafter described.

Finish. 3. (a) The wire, in all shapes, must be free from all imperfections not consistent with the best commercial practice.

(b) Necessary brazes in hard-drawn wire must be made in accordance with best commercial practice, and tests upon a section of wire containing a braze must show at least 95 per cent of the tensile strength of the unbrazed wire. Elongation tests are not to be made upon test sections including brazes.

Packages. 4. (a) Package sizes for round wire shall be agreed upon in the placing of individual orders; standard packages of grooved trolley wire shall be shipments upon reels holding about 2500 lb. each.

(b) The wire shall be protected against damage in ordinary handling and shipping.

(386)
5. For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken as 8.89 at 20° C.

6. All testing and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to enable him to satisfy himself that the material conforms to the requirements of these specifications.

**Hard-Drawn Round Wire.**

7. *(a)* Size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals; that is, in mils.

 *(b)* Wire is expected to be accurate in diameter; permissible variations from nominal diameter shall be:

For wire 0.100 in. in diameter and larger, one per cent over or under;

For wire less than 0.100 in. in diameter, one mil over or under.

*(c)* Each coil is to be gaged at three places, one near each end, and one approximately at the middle; the coil may be rejected if, two points being within the accepted limits, the third point is off gage more than 2 per cent in the case of wire 0.064 in. in diameter and larger, or more than 3 per cent in the case of wire less than 0.064 in. in diameter.

8. Wire shall be so drawn that its tensile strength and elongation shall be at least equal to the value stated in Table I. Tensile tests shall be made upon fair samples, and the elongation of wire larger in diameter that 0.204 in. shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally 10 in. apart. The elongation of wire 0.204 in. in diameter and smaller shall be determined by measurements made between the jaws of the testing machine. The zero length shall be the distance between the jaws when a load equal to ten per cent of the required ultimate breaking strength shall have been applied, and the final length shall be the distance between the jaws at the time of rupture. The zero length shall be as near 60 in. as
Specifications for Hard-Drawn Copper Wire.

possible. The fracture shall be between the bench marks in the case of wire larger than 0.204 in. in diameter and between the jaws in the case of smaller wire, and not closer than 1 in. to either bench mark or jaw. If upon testing a sample from any coil of wire, the results are found to be below the values stated in the table, tests upon two additional samples shall be made, and the average of the three tests shall determine acceptance or rejection of the coil. For wire whose nominal diameter is between listed sizes, the requirements shall be those of the next larger size included in the table.

<table>
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<tr>
<th>Diameter, in.</th>
<th>Area, circular mils.</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Elongation in 10 in., per cent.</th>
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<tr>
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<td>211 600</td>
<td>49 000</td>
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<td>0.410</td>
<td>168 100</td>
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<td>57 600</td>
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<td>52 440</td>
<td>59 000</td>
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<table>
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<tr>
<th>Diameter, in.</th>
<th>Area, circular mils.</th>
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<th>Elongation in 10 in., per cent.</th>
</tr>
</thead>
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</table>
9. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.). The wire shall not exceed the following limits:

For diameters 0.460 in. to 0.325 in., 900.77 lb. per mile-ohm at 20° C;
For diameters 0.324 in. to 0.040 in., 910.15 lb. per mile-ohm at 20° C.

**Grooved Trolley Wire.**

10. Standard sections shall be those known as the "American Standard Grooved Trolley Wire Sections," the shape and dimensions of which are as shown in Fig. 1.

11. (a) Size shall be expressed as the area of cross-section in circular mils, the standard sizes being as follows:

211,600 circular mils, weighing 3,386 lb. per mile.
168,100 " " " 2,690 " " "
133,200 " " " 2,132 " " "

(b) Grooved trolley wire may vary 4 per cent over or under in weight per unit length from standard, as determined from the nominal cross-section.

12. The physical tests shall be made in the same manner as those upon round wire. The tensile strength of grooved wire shall be at least 95 per cent of that required for round wire of the same sectional area; the elongation shall be the same as that required for round wire of the same sectional area.
13. The requirements for electric resistivity shall be the same as those for round wire of the same sectional area.

**Figure-Eight Trolley Wire.**

14. Standard sections of figure-eight trolley wire shall be as shown in Fig. 2.

15. The requirements for weight, physical properties, and electric resistivity of figure-eight trolley wire shall be the same as for the same sizes of grooved trolley wire.

![Diagram of figure-eight trolley wire sections](image)

**Fig. 2.**

**Explanatory Notes on Standard Specifications for Hard-Drawn Copper Wire.**

5. The specific gravity of copper was formerly standardized in these specifications at 8.90. The value has been changed to 8.89, since that is the value adopted as standard by the American Institute of Electrical Engineers and the International Electrotechnical Commission.

7. (a) The use of arbitrary gage numbers to express dimensions cannot be too strongly condemned. There are many such gages in existence, and confusion is to be expected unless the particular gage to be used is specified. Many of the gages have their dimensions stated in absurd figures, such as 0.090742 in., when it is not especially easy to measure dimensions in the fourth decimal place by workshop tools. Definite diameters in measurable units are evidently preferable.

8. Many other physical tests than those provided in these
specifications are included in existing specifications. The reasons for the omission of some of the more common are given as follows:

Twist Tests.—The wire is sometimes required to permit twisting through a stated number of revolutions before breaking. The results are so easily influenced by temperature, speed of rotation, method of gripping, and other variables not easily defined or controlled, that the test is at least of doubtful value. It is the opinion of the committee\(^1\) that it is impractical to so define the conditions of the test that a twist test can be made definite and reliable; hence there is no warrant for its inclusion in specifications.

Wrap Tests.—Wire is sometimes required to permit tight wrapping about a wire of its own diameter, unwrapping and again re-wrapping. It is obvious that the making of a test of this kind with wire that is already hard-drawn is exceedingly difficult. Every one who has tried to break off a piece of tough wire by bending it back and forth between the fingers, knows how hard it is to confine the bend to one place, because of the hardening action of the previous bends. Hard wire which has been wrapped around a wire of small diameter is hardened still more and it is almost impossible to straighten the wire, let alone re-coil it in the opposite direction. In the opinion of the committee, it is inadvisable to include a test which at best is so indefinite as a wrap test. Furthermore, it is the opinion of the committee that wire which will meet the physical tests included in these specifications will meet any properly made twist or wrap test that would reasonably be required.

Since the adoption of the Standard Specifications for Hard-Drawn Copper Wire, proposed in 1909, the committee has very carefully considered the matter of twist and wrap tests, and it is their final opinion that while there might be some possible reason for requiring that wire shall stand wrapping around a wire of equal diameter, there can be no good reason for including in specifications the requirement that it shall stand unwrapping and re-wrapping, because such a test is indefinite and cannot be made otherwise. It is almost physically impossible to unwrap and re-wrap hard-drawn wire about a wire of its own diameter. With respect to twist tests, the committee has nothing to add to

\(^{\text{Committee B-1 on Standard Specifications for Copper Wire.}}\)
the statement already on record, condemning this character of test.

Elastic Limit.—During the tension test on wire, there is seldom to be observed any definite drop of the beam or increase in the rate of elongation, corresponding to the yield point commonly observed in testing steel. The only way in which the elastic limit of hard wire may be determined is by the actual plotting of the elastic curve from extensometer readings. Even such tests are difficult of interpretation, because the wire when available for tests is usually curved, due to its having been put up in a coil. There are little sets observable before the true elastic limit has been reached, owing to the fact that one side of the wire, having been stretched in coiling, is really a little harder that the other side, and the pull is, therefore, not even. Considering the difficulty of making the test and the uncertainty of the results obtained, it is the opinion of the committee that it would be inadvisable to include an elastic limit test in these specifications. It is evident that if the designing engineer requires a knowledge of the location of the elastic limit, for purposes of calculation in designing, such data can be obtained by special tests on representative sizes of wire, which will fix the relation of the elastic limit to the ultimate strength for all wire which is properly made.

Tests carefully made by members of the committee show that the elastic limit of hard-drawn copper wire from sizes 0.460 to 0.325 in., inclusive, averages 55 per cent of the ultimate tensile strength required in these specifications, with a minimum value of 50 per cent; for sizes 0.324 to 0.040 in., inclusive, it averages 60 per cent of the ultimate tensile strength required in these specifications, with a minimum value of 55 per cent. This statement of experience is based on the definition of elastic limit as “that point on the elastic curve beyond which the ratio of stress to strain ceases to be constant.”

9. Conductivity.—Electric conductivity was formerly expressed as a percentage on the basis of a determination made by Matthiessen about 1865, of the electric resistivity of supposedly pure copper. Since that time the methods of refining copper have advanced, so that it is not uncommon to find copper of over 100 per cent conductivity on the Matthiessen basis.
There has until recently not been international agreement on the electric resistivity of copper to be considered the standard for the expression of conductivity. While international agreement upon the value 0.15328 ohms per meter-gram at 20° C. for the resistivity of copper equal to 100 per cent conductivity was reached by the International Electro-Technical Commission in 1913, it has been deemed preferable to express the requirements in standard specifications in the terms of quantities directly measurable, rather than by reference to some quantity whose standard value is the subject of agreement only. The use of the arbitrary term "conductivity" has no more warrant than the employment of arbitrary gage numbers. Therefore, in these specifications the requirements are stated as the maximum rejection limits to the resistivity.

For the convenience of those who are accustomed to express resistivity in any of the several more or less common units, the following table of equivalents has been prepared, giving the resistivity of copper at 20° C.:

900.77 lb. per mile-ohm is equal to:
- 0.15775 ohms per meter-gram,
- 1.7745 microhms per centimeter-cube,
- 0.69863 microhms per inch-cube,
- 10.674 ohms per mil-foot.

910.15 lb. per mile-ohm is equal to:
- 0.15940 ohms per meter-gram,
- 1.7930 microms per centimeter-cube,
- 0.70590 microhms per inch-cube,
- 10.785 ohms per mil-foot.

10. It is obvious that the simplest designation of irregular shapes of similar outline is by sectional area, and the most commonly used unit among electrical engineers is the circular mil. Therefore, while the sizes of grooved trolley wire regularly used are generally known by B & S gage number, corresponding to their sectional area, it has been deemed advisable by the committee to list these sizes, in specifications, by their sectional area expressed in circular mils. The three sizes which are most
Specifications for Hard-Drawn Copper Wire.

Extensively used commercially are the only ones listed; a fourth size is but little used, and the use is growing less.

11. The only way in which gage variations are easily determinable in irregular shapes is by recourse to weights of standard lengths, and this has been the method adopted in the specifications.
STANDARD SPECIFICATIONS FOR MEDIUM HARD-DRAWN COPPER WIRE.


The specifications for this material are issued under the fixed designation B 2; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912; REVISED, 1913, 1915.

1. The copper shall be of such quality and purity that Material, when drawn medium-hard, it shall have the properties and characteristics herein required.

2. These specifications cover medium hard-drawn round Shapes. wire, as hereinafter described.

3. (a) The wire must be free from all imperfections not Finish. consistent with the best commercial practice.

    (b) Necessary brazes in medium hard-drawn wire must be made in accordance with the best commercial practice, and tests upon a section of wire containing a braze must show at least 95 per cent of the tensile strength of the unbrazed wire. Elongation tests are not to be made upon test sections including brazes.

4. (a) Packing sizes for round wire shall be agreed upon Packages. in the placing of individual orders.

    (b) The wire shall be protected against damage in ordinary handling and shipping.

5. For the purpose of calculating weights, cross-sections, Specific Gravi etc., the specific gravity of copper shall be taken as 8.89 at 20° C.
6. All testing and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to the requirements of these specifications.

**Medium Hard-Drawn Round Wire.**

7. (a) The size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals; that is, in mils.

(b) Wire is expected to be accurate in diameter; permissible variations from nominal diameter shall be:

   For wire 0.100 in. in diameter and larger, one per cent over or under;
   For wire less than 0.100 in. in diameter, one mil over or under.

(c) Each coil is to be gaged at three places, one near each end, and one approximately at the middle; the coil may be rejected, if, two points being within the accepted limits, the third point is off gage more than 2 per cent in the case of wire 0.064 in. in diameter and larger, or more than 3 per cent in the case of wire less than 0.064 in. in diameter.

8. Wire shall be so drawn that its tensile strength shall not be greater than the maximum values and not less than the minimum values stated in Table I, and its elongation shall not be less than the minimum values stated in Table I. Tension tests shall be made upon fair samples, and the elongation of wire larger in diameter than 0.204 in. shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally 10 in. apart. The elongation of wire 0.204 in. in diameter and smaller shall be determined by measurements made between the jaws of the testing machine. The zero length shall be the distance between the jaws when a load equal to 10 per cent of the required ultimate breaking strength shall have been applied, and the final length shall be the distance between the jaws at the time of rupture. The zero length shall be as near
60 in. as possible. The fracture shall be between the bench marks in the case of wire larger than 0.204 in. in diameter and between the jaws in the case of smaller wire, and not closer than 1 in. to either bench mark or jaw. If upon testing a sample from any coil of wire, the results are found to be below the values stated in the table, tests upon two additional samples shall be made, and the average of the three tests shall determine acceptance or rejection of the coil. For wire whose nominal diameter is between

<table>
<thead>
<tr>
<th>Diameter, in.</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Elongation in 10 in. per cent.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>0.460</td>
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<td>50 330</td>
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</tr>
<tr>
<td>0.091</td>
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<td>52 330</td>
<td>59 330</td>
</tr>
<tr>
<td>0.045</td>
<td>52 660</td>
<td>59 660</td>
</tr>
<tr>
<td>0.040</td>
<td>53 000</td>
<td>60 000</td>
</tr>
</tbody>
</table>

listed sizes, the requirements shall be those of the next larger size included in the table.

9. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.). The wire shall not exceed the following limits:

For diameters 0.460 in. to 0.325 in., 896.15 lb. per mile-ohm at 20° C.

For diameters 0.324 in. to 0.040 in., 905.44 lb. per mile-ohm at 20° C.
EXPLANATORY NOTES.

Definition.—Medium Hard-Drawn Wire is essentially and necessarily a special product, because when wire has once started on its course through the drawing operations, it can only finish as a hard-drawn wire to be used as such or to be annealed and become soft or annealed wire. Medium hard-drawn wire is annealed wire drawn to a slightly smaller diameter.

5. The specific gravity of copper was formerly standardized in these specifications at 8.90. The value has been changed to 8.89, since that is the value adopted as standard by the American Institute of Electrical Engineers and the International Electrotechnical Commission.

7. (a) The use of arbitrary gage numbers to express dimensions cannot be too strongly condemned. There are many such gages in existence, and confusion is to be expected unless the particular gage to be used is specified. Many of the gages have their dimensions stated in absurd figures, such as 0.090742 in., when it is not especially easy to measure dimensions in the fourth decimal place by work-shop tools. Definite diameters in measurable units are evidently preferable.

8. Medium hard-drawn wire approaches hard-drawn wire in its characteristics, but from the very nature of the product, exact uniformity in tensile strength cannot be obtained; hence, the necessity for establishing a range of tensile strength within which standard medium hard-drawn wire must be expected to be found. In the opinion of the committee,1 any narrowing or reduction in the range permitted in tensile strength can only result in an unjustifiable increase in the cost of production of the wire.

Many other physical tests than those provided in these specifications are included in existing specifications. The reasons for the omission of some of the more common are given as follows:

Twist Tests.—The wire is sometimes required to permit twisting through a stated number of revolutions before breaking. The results are so easily influenced by temperature, speed of rotation, method of gripping, and other variables not easily defined or controlled, that the test is at least of doubtful value.

1 Committee B-1 on Standard Specifications for Copper Wire.
It is the opinion of the committee that it is impractical to so define the conditions of the test that a twist test can be made definite and reliable; hence there is no warrant for its inclusion in specifications.

**Wrap Tests.**—Wire is sometimes required to permit tight wrapping about a wire of its own diameter, unwrapping and again re-wrapping. It is obvious that the making of a test of this kind with wire that is already hard is exceedingly difficult. Every one who has tried to break off a piece of tough wire by bending it back and forth between the fingers, knows how hard it is to confine the bend to one place, because of the hardening action of the previous bends. Hard wire which has been wrapped around a wire of small diameter is hardened still more and it is almost impossible to straighten the wire, let alone re-coil it in the opposite direction. In the opinion of the committee, it is inadvisable to include a test which at best is so indefinite as a wrap test. Furthermore, it is the opinion of the committee that wire which will meet the physical tests included in these specifications will meet any properly made twist or wrap test that would reasonably be required

The committee has carefully considered the matter of twist and wrap tests in connection with both hard-drawn and medium hard-drawn wire, and it is their final opinion that while there might be some possible reason for requiring that wire shall stand wrapping around a wire of equal diameter, there can be no good reason for including in specifications the requirement that it shall stand unwrapping and re-wrapping, because such a test is indefinite and cannot be made otherwise. It is almost physically impossible to unwrap and re-wrap hard-drawn wire about a wire of its own diameter.

**Elastic Limit.**—During the tension test on wire, there is seldom to be observed any definite drop of the beam or increase in the rate of elongation, corresponding to the yield point commonly observed in testing steel. The only way in which the elastic limit of hard wire may be determined is by the actual plotting of the elastic curve from extensometer readings. Even such tests are difficult of interpretation, because the wire when available for tests is usually curved, due to its having been put up in a coil. There are little sets observable before the true
elastic limit has been reached, owing to the fact that one side of the wire, having been stretched in coiling, is really a little harder than the other side, and the pull is, therefore, not even. Considering the difficulty of making the test and the uncertainty of the results obtained, it is the opinion of the committee that it would be inadvisable to include an elastic limit test in these specifications. It is evident that if the designing engineer requires a knowledge of the location of the elastic limit, for purposes of calculation in designing, such data can be obtained by special tests on representative sizes of wire, which will fix the relation of the elastic limit to the ultimate strength for all wire which is properly made.

Tests carefully made by members of the committee show that the elastic limit of medium hard-drawn wire averages 50 per cent of the ultimate tensile strength required in these specifications. This statement of experience is based on the definition of elastic limit as "that point on the elastic curve beyond which the ratio of stress to strain ceases to be constant."

9. Conductivity.—Electric conductivity was formerly expressed as a percentage on the basis of a determination made by Matthiessen about 1865, of the electric resistivity of supposedly pure copper. Since that time the methods of refining copper have advanced, so that it is not uncommon to find copper of over 100 per cent conductivity on the Matthiessen basis. There has until recently not been international agreement on the electric resistivity of copper to be considered the standard for the expression of conductivity. While international agreement upon the value 0.15328 ohms per meter-gram at 20° C. for the resistivity of copper equal to 100 per cent conductivity was reached by the International Electro-Technical Commission in 1913, it has been deemed preferable to express the requirements in standard specifications in the terms of quantities directly measurable, rather than by reference to some quantity whose standard value is the subject of agreement only. The use of the arbitrary term "conductivity" has no more warrant than the employment of arbitrary gage numbers. Therefore, in these specifications the requirements are stated as the maximum rejection limits to the resistivity.

For the convenience of those who are accustomed to express
resistivity in any one of the several more or less common units, the following table of equivalents has been prepared, giving the resistivity of copper at 20° C.:

896.15 lb. per mile-ohm is equal to:
- 0.15694 ohms per meter-gram,
- 1.7654 microhms per centimeter-cube,
- 0.69504 microhms per inch-cube,
- 10.619 ohms per mil-foot.

905.44 lb. per mile-ohm is equal to:
- 0.15857 ohms per meter-gram,
- 1.7837 microhms per centimeter-cube,
- 0.70224 microhms per inch-cube,
- 10.729 ohms per mil-foot.
STANDARD SPECIFICATIONS.

FOR

SOFT OR ANNEALED COPPER WIRE.


The specifications for this material are issued under the fixed designation B 3; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912; REVISED, 1913, 1915.

Material. 1. The copper shall be of such quality and purity that, when drawn and annealed, it shall have the properties and characteristics herein required.

Shapes. 2. These specifications cover untinned drawn and annealed round wire.

Finish. 3. (a) The wire must be free from all imperfections not consistent with the best commercial practice.

(b) Necessary brazes in soft or annealed wire must be made in accordance with the best commercial practice.

Packages. 4. (a) Wire may be shipped in coils or on reels as agreed upon by the purchaser and manufacturer. In Table I there are stated the maximum and minimum weights of wire of the stated sizes which may be shipped in any one package, whether coil, reel or spool; in the case of wire larger than 0.010 in. in diameter, the maximum and minimum package weights are net, and in the case of wire 0.010 in. and less in diameter, the maximum package weights are gross, and the minimum package weights are net. The table also states the limiting dimensions of the coils, reels and spools on which wire may be shipped. The length
and diameter stated for reels and spools are to be measured overall and are maximum sizes; reels or spools smaller than these may be used provided the minimum weights called for are carried by the reel or spool. In the table, there are also stated the diameters of the draw-block on which the final drawing of the wire is to be made, when wire is shipped in coils; it being understood that the wire is not to be re-wound after final drawing. This provision is made to insure that coils of wire of a given gage, when supplied by different manufacturers, will be of the same general dimensions.

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<td>2½</td>
<td>4</td>
<td>1½ to 2½</td>
<td></td>
</tr>
</tbody>
</table>

Wire 0.204 in. in diameter and larger may be shipped in larger packages when agreed upon.

(b) The wire shall be protected against damage in ordinary handling and shipping.

5. For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken as 8.89 at 20° C.

6. (a) Size shall be expressed as the diameter of the wire in decimal fractions of an inch.

(b) Wire shall be accurate in diameter; permissible variations from nominal diameter shall be:

For wire 0.010 in. in diameter and larger, one per cent over or under;
Specifications for Soft Copper Wire.

For wire less than 0.010 in. in diameter, 0.1 mil (0.0001 in.) over or under.

(c) Each coil shall be gaged at three places, one near each end and one approximately at the middle; from spools, approximately 12 ft. shall be reeled off, the wire shall be gaged in six places between the second and twelfth foot from the end. The coils or spools will be rejected if the average of the measurements obtained is not within the limits specified in Paragraph (b).

7. Wire shall be so drawn and annealed that its tensile strength shall not be greater than the value stated in Table II and its elongation not less than the value stated in Table II. Tensile tests shall be made upon fair samples, and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally 10 in. apart. The fracture shall be between the bench marks and not closer than 1 in. to either bench mark. If upon testing a sample from any coil, reel or spool of wire, the results are found to be below the stated value in elongation or above the stated value in tensile strength, tests upon two additional samples shall be made, and the average of the three tests shall determine acceptance or rejection of the coil. For wire whose nominal diameter is between listed sizes, the requirements shall be those of the next larger size included in the table.

Table II.

<table>
<thead>
<tr>
<th>Diameter, in.</th>
<th>Tensile Strength, lb. per sq. in.</th>
<th>Elongation in 10 in., per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.460 to 0.290</td>
<td>36 000</td>
<td>35</td>
</tr>
<tr>
<td>0.289 &quot; 0.103</td>
<td>37 000</td>
<td>30</td>
</tr>
<tr>
<td>0.102 &quot; 0.021</td>
<td>38 500</td>
<td>25</td>
</tr>
<tr>
<td>0.020 &quot; 0.003</td>
<td>40 000</td>
<td>20</td>
</tr>
</tbody>
</table>

8. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.), and it shall not exceed 891.58 lb. per mile-ohm.

9. All testing and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to the requirements of these specifications.
EXPLANATORY NOTES.

Soft or annealed copper wire is wire which has been drawn by customary operations and annealed, and finished by cleaning when necessary to remove scale or oxide. The wire is so soft and ductile that it is easily marred and even stretched by careless handling in the operations of winding or cabling, hence the necessity for confining specifications and inspection to wire in packages as it leaves the manufacturer, and before being put through processes incident to its use by the purchaser.

4. (a) Attention is called to the necessity for the purchaser and manufacturer agreeing on the package weights which will be standard under any individual contract. The committee\(^1\) has indicated limitations to standard package weights which in their opinion will provide packages of sufficient size to be desirable, and without being so large that the wire is apt to be damaged in handling.

5. The specific gravity of copper was formerly standardized in these specifications at 8.90. The value has been changed to 8.89, since that is the value adopted as standard by the American Institute of Electrical Engineers and the International Electrotechnical Commission.

6. The use of arbitrary gage numbers to express dimensions cannot be too strongly condemned. There are many such gages in existence, and confusion is to be expected unless the particular gage to be used is specified. Many of the gages have their dimensions stated in absurd figures, such as 0.090742 in., when it is not especially easy to measure dimensions in the fourth decimal place by workshop tools. Definite diameters in measurable units are evidently preferable.

8. Electric conductivity was formerly expressed as a percentage on the basis of a determination made by Matthiessen about 1865, of the electric resistivity of supposedly pure copper. Since that time the methods of refining copper have advanced, so that it is not uncommon to find copper of over 100 per cent conductivity on the Matthiessen basis. There has until recently not been international agreement on the electric resistivity of copper to be considered the standard for the expression of conductivity. While international agreement upon the value

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\(^1\) Committee B-1 on Standard Specifications for Copper Wire.
Specifications for Soft Copper Wire.

0.15328 ohms per meter-gram at 20° C. for the resistivity of copper equal to 100 per cent conductivity was reached by the International Electro-Technical Commission in 1913, it has been deemed preferable to express the requirements in standard specifications in the terms of quantities directly measurable, rather than by reference to some quantity whose standard value is the subject of agreement only. The use of the arbitrary term "conductivity" has no more warrant than the employment of arbitrary gage numbers. Therefore, in these specifications the requirements are stated as the maximum rejection limits to the resistivity.

For the convenience of those who are accustomed to express resistivity in any one of the several more or less common units, the following table of equivalents has been prepared, giving the resistivity of copper at 20° C.:

891.58 lb. per mile-ohm is equal to:

0.15614 ohms per meter-gram,
1.7564 microhms per centimeter-cube,
0.69150 microhms per inch-cube,
10.565 ohms per mil-foot.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS
FOR
BARE CONCENTRIC-LAY COPPER CABLE:
HARD, MEDIUM-HARD, OR SOFT.

Serial Designation: B 8–16.

The specifications for this material are issued under the fixed designation B 8; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

I. MANUFACTURE.

1. (a) These specifications cover bare concentric-lay cables made from round copper wires laid helically around a central core in one or more layers. The central core shall be made of wire having the same quality and temper as the concentric layers, unless otherwise especially provided for in separate specifications governing the individual case.

(b) The purposes for which the several classes of concentric-lay cables are generally used are as follows:

Class A, for bare, weatherproof, slow-burning, and slow-burning weatherproof cable for aerial use.

Class B, for various insulated cable, such as rubber, paper, varnished cloth, etc.

Class C, for cable where greater flexibility is required than in Class B.

2. The copper wires entering into the construction of standard concentric-lay cable shall, before stranding, meet all Requirements of Wires.
the requirements of that one of the Standard Specifications of the American Society for Testing Materials for Hard-Drawn, Medium Hard-Drawn, or Soft or Annealed Copper Wire (Serial Designations: B 1, B 2, or B 3), which applies.

3. Brazes may be made in the wire when finished and ready for cabling. Such brazes shall be made in accordance with the best commercial practice. No brazes in cable made from hard, or medium hard-drawn copper wire may be closer together than 50 ft.

Pitch and Lay. 4. The pitch of standard cable shall not be less than 12 nor more than 16 diameters of the cable, and the lay may be right or left-handed, unless one direction of lay is specified by the purchaser.

II. PHYSICAL PROPERTIES AND TESTS.

5. Tests for the physical and electrical properties of the wires composing the cables may be made before, but not after, stranding. Experience indicates that the tensile strength of concentric-lay copper cable of standard pitch is at least 90 per cent of the total strength required of the wires forming the cable.

6. For the purpose of calculating weights, cross-sections, etc., the specific gravity of copper shall be taken as 8.89 at 20° C. The resistance and mass of a stranded conductor are greater than in a solid conductor of the same cross-sectional area, depending on the lay (that is, the pitch of the twist of the wires). Two per cent shall be taken as the standard increment of resistance and of mass. In cases where the lay is definitely known, the increment shall be calculated and not assumed.

7. The area of cross-section of the completed cable shall not be more than 2 per cent below the area specified, as determined by weight.

8. The area of cross-section, number and diameter of wires, in standard cable Classes A, B, and C, shall be as specified in Table I.

III. PACKING AND SHIPPING.

9. (a) Package sizes for cable shall be agreed upon in the placing of individual orders.
(b) The cable shall be protected against damage in ordinary handling and transportation.

<table>
<thead>
<tr>
<th>Area of Cross-Section, circular mils.</th>
<th>Approximate A. W. G. or B. &amp; S. Gage Sizes.</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
</tr>
</thead>
<tbody>
<tr>
<td>200000</td>
<td>91</td>
<td>148.2</td>
<td>127</td>
<td>125.5</td>
</tr>
<tr>
<td>190000</td>
<td>91</td>
<td>144.5</td>
<td>127</td>
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<td>140.6</td>
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<td>170000</td>
<td>91</td>
<td>136.6</td>
<td>127</td>
<td>115.7</td>
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<tr>
<td>160000</td>
<td>91</td>
<td>132.6</td>
<td>127</td>
<td>112.2</td>
</tr>
<tr>
<td>150000</td>
<td>61</td>
<td>156.8</td>
<td>91</td>
<td>128.4</td>
</tr>
<tr>
<td>140000</td>
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<td>151.5</td>
<td>91</td>
<td>124.0</td>
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<tr>
<td>120000</td>
<td>61</td>
<td>140.3</td>
<td>91</td>
<td>114.8</td>
</tr>
<tr>
<td>110000</td>
<td>61</td>
<td>134.3</td>
<td>91</td>
<td>109.9</td>
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<td>7-19</td>
<td>173.0-105.5</td>
<td>19</td>
<td>105.5</td>
</tr>
<tr>
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<td>3/0</td>
<td>155.0-94.0</td>
<td>19</td>
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</tr>
<tr>
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<td>2/0</td>
<td>138.0</td>
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<tr>
<td>106000</td>
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<td>7</td>
<td>97.4</td>
</tr>
<tr>
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<tr>
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<td>4</td>
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<td>68.8</td>
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<td>5</td>
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<td>7</td>
<td>61.2</td>
</tr>
<tr>
<td>20800</td>
<td>7</td>
<td>54.5</td>
<td>7</td>
<td>54.5</td>
</tr>
<tr>
<td>16500</td>
<td>8</td>
<td>48.6</td>
<td>7</td>
<td>48.6</td>
</tr>
</tbody>
</table>

Note.—Class A cable, sizes 4/0 and 3/0, is usually 7-strand when bare and 19-strand when weatherproof, etc.

IV. INSPECTION.

10. (a) All testing and inspection, both of individual wires entering into the construction of the cable, and of the completed cable, shall be made at the place of manufacture. Tests on individual wires shall be made on samples taken before cabling, and not on wires removed from the completed cable.
(b) The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to the requirements of these specifications.

V. DEFINITION OF TERMS.

11. Concentric-Lay Cable.—A single conductor cable composed of a central core surrounded by one or more layers of helically laid wires.

12. Lay.—The lay of a cable is the length expressed in inches for each complete turn of the wire around the axis, measured along its axis.

13. Direction of Lay.—The direction of lay is the lateral direction in which the strands of a cable run over the top of the cable as they recede from an observer looking along the axis of the cable.

EXPLANATORY NOTES.

1. Classes of Cable.—These specifications have been drawn to cover cables made from hard-drawn, medium hard-drawn, and soft copper wire, since the manufacturing of cables from the various classes of wire is similar, and the physical properties of the cable depend upon, and are usually expressed in, terms of those of the class of wire employed.

2. Physical Properties.—The accurate testing of cable for its physical properties is practically impossible in commercial laboratories. In order to do this, it is necessary to use long lengths and hold the samples in such a way that the wires shall all be in equal tension. Otherwise the strength will be considerably below the actual strength of the cable. A much more accurate idea of the quality of the cable may be obtained by testing the individual wires before cabling than by attempting tests of the physical properties of the finished cable.

Wires unlaid from cable will manifestly have different physical and electrical properties from those of the wire when prepared for cabling, on account of the deformation brought about by laying and again straightening for test.

3. Stranding Table.—The stranding table covers present practice. Class A covers the usual bare and weatherproof con-
Serial Designation: B 8-16.

struction. Class B is the same as adopted by the Standards Committee of the American Institute of Electrical Engineers, and is given in the Bureau of Standards Circular No. 31, Table XII.

In Class C the figures are those of the Bureau of Standards, Circular No. 31, Table XII, with additions to cover well-established practice. There is need for a table to cover extra-flexible stranding from soft wire, but there are differences of opinion in regard to what should become standard practice. The Standards Committee of the A. I. E. E. have this matter under consideration, and it has seemed best not to attempt to include figures for extra-flexible stranding in this specification. The stranding table will necessarily be the subject of revision which will be undertaken in cooperation with the Standards Committee of the A. I. E. E.
STANDARD SPECIFICATIONS
FOR
HIGH-STRENGTH BRONZE TROLLEY WIRE,
ROUND AND GROOVED:
40 AND 65-PER-CENT CONDUCTIVITY.

Serial Designation: B 9 – 16.

The specifications for this material are issued under the fixed designation B 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

I. MANUFACTURE.

1. These specifications cover round and grooved bronze trolley wire.

2. The material used shall be bronze of such nature and composition as to secure, by proper treatment, the qualities hereinafter specified for the finished wire. Bronze of two qualities may be required—one to have a conductivity of 40 per cent, and the other a conductivity of 65 per cent.

3. Necessary brazes in trolley wire shall be made in accordance with the best commercial practice, and tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.
II. PHYSICAL PROPERTIES AND TESTS.

4. (a) Round wire shall conform to the requirements as Tension Tests. to tensile properties specified in Table I.

(b) The tensile strength of grooved wire shall be at least 95 per cent of that required for round wire of the same sectional area; the elongation of grooved wire shall be the same as that required for round wire of the same sectional area.

5. Tension tests shall be made upon fair samples, and the elongation of the wire shall be determined as permanent increase in length, due to the breaking of the wire in tension, measured between bench marks placed upon the wire originally 10 in. apart. The fracture shall be between the bench marks, and

<table>
<thead>
<tr>
<th>Table I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-per-cent Conductivity Bronze.</td>
</tr>
<tr>
<td>Diameter, in.</td>
</tr>
<tr>
<td>0.460</td>
</tr>
<tr>
<td>0.410</td>
</tr>
<tr>
<td>0.365</td>
</tr>
<tr>
<td>0.325</td>
</tr>
</tbody>
</table>

| 65-per-cent Conductivity Bronze. |
| Diameter, in. | Area, circular mils. | Tensile Strength, lb. per sq. in. | Elongation in 10 in., per cent. |
| 0.460 | 211,600 | 58,300 | 3.00 |
| 0.410 | 168,100 | 59,800 | 3.00 |
| 0.365 | 133,225 | 61,600 | 2.50 |
| 0.325 | 105,025 | 66,300 | 2.25 |

not closer than 1 in. to either mark. If, upon testing a sample from any coil or reel of wire, the results are found to be below the value stated in the table, tests on two additional samples shall be made, and the average of the three tests shall determine the acceptance or rejection of the coil or reel.

6. (a) Round wire, known as “40-per-cent Conductivity,” shall have a conductivity of not less than 40 per cent, figured according to the International Annealed Copper Standard, which is 0.15328 ohms per meter-gram at 20° C.

Round wire, known as “65-per-cent Conductivity,” shall have a conductivity of not less than 65 per cent, figured according to the same standard.
(b) The requirements for conductivity of grooved wire shall be the same as those for round wire of the same sectional area.

III. STANDARD SIZES AND DIMENSIONS.

7. (a) The size of round wire shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals, that is, in mils.

(b) Round wire is expected to be accurate in diameter. Variations of one per cent over or under nominal diameter shall be permissible.

8. (a) Standard sections of grooved trolley wire shall be those known as the "American Standard Grooved Trolley Wire Sections," the shape and dimensions of which are shown in Fig. 1.

(b) The size of grooved wire shall be expressed as the area of cross-section in circular mils, the standard sizes being as follows:

- 211,600 circular mils, weighing................ 3,386 lb. per mile
- 168,100 " " " 2,690 " " "
- 133,200 " " " 2,132 " " "

(c) Grooved trolley wire may vary 4 per cent over or under in weight per unit length from standard as determined from the nominal cross-section.

IV. WORKMANSHIP AND FINISH.

9. The wire shall be free from all imperfections not consistent with the best commercial practice.
V. PACKING AND SHIPPING.

10. All wire shall be furnished on substantial reels, suitable for the weight of the wire handled, and shall be protected against damage in ordinary handling and transportation. The length or weight of wire to be wound upon reels shall be agreed upon in placing individual orders.

VI. INSPECTION.

11. (a) All testing and inspection shall be made at the place of manufacture.

(b) The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to the requirements of these specifications.
STANDARD SPECIFICATIONS
FOR
LAKE COPPER WIRE BARS, CAKES, SLABS, BILLETS, INGOTS, AND INGOT BARS.


The specifications for this material are issued under the fixed designation B 4; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOP TED, 1911; REVISED, 1913.

**Definition.**

1. In order to be classed as Lake, copper must originate on the northern peninsula of Michigan, U. S. A.

**Marks.**

2. All wire bars, cakes, slabs, and billets shall be stamped with the maker's brand and furnace charge mark. Ingots and ingot bars shall have a brand stamped or cast in, but need have no furnace charge mark.

**Lots.**

3. The refiner shall arrange carloads or lots so that as far as possible each shall contain pieces from but one furnace charge, in order to facilitate testing by the user.

**Resistivity.**

4. *(a)* Low Resistance Lake.—Lake copper offered for electrical purposes, whether fire or electrolytically refined, shall be known as "Low Resistance Lake."

Low Resistance Lake wire bars shall have a resistivity not to exceed 0.15535 international ohms per meter-gram at 20° C. (annealed). All ingots and ingot bars shall have a resistivity not to exceed 0.15694 international ohms per meter-gram at 20° C. (annealed).
Cakes, slabs, and billets shall come under the ingot classification, except when specified for electrical use at time of purchase; in which case wire-bar classification shall apply.

(b) **High Resistance Lake.**—Lake copper having a resistivity greater than 0.15694 international ohms per meter-gram at 20°C. shall be known as "High Resistance Lake."

5. (a) Low Resistance Lake copper shall have a purity of at least 99.880 per cent as determined by electrolytic assay, silver being counted as copper.

(b) High Resistance Lake copper shall have a purity of at least 99.880 per cent, copper, silver, and arsenic being counted together. The arsenic content of High Resistance Lake copper, when required for special purposes, shall be the subject of agreement at time of purchase.

6. Wire bars, cakes, slabs, and billets shall be substantially free from shrink holes, cold sets, pits, sloppy edges, concave tops and similar defects in set or casting. This clause shall not apply to ingots or ingot bars, in which case physical defects are of no consequence.

7. Five per cent variation in weight or \( \frac{1}{4} \) in. variation in any dimension from the refiner's published list or purchaser's specified size shall be considered good delivery; provided, however, that wire bars may vary in length 1 per cent from the listed or specified length, and cakes 3 per cent from the listed or specified size in any dimension greater than 8 in. The weight of ingot and ingot-bar copper shall not exceed that specified by more than 10 per cent, but otherwise its variation is not important.

8. Claims shall be made in writing within thirty days of receipt of copper at the customer's mill, and the results of the customer's tests shall accompany such claims. The refiner shall be given one week from date of receipt of complaint to investigate his records, and shall then either agree to replace the defective copper or send a representative to the mill. No claims will be considered unless made as above stated, and if the copper in question, unused, cannot be shown to the refiner's representative.

Claims against quality will be considered as follows:
Specifications for Lake Copper.

(a) Resistivity by furnace charges, ingot lots, or ingot-bar lots.

(b) Metal contents by furnace charges, ingot lots, or ingot-bar lots.

(c) Physical defects by individual pieces.

(d) Variation in weights or dimensions by individual pieces.

9. The refiner's representative shall inspect all pieces where physical defects or variation in weight or dimension are claimed. If agreement is not reached, the question of fact shall be submitted to a mutually agreeable umpire, whose decision shall be final.

In a question of metal contents each party shall select a sample of two pieces. These shall be drilled in the presence of both parties, several holes approximately \( \frac{1}{2} \) in. in diameter being drilled completely through each piece; scale from set shall be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of chips. The resulting samples shall be cut up, mixed, and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact, and whose determination shall be final.

In a question of resistivity each party shall select two samples, and in the presence of both parties these shall be rolled hot and drawn cold into wire of 0.080 in. diameter, approximately, which shall be annealed at approximately 500° C. Three samples shall be cut from each coil and the same procedure followed as described in the previous paragraph.

10. The expenses of the shipper's representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. In case of rejection being established, the damage shall be limited to payment of freight both ways by the refiner for substitution of an equivalent weight of copper meeting these specifications.
EXPLANATORY NOTE.

These specifications have been drawn to cover the peculiar trade situation which has classified the large production of copper from this geographical district as a product in a class by itself.

It is realized that a better classification from an academic point of view could be made by method of production or by chemical composition, but the trade does not yet seem ready for such a step.
STANDARD SPECIFICATIONS
FOR
ELECTROLYTIC COPPER WIRE BARS, CAKES, SLABS, BILLETS, INGOTS, AND INGOT BARS.


The specifications for this material are issued under the fixed designation B 5; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1911; Revised, 1913.

Marks. 1. All wire bars, cakes, slabs, and billets shall be stamped with the maker's brand and furnace charge mark. Ingots and ingot bars shall have a brand stamped or cast in, but need have no furnace charge mark.

Lots. 2. The refiner shall arrange carloads or lots so that as far as possible each shall contain pieces from but one furnace charge, in order to facilitate testing by the user.

Quality. 3. (a) Metal Content.—The copper in all shapes shall have a purity of at least 99.880 per cent, as determined by electrolytic assay, silver being counted as copper.

(b) Resistivity.—All wire bars shall have a resistivity not to exceed 0.15535 international ohms per meter-gram at 20° C. (annealed); all ingot and ingot bars shall have a resistivity not to exceed 0.15694 international ohms per meter-gram at 20° C. (annealed).

Cakes, slabs, and billets shall come under the ingot classification, except when specified for electrical use at time of purchase, in which case wire-bar classification shall apply.
4. Wire bars, cakes, slabs, and billets shall be substantially free from shrink holes, cold sets, pits, sloppy edges, concave tops, and similar defects in set or casting. This clause shall not apply to ingots or ingot bars, in which case physical defects are of no consequence.

5. Five per cent variation in weight or \( \frac{1}{4} \) in. variation in any dimension from the refiner's published list or purchaser's specified size shall be considered good delivery; provided, however, that wire bars may vary in length 1 per cent from the listed or specified length, and cakes 3 per cent from the listed or specified size in any dimension greater than 8 in. The weight of ingot and ingot-bar copper shall not exceed that specified by more than 10 per cent, but otherwise its variation is not important.

6. Claims shall be made in writing within thirty days of receipt of copper at the customer's mill, and the results of the customer's tests shall accompany such claims. The refiner shall be given one week from date of receipt of complaint to investigate his records, and shall then either agree to replace the defective copper or send a representative to the mill. No claims shall be considered unless made as above stated, and if the copper in question, unused, cannot be shown to the refiner's representative.

Claims against quality will be considered as follows:

(a) Resistivity by furnace charges, ingot lots, or ingot-bar lots.

(b) Metal contents by furnace charges, ingot lots, or ingot-bar lots.

(c) Physical defects by individual pieces.

(d) Variation in weights or dimensions by individual pieces.

7. The refiner's representative shall inspect all pieces where physical defects or variation in weight or dimension are claimed. If agreement is not reached, the question of fact shall be submitted to a mutually agreeable umpire, whose decision shall be final.

In a question of metal contents each party shall select a sample of two pieces. These shall be drilled in the presence of both parties, several holes approximately \( \frac{1}{4} \) in. in diameter.
being drilled completely through each piece; scale from set shall be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of chips. The resulting samples shall be cut up, mixed, and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact, and whose determination shall be final.

In a question of resistivity each party shall select two samples, and in the presence of both parties these shall be rolled hot and drawn cold into wire of 0.080 in. diameter, approximately, which shall be annealed at approximately 500° C. Three samples shall be cut from each coil and the same procedure followed as described in the previous paragraph.

8. The expenses of the shipper’s representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. In case of rejection being established, the damage shall be limited to payment of freight both ways by the refiner for substitution of an equivalent weight of copper meeting these specifications.
STANDARD SPECIFICATIONS
FOR
SPELTHER.

Serial Designation: B 6–14.

The specifications for this material are issued under the fixed designation B 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1911; Revised, 1914.

1. Under these specifications Virgin Spelter, that is, spelter Grades made from ore or similar raw material by a process of reduction and distillation and not produced from reworked metal, is considered in four grades, as follows:

   A .................. High Grade.
   B .................. Intermediate.
   C .................. Brass Special.
   D .................. Prime Western.

2. A brand shall be cast in each slab by which the maker Marks and grade can be identified.

3. The maker shall use care to have each carload of as Lots. uniform quality as possible.

4. A. High Grade.—The spelter shall not contain over: Composition.

   0.07 per cent lead.
   0.03 " iron.
   0.05 " cadmium.

It shall be free from aluminum.
The sum of the lead, iron, and cadmium shall not exceed 0.10 per cent.

B. Intermediate.—The spelter shall not contain over:

0.20 per cent lead.
0.03 " iron.
0.50 " cadmium.

It shall be free from aluminum.
The sum of the lead, iron, and cadmium shall not exceed 0.50 per cent.

C. Brass Special.—The spelter shall not contain over:

0.75 per cent lead.
0.04 " iron.
0.75 " cadmium.

It shall be free from aluminum.
The sum of the lead, iron, and cadmium shall not exceed 1.20 per cent.

D. Prime Western.—The spelter shall not contain over:

1.50 per cent lead.
0.08 " iron.

Physical. 5. The slabs shall be reasonably free from surface corrosion or adhering foreign matter.

Sampling. 6. Not less than ten slabs shall be taken as a sample from each car; for smaller lots, in the same proportion to the total number, but in no case less than three slabs. In case of dispute half of the sample is to be taken by the maker and half by the purchaser; and the whole shall be mixed.

The slabs selected as samples are to be sawed completely across and the sawdust used as a sample. In case no saw is available for this purpose, the slabs should be drilled completely through and the drillings cut up into short lengths. The saw or drill used must be thoroughly cleaned. No lubricant shall be used in either sawing or drilling, and the sawdust or drilling must be carefully treated with a magnet to remove any particles of iron derived from the tools.

Analysis. 7. Lead.—For the determination of lead in High Grade not less than 25 g., in Intermediate not less than 15, in Brass Special not less than 10, and in Prime Western not less than 5 g., shall
be taken; that is, the sample used for analysis should not contain less than 0.01 g. lead.

_Iron._—The sample for iron should contain not less than 25 g. for the three higher grades and not less than 10 g. for Prime Western. The entire sample must be dissolved, the iron precipitated as ferric hydroxide, then redissolved, reduced, and the iron determined by titration.

_Cadmium._—Dissolve 25 g. in 330 cc. of a solution of one part of hydrochloric acid (specific gravity 1.2) and five parts of water. Let it stand over night; filter and wash; reject filtrate and dissolve the residue, which should be about 5 per cent of the zinc, in nitric acid. Add 10 cc. of sulfuric acid; evaporate to fumes; dilute and filter out and wash the lead sulfate. Dilute the solution to 500 cc.; add 5 g. of ammonium chloride; pass a slow stream of hydrogen sulfide for one hour and let stand for about five hours; filter, wash with hot water; dissolve by boiling in 10 cc. of sulfuric acid and 50 cc. of water; filter and wash. Dilute to 400 cc.; precipitate with hydrogen sulfide as before. Weigh as cadmium sulfide or dissolve in hydrochloric acid and titrate with potassium ferrocyanide.

8. Claims to be considered shall be in writing within thirty days of receipt of material at customer’s mill and the results of customer’s test shall be given. The shipper shall be given one week from date of receipt of such claim to investigate his records and then shall either agree to satisfy the claim or send a representative to the mill.

(a) _Analysis by Car Lots._—No claims shall be considered unless the minimum samples as specified for the grade in question can be shown to such representative.

(b) _Physical Defects of Individual Pieces._—No claims shall be considered unless the spelter in question, unused, can be shown to such representative.

9. Where the spelter satisfies the chemical and physical requirements of these specifications, it shall not be condemned for defects of alloys in which it is used or for defects in the coating of galvanized products.

10. The maker’s representative shall inspect all pieces where physical defects are claimed. If agreement is not reached the question of fact shall be submitted to a mutually agreeable umpire, whose decision shall be final.
On a question of metal contents an adequate sample shall be drawn by the representatives of both parties; the sample shall be prepared from the slabs so selected as described under "Sampling." The sample shall be mixed and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality and whose determination shall be final.

11. The expenses of the maker's representative and of the umpire shall be paid by the loser or divided in proportion to concession made in case of compromise.

In case of rejection being established, damages shall be limited to the payment of freight both ways by the maker for substitution of an equivalent weight of spelter meeting these specifications.
STANDARD SPECIFICATIONS
FOR
MANGANESE-BRONZE INGOTS FOR SAND CASTINGS.

Serial Designation: B 7–14.

The specifications for this material are issued under the fixed designation B 7; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1911; REVISED, 1914.

1. These specifications are intended to cover the copper-zinc alloy, known commercially as manganese-bronze, in the form of ingots having notched flat bottoms, approximately 3 by 2\(\frac{3}{4}\) in. wide by 12 in. long, properly tapered to strip easily from an iron mold.

2. The chemical composition shall be as follows:

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition</th>
<th>per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>...</td>
<td>53 to 62</td>
</tr>
<tr>
<td>Zinc</td>
<td>...</td>
<td>36 to 45</td>
</tr>
<tr>
<td>Aluminum</td>
<td>...</td>
<td>0.05 to 0.5</td>
</tr>
<tr>
<td>Lead</td>
<td>...</td>
<td>not over 0.15</td>
</tr>
</tbody>
</table>

3. The ultimate tensile strength shall be not less than 70,000 lb. per sq. in.

The elongation in 2 in. shall be not less than 20 per cent.

4. The standard turned test specimen, as shown by Fig. 1, 0.5 in. diameter and 2 in. gage length, shall be used to determine the physical properties as specified above.

(427)
5. One test ingot shall be selected by the inspector to represent 10,000 lb. of ingots or fraction thereof. The test specimen shall be cut from one corner near the bottom of the ingot. In case the test specimen shows a flaw, two additional tests may be selected by the inspector from the same lot, and tested to represent the lot in question.

6. Each ingot shall be stamped with its proper heat or charge number.

7. All ingots in each lot will be rejected upon the physical tests or chemical composition, irrespective of the heat or heats from which the test ingots are selected.

8. In case the buyer's tests show that the material does not meet these specifications, the seller shall have an opportunity to inspect the material and each party shall select a sample for retest. If the results do not agree, each shall select a sample to be sent to a mutually agreeable umpire, whose decision shall be final. The costs of such retests shall be paid by the loser.
STANDARD SPECIFICATIONS AND TESTS
FOR
PORTLAND CEMENT.

These specifications are the result of several years' work of a special committee representing a United States Government Departmental Committee, the Board of Direction of the American Society of Civil Engineers, and Committee C-1 on Cement of the American Society for Testing Materials.

Serial Designation: C 9 - 17.

The specifications and tests for this material are issued under the fixed designation C 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1904; Revised, 1908, 1909, 1916.

Specifications.

1. Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion, an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

I. CHEMICAL PROPERTIES.

2. The following limits shall not be exceeded:

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss on ignition, per cent</td>
<td>4.00</td>
</tr>
<tr>
<td>Insoluble residue, per cent</td>
<td>0.85</td>
</tr>
<tr>
<td>Sulfuric anhydride (SO₃), per cent</td>
<td>2.00</td>
</tr>
<tr>
<td>Magnesia (MgO), per cent</td>
<td>5.00</td>
</tr>
</tbody>
</table>

¹ These specifications and tests were adopted by letter ballot of the Society on September 1, 1916, with the understanding that they will not become effective till January 1, 1917.
II. PHYSICAL PROPERTIES.

Specific Gravity. 3. The specific gravity of cement shall be not less than 3.10 (3.07 for white Portland cement). Should the test of cement as received fall below this requirement a second test may be made upon an ignited sample. The specific gravity test will not be made unless specifically ordered.

Finesness. 4. The residue on a standard No. 200 sieve shall not exceed 22 per cent by weight.

Soundness. 5. A pat of neat cement shall remain firm and hard, and show no signs of distortion, cracking, checking, or disintegration in the steam test for soundness.

Time of Setting. 6. The cement shall not develop initial set in less than 45 minutes when the Vicat needle is used or 60 minutes when the Gillmore needle is used. Final set shall be attained within 10 hours.

Tensile Strength. 7. The average tensile strength in pounds per square inch of not less than three standard mortar briquettes (see Section 51) composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

<table>
<thead>
<tr>
<th>Age at Test, days</th>
<th>Storage of Briquettes</th>
<th>Tensile Strength, lb. per sq. in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1 day in moist air, 6 days in water</td>
<td>200</td>
</tr>
<tr>
<td>28</td>
<td>1 day in moist air, 27 days in water</td>
<td>300</td>
</tr>
</tbody>
</table>

8. The average tensile strength of standard mortar at 28 days shall be higher than the strength at 7 days.

III. PACKAGES, MARKING AND STORAGE.

Packages and Marking. 9. The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon, unless shipped in bulk. A bag shall contain 94 lb. net. A barrel shall contain 376 lb. net.

Storage. 10. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness.
IV. INSPECTION.

11. Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least 10 days from the time of sampling shall be allowed for the completion of the 7-day test, and at least 31 days shall be allowed for the completion of the 28-day test. The cement shall be tested in accordance with the methods hereinafter prescribed. The 28-day test shall be waived only when specifically so ordered.

V. REJECTION.

12. The cement may be rejected if it fails to meet any of the requirements of these specifications.

13. Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest after drying at 100° C. for one hour it meets this requirement.

14. Cement failing to meet the test for soundness in steam may be accepted if it passes a retest using a new sample at any time within 28 days thereafter.

15. Packages varying more than 5 per cent from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

TESTS.

VI. SAMPLING.

16. Tests may be made on individual or composite samples as may be ordered. Each test sample should weigh at least 8 lb.

17. (a) Individual Sample.—If sampled in cars one test sample shall be taken from each 50 bbl. or fraction thereof. If sampled in bins one sample shall be taken from each 100 bbl.

(b) Composite Sample.—If sampled in cars one sample shall be taken from one sack in each 40 sacks (or 1 bbl. in each 10 bbl.) and combined to form one test sample. If sampled in bins or warehouses one test sample shall represent not more than 200 bbl.
18. Cement may be sampled at the mill by any of the following methods that may be practicable, as ordered:

(a) From the Conveyor Delivering to the Bin.—At least 8 lb. of cement shall be taken from approximately each 100 bbl. passing over the conveyor.

(b) From Filled Bins by Means of Proper Sampling Tubes.—Tubes inserted vertically may be used for sampling cement to a maximum depth of 10 ft. Tubes inserted horizontally may be used where the construction of the bin permits. Samples shall be taken from points well distributed over the face of the bin.

(c) From Filled Bins at Points of Discharge.—Sufficient cement shall be drawn from the discharge openings to obtain samples representative of the cement contained in the bin, as determined by the appearance at the discharge openings of indicators placed on the surface of the cement directly above these openings before drawing of the cement is started.

19. Samples preferably shall be shipped and stored in air-tight containers. Samples shall be passed through a sieve having 20 meshes per linear inch in order to thoroughly mix the sample, break up lumps and remove foreign materials.

VII. CHEMICAL ANALYSIS.

Loss on Ignition.

20. One gram of cement shall be heated in a weighed covered platinum crucible, of 20 to 25-cc. capacity, as follows, using either method (a) or (b) as ordered:

(a) The crucible shall be placed in a hole in an asbestos board, clamped horizontally so that about three-fifths of the crucible projects below, and blasted at a full red heat for 15 minutes with an inclined flame; the loss in weight shall be checked by a second blasting for 5 minutes. Care shall be taken to wipe off particles of asbestos that may adhere to the crucible when withdrawn from the hole in the board. Greater neatness and shortening of the time of heating are secured by making a hole to fit the crucible in a circular disk of sheet platinum and placing this disk over a somewhat larger hole in an asbestos board.

(b) The crucible shall be placed in a muffle at any tempera-
ture between 900 and 1000° C. for 15 minutes and the loss in weight shall be checked by a second heating for 5 minutes.

21. A permissible variation of 0.25 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 4 per cent.

**Insoluble Residue.**

22. To a 1-g. sample of cement shall be added 10 cc. of water and 5 cc. of concentrated hydrochloric acid; the liquid shall be warmed until effervescence ceases. The solution shall be diluted to 50 cc. and digested on a steam bath or hot plate until it is evident that decomposition of the cement is complete. The residue shall be filtered, washed with cold water, and the filter paper and contents digested in about 30 cc. of a 5-per-cent solution of sodium carbonate, the liquid being held at a temperature just short of boiling for 15 minutes. The remaining residue shall be filtered, washed with cold water, then with a few drops of hot hydrochloric acid, 1 : 9, and finally with hot water, and then ignited at a red heat and weighed as the insoluble residue.

23. A permissible variation of 0.15 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 0.85 per cent.

**Sulfuric Anhydride.**

24. One gram of the cement shall be dissolved in 5 cc. of concentrated hydrochloric acid diluted with 5 cc. of water, with gentle warming; when solution is complete 40 cc. of water shall be added, the solution filtered, and the residue washed thoroughly with water. The solution shall be diluted to 250 cc., heated to boiling and 10 cc. of a hot 10-per-cent solution of barium chloride shall be added slowly, drop by drop, from a pipette and the boiling continued until the precipitate is well formed. The solution shall be digested on the steam bath until the precipitate has settled. The precipitate shall be filtered, washed, and the paper and contents placed in a weighed, platinum crucible and the paper slowly charred and consumed without flaming. The barium sulfate shall then be ignited and weighed. The weight obtained multiplied by 34.3 gives the percentage of sulfuric anhydride. The acid filtrate obtained in
the determination of the insoluble residue may be used for the estimation of sulfuric anhydride instead of using a separate sample.

25. A permissible variation of 0.10 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 2.00 per cent.

Magnesia.

26. To 0.5 g. of the cement in an evaporating dish shall be added 10 cc. of water to prevent lumping and then 10 cc. of concentrated hydrochloric acid. The liquid shall be gently heated and agitated until attack is complete. The solution shall then be evaporated to complete dryness on a steam or water bath. To hasten dehydration the residue may be heated to 150 or even 200° C. for one-half to one hour. The residue shall be treated with 10 cc. of concentrated hydrochloric acid diluted with an equal amount of water. The dish shall be covered and the solution digested for ten minutes on a steam bath or water bath. The diluted solution shall be filtered and the separated silica washed thoroughly with water.¹ Five cubic centimeters of concentrated hydrochloric acid and sufficient bromine water to precipitate any manganese which may be present, shall be added to the filtrate (about 250 cc.). This shall be made alkaline with ammonium hydroxide, boiled until there is but a faint odor of ammonia, and the precipitated iron and aluminum hydroxides, after settling, shall be washed with hot water, once by decantation and slightly on the filter. Setting aside the filtrate, the precipitate shall be transferred by a jet of hot water to the precipitating vessel and dissolved in 10 cc. of hot hydrochloric acid. The paper shall be extracted with acid, the solution and washings being added to the main solution. The aluminum and iron shall then be reprecipitated at boiling heat by ammonium hydroxide and bromine water in a volume of about 100 cc., and the second precipitate shall be collected and washed on the filter used in the first instance if this is still intact. To the combined filtrates from the hydroxides of iron and aluminum, reduced in volume if need be, 1 cc. of ammonium hydroxide shall be added, the solution brought

¹Since this procedure does not involve the determination of silica, a second evaporation is unnecessary.
to boiling, 25 cc. of a saturated solution of boiling ammonium oxalate added, and the boiling continued until the precipitated calcium oxalate has assumed a well-defined granular form. The precipitate after one hour shall be filtered and washed, then with the filter shall be placed wet in a platinum crucible, and the paper burned off over a small flame of a Bunsen burner; after ignition it shall be redissolved in hydrochloric acid and the solution diluted to 100 cc. Ammonia shall be added in slight excess, and the liquid boiled. The lime shall then be reprecipitated by ammonium oxalate, allowed to stand until settled, filtered and washed. The combined filtrates from the calcium precipitates shall be acidified with hydrochloric acid, concentrated on the steam bath to about 150 cc., and made slightly alkaline with ammonium hydroxide, boiled and filtered (to remove a little aluminum and iron and perhaps calcium). When cool, 10 cc. of saturated solution of sodium-ammonium-hydrogen phosphate shall be added with constant stirring. When the crystalline ammonium-magnesium orthophosphate has formed, ammonia shall be added in moderate excess. The solution shall be set aside for several hours in a cool place, filtered and washed with water containing 2.5 per cent of NH₃. The precipitate shall be dissolved in a small quantity of hot hydrochloric acid, the solution diluted to about 100 cc., 1 cc. of a saturated solution of sodium-ammonium-hydrogen phosphate added, and ammonia drop by drop, with constant stirring, until the precipitate is again formed as described and the ammonia is in moderate excess. The precipitate shall then be allowed to stand about two hours, filtered and washed as before. The paper and contents shall be placed in a weighed platinum crucible, the paper slowly charred, and the resulting carbon carefully burned off. The precipitate shall then be ignited to constant weight over a Meker burner, or a blast not strong enough to soften or melt the pyrophosphate. The weight of magnesium pyrophosphate obtained multiplied by 72.5 gives the percentage of magnesia. The precipitate so obtained always contains some calcium and usually small quantities of iron, aluminum, and manganese as phosphates.

27. A permissible variation of 0.4 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 5.00 per cent.
VIII. DETERMINATION OF SPECIFIC GRAVITY.

Apparatus. 28. The determination of specific gravity shall be made with a standardized Le Chatelier apparatus which conforms to the requirements illustrated in Fig. 1. This apparatus is standardized by the United States Bureau of Standards. Kerosene free from water, or benzine not lighter than 62° Baumé, shall be used in making this determination.

Method. 29. The flask shall be filled with either of these liquids to a point on the stem between zero and one cubic centimeter, and 64 g. of cement, of the same temperature as the liquid, shall be slowly introduced, taking care that the cement does not adhere to the inside of the flask above the liquid and to free the cement from air by rolling the flask in an inclined position. After all the cement is introduced, the level of the liquid will rise to some division of the graduated neck; the difference between readings is the volume displaced by 64 g. of the cement.

The specific gravity shall then be obtained from the formula

$$\text{Specific gravity} = \frac{\text{Weight of cement (g.)}}{\text{Displaced volume (cc.)}}$$

30. The flask, during the operation, shall be kept immersed in water, in order to avoid variations in the temperature of the liquid in the flask, which shall not exceed 0.5 C. The results of repeated tests should agree within 0.01.

31. The determination of specific gravity shall be made on the cement as received; if it falls below 3.10, a second determination shall be made after igniting the sample as described in Section 20.

IX. DETERMINATION OF FINENESS.

Apparatus. 32. Wire cloth for standard sieves for cement shall be woven (not twilled) from brass, bronze, or other suitable wire, and mounted without distortion on frames not less than 1\(\frac{1}{2}\) in. below the top of the frame. The sieve frames shall be circular, approximately 8 in. in diameter, and may be provided with a pan and cover.

33. A standard No. 200 sieve is one having nominally an 0.0029-in. opening and 200 wires per inch standardized by the
FIG. 1.—Le Chatelier Apparatus.
Specifications and Tests for Portland Cement.

U. S. Bureau of Standards, and conforming to the following requirements:

The No. 200 sieve should have 200 wires per inch, and the number of wires in any whole inch shall not be outside the limits of 192 to 208. No opening between adjacent parallel wires shall be more than 0.0050 in. in width. The diameter of the wire should be 0.0021 in. and the average diameter shall not be outside the limits 0.0019 to 0.0023 in. The value of the sieve as determined by sieving tests made in conformity with the standard specification for these tests on a standardized cement which gives a residue of 25 to 20 per cent on the No. 200 sieve, or on other similarly graded material, shall not show a variation of more than 1.5 per cent above or below the standards maintained at the Bureau of Standards.

34. The test shall be made with 50 g. of cement. The sieve shall be thoroughly clean and dry. The cement shall be placed on the No. 200 sieve, with pan and cover attached, if desired, and shall be held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side about 150 times per minute against the palm of the other hand on the up stroke. The sieve shall be turned every 25 strokes about one-sixth of a revolution in the same direction. The operation shall continue until not more than 0.05 g. passes through in one minute of continuous sieving. The fineness shall be determined from the weight of the residue on the sieve expressed as a percentage of the weight of the original sample.

35. Mechanical sieving devices may be used, but the cement shall not be rejected if it meets the fineness requirement when tested by the hand method described in Section 34.

36. A permissible variation of 1 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 22 per cent.

X. MIXING CEMENT PASTES AND MORTARS.

37. The quantity of dry material to be mixed at one time shall not exceed 1000 g. nor be less than 500 g. The proportions of cement or cement and sand shall be stated by weight in grams of the dry materials; the quantity of water shall be
expressed in cubic centimeters (1 cc. of water = 1 g.). The dry materials shall be weighed, placed upon a non-absorbent surface, thoroughly mixed dry if sand is used, and a crater formed in the center, into which the proper percentage of clean water shall be poured; the material on the outer edge shall be turned into the crater by the aid of a trowel. After an interval of ½ minute for the absorption of the water the operation shall be completed by continuous, vigorous mixing, squeezing and kneading with the hands for at least one minute. During the operation of mixing, the hands should be protected by rubber gloves.

38. The temperature of the room and the mixing water shall be maintained as nearly as practicable at 21° C. (70° F.).

XI. NORMAL CONSISTENCY.

39. The Vicat apparatus consists of a frame A (Fig. 2) bearing a movable rod B, weighing 300 g., one end C being 1 cm. in diameter for a distance of 6 cm., the other having a removable needle D, 1 mm. in diameter, 6 cm. long. The rod is reversible, and can be held in any desired position by a screw E, and has midway between the ends a mark F which moves under a scale (graduated to millimeters) attached to the frame A. The paste is held in a conical, hard-rubber ring G, 7 cm. in diameter at the base, 4 cm. high, resting on a glass plate H about 10 cm. square.

40. In making the determination, 500 g. of cement, with a measured quantity of water, shall be kneaded into a paste, as described in Section 37, and quickly formed into a ball with the hands, completing the operation by tossing it six times from one hand to the other, maintained about 6 in. apart; the ball resting in the palm of one hand shall be pressed into the larger end of the rubber ring held in the other hand, completely filling the ring with paste; the excess at the larger end shall then be removed by a single movement of the palm of the hand; the ring shall then be placed on its larger end on a glass plate and

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1 In order to secure uniformity in the results of tests for the time of setting and tensile strength the manner of mixing above described should be carefully followed. At least one minute is necessary to obtain the desired plasticity which is not appreciably affected by continuing the mixing for several minutes. The exact time necessary is dependent upon the personal equation of the operator. The error in mixing should be on the side of over mixing.
the excess paste at the smaller end sliced off at the top of the ring by a single oblique stroke of a trowel held at a slight angle with the top of the ring. During these operations care shall be taken not to compress the paste. The paste confined in the ring, resting on the plate, shall be placed under the rod, the larger end of which shall be brought in contact with the surface of the paste; the scale shall be then read, and the rod quickly released. The paste shall be of normal consistency when the rod settles to a point 10 mm. below the original surface in \( \frac{1}{2} \) minute after being released. The apparatus shall be free from all vibrations during the test. Trial pastes shall be made with varying percentages of water until the normal consistency
is obtained. The amount of water required shall be expressed in percentage by weight of the dry cement.

41. The consistency of standard mortar shall depend on the amount of water required to produce a paste of normal consistency from the same sample of cement. Having determined the normal consistency of the sample, the consistency of standard mortar made from the same sample shall be as indicated in Table I, the values being in percentage of the combined dry weights of the cement and standard sand.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>15</td>
<td>9.0</td>
<td>23</td>
<td>10.3</td>
</tr>
<tr>
<td>16</td>
<td>9.2</td>
<td>24</td>
<td>10.5</td>
</tr>
<tr>
<td>17</td>
<td>9.3</td>
<td>25</td>
<td>10.7</td>
</tr>
<tr>
<td>18</td>
<td>9.5</td>
<td>26</td>
<td>10.8</td>
</tr>
<tr>
<td>19</td>
<td>9.7</td>
<td>27</td>
<td>11.0</td>
</tr>
<tr>
<td>20</td>
<td>9.8</td>
<td>28</td>
<td>11.2</td>
</tr>
<tr>
<td>21</td>
<td>10.0</td>
<td>29</td>
<td>11.3</td>
</tr>
<tr>
<td>22</td>
<td>10.2</td>
<td>30</td>
<td>11.5</td>
</tr>
</tbody>
</table>

XII. DETERMINATION OF SOUNDNESS.

42. A steam apparatus, which can be maintained at a temperature between 98 and 100° C., or one similar to that shown in Fig. 3, is recommended. The capacity of this apparatus may be increased by using a rack for holding the pats in a vertical or inclined position.

43. A pat from cement paste of normal consistency about 3 in. in diameter, $\frac{1}{2}$ in. thick at the center, and tapering to a thin edge, shall be made on clean glass plates about 4 in. square,

---

1 Unsoundness is usually manifested by change in volume which causes distortion, cracking, checking or disintegration.

Pats improperly made or exposed to drying may develop what are known as shrinkage cracks within the first 24 hours and are not an indication of unsoundness. These conditions are illustrated in Fig. 4.

The failure of the pats to remain on the glass or the cracking of the glass to which the pats are attached does not necessarily indicate unsoundness.
FIG. 3.—Apparatus for Making Soundness Test of Cement.
FIG. 4.—Typical Failures in Soundness Test.

Distortion.

Disintegration.

Shrinkage.

Checking.

Shrinkage.

Cracking.
and stored in moist air for 24 hours. In molding the pat, the cement paste shall first be flattened on the glass and the pat then formed by drawing the trowel from the outer edge toward the center.

44. The pat shall then be placed in an atmosphere of steam at a temperature between 98 and 100° C. upon a suitable support 1 in. above boiling water for 5 hours.

45. Should the pat leave the plate, distortion may be detected best with a straight edge applied to the surface which was in contact with the plate.

XIII. DETERMINATION OF TIME OF SETTING.

46. The following are alternate methods, either of which may be used as ordered:

47. The time of setting shall be determined with the Vicat apparatus described in Section 39. (See Fig. 2.)

48. A paste of normal consistency shall be molded in the hard-rubber ring G as described in Section 40, and placed under the rod B, the smaller end of which shall then be carefully brought in contact with the surface of the paste, and the rod quickly released. The initial set shall be said to have occurred when the needle ceases to pass a point 5 mm. above the glass plate in \( \frac{1}{2} \) minute after being released; and the final set, when the needle does not sink visibly into the paste. The test pieces shall be kept in moist air during the test. This may be accomplished by placing them on a rack over water contained in a pan and covered by a damp cloth, kept from contact with them by means of a wire screen; or they may be stored in a moist closet. Care shall be taken to keep the needle clean, as the collection of cement on the sides of the needle retards the penetration, while cement on the point may increase the penetration. The time of setting is affected not only by the percentage and temperature of the water used and the amount of kneading the paste receives, but by the temperature and humidity of the air, and its determination is therefore only approximate.

49. The time of setting shall be determined by the Gillmore needles. The Gillmore needles should preferably be mounted as shown in Fig. 5 (b).
50. The time of setting shall be determined as follows: A pat of neat cement paste about 3 in. in diameter and \( \frac{1}{2} \) in. in thickness with a flat top (Fig. 5 (a)), mixed to a normal consistency, shall be kept in moist air at a temperature maintained as nearly as practicable at 21° C. (70° F.). The cement shall be considered to have acquired its initial set when the pat will bear, without appreciable indentation, the Gillmore needle \( \frac{1}{2} \) in. in diameter, loaded to weigh \( \frac{1}{4} \) lb. The final set has been acquired when the pat will bear without appreciable indentation, the Gillmore needle \( \frac{3}{4} \) in. in diameter, loaded to weigh 1 lb. In making the test, the needles shall be held in a vertical position, and applied lightly to the surface of the pat.
XIV. TENSION TESTS.

51. The form of test piece shown in Fig. 6 shall be used. The molds shall be made of non-corroding metal and have sufficient material in the sides to prevent spreading during molding. Gang molds when used shall be of the type shown in Fig. 7. Molds shall be wiped with an oily cloth before using.

52. The sand to be used shall be natural sand from Ottawa, Ill., screened to pass a No. 20 sieve and retained on a No. 30 sieve. This sand may be obtained from the Ottawa Silica Co., at a cost of two cents per pound, f. o. b. cars, Ottawa, Ill.
53. This sand, having passed the No. 20 sieve, shall be considered standard when not more than 5 g. pass the No. 30 sieve after one minute continuous sieving of a 500-g. sample.

54. The sieves shall conform to the following specifications:

The No. 20 sieve shall have between 19.5 and 20.5 wires per whole inch of the warp wires and between 19 and 21 wires per whole inch of the shoot wires. The diameter of the wire should be 0.0165 in. and the average diameter shall not be outside the limits of 0.0160 and 0.0170 in.

The No. 30 sieve shall have between 29.5 and 30.5 wires per whole inch of the warp wires and between 28.5 and 31.5 wires per whole inch of the shoot wires. The diameter of the wire should be 0.0110 in. and the average diameter shall not be outside the limits 0.0105 to 0.0115 in.

55. Immediately after mixing, the standard mortar shall be placed in the molds, pressed in firmly with the thumbs and smoothed off with a trowel without ramming. Additional mortar shall be heaped above the mold and smoothed off with a trowel; the trowel shall be drawn over the mold in such a manner as to exert a moderate pressure on the material. The mold shall then be turned over and the operation of heaping, thumbing and smoothing off repeated.

56. Tests shall be made with any standard machine. The briquettes shall be tested as soon as they are removed from the water. The bearing surfaces of the clips and briquettes shall be free from grains of sand or dirt. The briquettes shall be carefully centered and the load applied continuously at the rate of 600 lb. per minute.

57. Testing machines should be frequently calibrated in order to determine their accuracy.
58. Briquettes that are manifestly faulty, or which give strengths differing more than 15 per cent from the average value of all test pieces made from the same sample and broken at the same period, shall not be considered in determining the tensile strength.

XV. STORAGE OF TEST PIECES.

Apparatus. 59. The moist closet may consist of a soapstone, slate or concrete box, or a wooden box lined with metal. If a wooden box is used, the interior should be covered with felt or broad wicking kept wet. The bottom of the moist closet should be covered with water. The interior of the closet should be provided with non-absorbent shelves on which to place the test pieces, the shelves being so arranged that they may be withdrawn readily.

Methods. 60. Unless otherwise specified all test pieces, immediately after molding, shall be placed in the moist closet for from 20 to 24 hours.

61. The briquettes shall be kept in molds on glass plates in the moist closet for at least 20 hours. After 24 hours in moist air the briquettes shall be immersed in clean water in storage tanks of non-corroding material.

62. The air and water shall be maintained as nearly as practicable at a temperature of 21° C. (70° F.).
STANDARD SPECIFICATIONS
FOR
NATURAL CEMENT.

Serial Designation: C 10 09.

The specifications for this material are issued under the fixed designation C 10; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

AIDOPTED, 1904; REVISED, 1908, 1909.

1. Natural cement is the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas. Definition.

I. PHYSICAL PROPERTIES.

2. The residue on a standard No. 100 sieve shall not exceed 10 per cent, and on a standard No. 200 sieve shall not exceed 30 per cent, by weight.

3. Pats of neat cement about 3 in. in diameter, ½ in. thick at center, tapering to a thin edge, shall be kept in moist air for a period of 24 hours.

(a) A pat shall then be kept in air at normal temperature. Soundness.

(b) Another pat shall be kept in water maintained as near 70° F. as practicable.

These pats shall be observed at intervals for at least 28 days, and, to satisfactorily pass the tests, shall remain firm
Specifications for Natural Cement.

and hard and show no signs of distortion, checking, cracking, or disintegrating.

Time of Setting.  
4. The cement shall not develop initial set in less than 10 minutes, using the Vicat needle. Final set shall be attained in not less than 30 minutes nor more than 3 hours, using the Vicat needle.

Tensile Strength.  
5. The minimum requirements for tensile strength for briquettes 1 sq. in. in cross-section shall be as follows, and the cement shall show no retrogression in strength within the periods specified:

<table>
<thead>
<tr>
<th>Age</th>
<th>Neat Cement</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 hours in moist air</td>
<td>75 lb.</td>
<td></td>
</tr>
<tr>
<td>7 days (1 day in moist air, 6 days in water)</td>
<td>150 &quot;</td>
<td></td>
</tr>
<tr>
<td>28 days (1 &quot; &quot; 27 &quot; &quot; )</td>
<td>250 &quot;</td>
<td></td>
</tr>
</tbody>
</table>

One Part Cement, Three Parts Standard Ottawa Sand.
7 days (1 day in moist air, 6 days in water)........... 50 lb.
28 days (1 " " 27 " " )............. 125 "

II. PACKAGES, MARKING AND STORAGE.

6. The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon. A bag shall contain 94 lb. net. A barrel shall contain 282 lb. net.

7. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight building which will protect the cement from dampness.

III. INSPECTION.

8. (a) Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least 10 days from the time of sampling shall be allowed for the completion of the 7-day test, and at least 31 days shall be allowed for the completion of the 28-day test.

(b) The cement shall be tested in accordance with the methods contained in the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.¹

¹ See pp. 429–448.
IV. REJECTION.

9. The cement may be rejected if it fails to meet any of the requirements of these specifications.

10. Cement failing to meet the 7-day requirements may be held awaiting the results of the 28-day tests before rejection.

Editorial Note.

In connection with its reports on the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9-17), Committee C-1 on Cement declared its purpose to give consideration during the ensuing year to the revision of the present above Standard Specifications for Natural Cement, and recommended that in the meantime the new methods of tests for Portland cement be applied to the testing of natural cement. In this connection attention is directed to the following feature:

Fineness.—The Standard Specifications for Natural Cement specify a standard No. 100 sieve (see Section 2), which is not included in the Standard Specifications and Tests for Portland cement. The requirements for the standard No. 100 sieve will therefore remain as published in the 1915 Year-Book, page 358, as follows:

<table>
<thead>
<tr>
<th>Diameter of Wire, in.</th>
<th>0.0042 – 0.0048</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meshes per Linear Inch</td>
<td></td>
</tr>
<tr>
<td>Warp</td>
<td>95 – 101</td>
</tr>
<tr>
<td>Woof</td>
<td>93 – 103</td>
</tr>
</tbody>
</table>
STANDARD SPECIFICATIONS FOR DRAIN TILE.

Serial Designation: C 4 – 16.

The specifications for this material are issued under the fixed designation C 4; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1914; Revised, 1916.

1. (a) These specifications cover three classes of drain tile, namely, Farm Drain Tile, Standard Drain Tile, and Extra-Quality Drain Tile.

(b) The purposes for which these classes are intended to be suitable are as follows:

Farm Drain Tile, for ordinary private drainage work on farms, for moderate sizes and depths;

Standard Drain Tile, for ordinary district land drainage at moderate depths;

Extra-Quality Drain Tile, for district land drainage, for considerable depths and where an extra quality is desired.

2. The purchaser shall specify the class or classes of tile to be supplied, whether Farm Drain Tile, Standard Drain Tile, or Extra-Quality Drain Tile. Standard Drain Tile shall be supplied where no other advance selection is stated.

3. (a) The acceptability of drain tile shall be determined (1) by the results of the chemical and physical tests hereinafter
specified, and (2) by visual inspection, to determine whether the tiles comply with the specifications as to dimensions, shape, and freedom from visible external and internal defects.

(b) The acceptance of drain tile as satisfactorily meeting one of these two general requirements shall not be construed as in any way waiving the other.

I. MATERIALS AND MANUFACTURE.

4. (a) These specifications shall apply to drain tile made of shale, fire clays or surface clays and to drain tile made of concrete.

(b) By shale is meant a stratified clay, usually red-burning, more or less indurated by heat or pressure, with well-marked cleavage, laid down prior to the present geological epoch.

(c) By fire clay is meant a stratified clay, usually buff-burning, usually less indurated than shales, with poorly marked cleavage, laid down prior to the present geological epoch.

(d) By surface clay is meant an unstratified, unconsolidated plastic glacial or alluvial clay, laid down by the glacial ice sheet, or on the flood plains of rivers, during the present geological epoch.

(e) By concrete is meant a suitable mixture of Portland cement, mineral aggregates and water, hardened by hydraulic chemical reaction.

(f) If the purchaser desires to exclude any of these materials he shall so specify in advance. All materials used shall be first-class of their kind and suitable for the purpose.

5. The method of manufacture shall be such as to insure excellence of product and uniformity in quality.

II. CHEMICAL TESTS AND REQUIREMENTS.

6. The purchaser may prescribe in advance special chemical requirements in cases where drainage waters have marked acid or alkaline character, or are of abnormally high temperature, and may use chemical analysis of the tile to ascertain whether these special requirements are met. Without a special agreement in advance, no drain tile shall be rejected by reason of its composition as determined by ultimate chemical analysis.

The presence in drain tile of visible grains or masses of caustic lime, iron pyrites, or any other minerals which are
Specifications for Drain Tile.

known to cause slaking or disintegration of the tile, shall be construed as a valid ground for rejection, unless satisfactory proof be submitted that the tiles are permanent and durable, and that the objectionable minerals are not present in quantity or condition to work damage.

III. PHYSICAL TESTS.

7. The physical tests of drain tile shall include (A) Strength Tests and (B) Absorption Tests; and may include (C) Freezing and Thawing Tests, when specified by the purchaser in advance, or when called for by the manufacturer or other seller as provided in Sections 34, 35, 47 and 52.

8. The specimens of tile shall all be selected at the factory or at the shipping destination, or at the trench, at the option of the purchaser. The selection shall be made by a competent inspector employed by the purchaser. The inspector shall divide the tile into sub-classes if lack of uniformity in any important particular warrants such division, and shall select enough representative specimens of tile from each subclass for a complete set of standard physical tests.

9. A standard physical test shall comprise tests of five individual tiles. Specimens of tile may be selected by the inspector in such number as he judges necessary to determine fairly the quality of all the tile. The manufacturer or other seller shall furnish specimens of tile without separate charge up to 0.5 per cent of the whole number of tile, and the purchaser shall pay for all in excess of that percentage at the same rate as for other tile.

(A) Strength Tests of Drain Tile.

10. The specimens of tile shall be unbroken, full-size tile.

11. The walls of the tile shall, at the time of testing, be as thoroughly wet as will result from completely covering with hay, cloth, or similar absorbent material, and keeping the covering wet for not less than 12 hours.

12. No specimen of tile shall be exposed to water or air temperatures lower than 40° F. from the beginning of wetting until tested. Frozen tile shall be completely thawed before the wetting begins.
13. Each specimen of tile shall be weighed on reliable scales just prior to testing, and the weights shall be reported.

14. Any machine or hand method which will apply the load continuously, or in increments not exceeding 5 per cent of the estimated total breaking load, may be used in making the test. The tile shall not be allowed to stand under load longer than is required for observing and recording the loads. All solid parts of the bearing frames and bearing blocks shall be so rigid that the distribution of the load will not be affected appreciably by the deformation of any part. All bearings and the specimens of tile shall be so accurately centered as to secure a symmetrical distribution of the loading on each side of the center of the tile in every direction.

15. The purchaser shall choose (1) sand bearings, (2) hydraulic bearings, or (3) three-point bearings, for use in making strength tests of drain tile. (See Sections 18, 19, and 20).

16. The test results shall be calculated and reported, in pounds per linear foot of tile, in terms of the "Ordinary Supporting Strength."

The ordinary supporting strength shall be calculated by multiplying the test breaking loads by the following factors: For sand bearings, 1.00; for hydraulic bearings, 1.25; for three-point bearings, 1.50.

The results of the strength tests shall be reported separately for each of the five individual specimens of tile constituting a standard test, together with the average.

17. The modulus of rupture may or may not be calculated and reported, at the option of the purchaser. When reported it shall be calculated by the equations

\[
M = 0.20 \frac{W}{12} \quad \text{(1)}
\]

\[
f = \frac{6M}{t^2} \quad \text{(2)}
\]

1 The "ordinary supporting strength," when calculated as specified in Section 16, is approximately equal to the actual supporting strength of a tile when laid in a ditch by the "ordinary" method. See note under Table II.

2 The coefficient of 0.20 in equation (1) approximates the value found by theoretical analysis and also that determined by extended tests.
where $M =$ maximum bending moment in wall in pound-inches per inch of length, $r =$ radius of middle line of tile wall in inches, $W =$ ordinary supporting strength, calculated as prescribed in Section 16, in pounds per linear foot of tile, $f =$ modulus of rupture in pounds per square inch, and $t =$ thickness of tile wall in inches.

Five-eighths of the weight of the tile per linear foot for sand bearings, or three-fourths for hydraulic or three-point bearings, shall be added to $W$ in computing the maximum bending moment $M$, when such addition exceeds 5 per cent of $W$. The value of $t$ used shall be the average thickness of the wall at the top of the tile or that at the bottom, selecting the lesser of the two.

18. (See Fig. 1.)—When sand bearings are used, the ends of each specimen of tile shall be accurately marked in quarters of the circumference prior to the test. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the tile measured on the middle line of the wall. The depth of bedding above and below the tile at the thinnest points shall be one-half the radius of the middle line of the wall.

The sand used shall be clean, and shall be such as will pass a No. 4 screen.

The top bearing frame shall not be allowed to come in contact with the tile nor with the top bearing plate. The upper surface of the sand in the top bearing shall be struck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, in such a manner as to permit free motion of the plate in all directions. For this purpose a spherical bearing is preferred, but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weight shall be piled symmetrically about a vertical line through the center of the tile, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made
of timbers so heavy as to avoid appreciable bending by the side pressure of the sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the tile during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the tile.

19. (See Fig. 2.)—When hydraulic bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

An hydraulic bearing shall be composed of a wooden platen, to which is attached, as hereinafter described, a section of rubber hose. The hose shall lie against the tile, and the pressure shall be applied to the hose through the platen.

The platen shall be built of strong wood, and shall be not less than 6 by 6 in. in section, and its least length shall be the length of the tile plus 8 in. One-inch quarter rounds, with their convex surfaces facing and 2 in. apart in the clear, shall be firmly attached to the bearing side. The straight portion of this face shall extend at least the length of the tile, and the platen beyond this length may be cut to the arc of a circle.

Between the quarter rounds shall be laid a piece of 2½-in. hose which shall be closed in a water-tight manner at each end by clamps. The hose shall contain a volume of water not less than one-half nor more than two-thirds its capacity, when completely distended. This hose may be attached to the platen at either end in any satisfactory manner which will not induce wrinkling when under test pressure.

The test load shall be applied at the middle of the top bearing, in such a way as to leave the bearing free to move in the vertical plane of the axis of the tile.

It is recommended that stops be screwed to the platen, symmetrical with the point of application of the load, and at a distance apart not greater than the length of the tile plus ½ in. This will help center the load coming upon the tile.

20. (See Fig. 3.)—When three-point bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

The lower bearings shall consist of two wooden strips with
vertical sides, each strip having its interior top corner rounded to a radius of approximately $\frac{1}{2}$ in. They shall be straight, and shall be securely fastened to a rigid block with their interior vertical sides 1 in. apart.

The upper bearing shall be a wooden block, straight and true from end to end.

The test load shall be applied through the upper bearing block in such a way as to leave the bearing free to move in a vertical plane passing midway between the lower bearings.

In testing a tile which is "out of straight," the lines of the bearings chosen shall be from those which appear to give most favorable conditions for fair bearings.

(B) Absorption Tests of Drain Tile.

21. Not less than three separate test specimens from each of five separate tiles shall be taken as a "standard sample" for the absorption test. Of the three specimens from each tile, one shall be taken from one end, another from the opposite end, and the third shall be taken from the middle portion of the tile. Each specimen shall be of from 12 to 20 sq. in. in area, measured upon the exterior or convex side, and shall be as nearly square as the nature of the material will readily permit. The specimens shall be obtained by breaking the tile, and shall be apparently sound, solid pieces of the wall of the tile, and shall not show cracks or fissures or shattered edges due to the shock of breaking or cutting. The specimens may be obtained from the broken pieces of the tiles used in the strength test, if the restrictions as to the size and location of the specimens can be duly observed. The specimens shall be so marked as to permit the identity of each one to be ascertained at any stage of the test.

22. Preparatory to the absorption test, all specimens shall be first weighed and then dried in a drier or oven, at a temperature of not less than 110° C. (230° F.) for not less than three hours. After removal from the drier, the specimens shall be allowed to cool to a temperature of 20 to 25° C. (68 to 77° F.) and reweighed. If the specimens were apparently dry when taken, and the second weight closely checks the first, the specimens shall be considered dry. If the specimens were known to
be wet when taken, they shall be placed in the drier for a further drying treatment of two hours, and reweighed. If the third weight checks the second, the specimens shall be considered dry. In case of any doubt, the specimens must be redried for two-hour periods until check weights are obtained.

23. The balance used shall be sensitive to 0.5 g. when loaded with 1 kg., and weighings shall be read at least to the nearest gram. Where other than metric weights are used, the same order of accuracy must be obtained.

In reweighing after immersion, the specimens shall be removed from the water, not allowed to drain for more than one minute, the superficial water removed by towel or blotting paper, and the specimens at once put upon the balance.

24. Specimens after weighing shall be placed in a suitable woven-wire receptacle, packed tightly enough to prevent jostling, covered with distilled water or rainwater, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of 10 to 15° C. (50 to 59° F.).

25. The test results shall be calculated as percentages of the initial dry weight, carried to the nearest first decimal place. The results shall be reported separately for each individual specimen, together with the mean of the fifteen or more specimens comprising the standard sample, the maximum and the minimum single observations entering into the mean, and the variation between the maximum and the minimum of the three specimens of each tile represented in the the standard sample.

(C) Freezing and Thawing Tests of Drain Tile.

26. The test specimens employed in making the absorption test shall preferably be used for the freezing and thawing test. In the event that the same specimens are not available, another set selected as specified in Section 21 shall be taken.

27. In the event that new specimens for the freezing and thawing test must be prepared, they shall be dried as specified in Section 22.

28. The same scales and weights as are specified in Section 23 for the absorption test or others of equivalent sensitiveness and accuracy shall be employed for the weighings required in
the freezing and thawing test. The same procedure in weigh-
ings and reweighing as specified in Section 23 shall be used.

29. In the event that new specimens for the freezing and
thawing test must be prepared, they shall be immersed and
boiled and cooled in water as specified in Section 24.

30. When the specimens, either from the absorption test or
from a specially prepared series, have been weighed after satu-
rating with water, they shall be returned to the water, and
kept immersed till the freezing test is begun. For freezing,
they shall be placed with their concave faces upward in water-
tight metal trays, suitably mounted in a rigid metal crate; and
immersed in ice water until the specimens have attained sub-
stantially the temperature of the water, after which the water
shall be drawn down to a depth of \( \frac{1}{2} \) in. in each tray. The crate
shall then be lifted as a whole, without disturbing the specimens,
and placed in the freezing apparatus.

Freezing shall be performed in a quiet atmosphere, free
from perceptible natural or artificial currents. If artificial
freezing apparatus is employed, the apparatus shall have suf-
cient heat-absorbent capacity to enable the temperature of
the freezing chamber to be brought to \(-10^\circ C. \sim -14^\circ F.\) or
below, within thirty minutes after the introduction of the speci-
mens. The temperature in the freezing apparatus shall not fall
lower than \(-20^\circ C. \sim -4^\circ F.\). The freezing shall be continued
until the water in the trays is frozen solid. Exposure to freez-
ing conditions in excess of this requirement shall be considered
as without significance.

At the conclusion of freezing under the specified condi-
tions, the crate of specimens shall be withdrawn and at once
immersed in water at a temperature of \(85 \sim 100^\circ C. \sim 185 \sim 212^\circ F.\) in a special receptacle of proper size. Heating shall be
continued so that the water will regain the required temperature
as soon as practicable after the specimens are immersed. A
temperature of \(85 \sim 100^\circ C. 185 \sim 212^\circ F.\) shall then be
maintained for not less than 15 minutes. At the conclusion of

---

1 Fig. 4 shows a crate and trays suitable for use in the box for artificial freezing illustrated in Plate I.

2 Artificial freezing will generally be necessary. It may be conducted in a commercial zero \(F.\) refrigerating room, or in an artificial freezing box similar to the one shown in Plate I., in which zero \(F.\) temperatures can readily be produced by the use of salt and ice.
Specifications for Drain Tile.

Front Elevation.

Side Elevation.

Top View,
Trays Removed.

Notes:
Rack Constructed of \( \frac{5}{8} '' \times \frac{5}{8} '' \times \frac{1}{8} '' \) Galvanized Angles, except as Noted.
All Connections Riveted or Soldered.
Trays, 11''x11''x1/2'' outside, Made of No.17 Galvanized Steel.

Fig. 4.—Suggested Plans for Freezing Crate and Trays.
SUGGESTED PLANS
FOR
FREEZING BOX
USING SALT AND ICE TO FREEZE

Note: Box to be Constructed of Seasoned White Pine, free from Defects, or other Suitable Timber, 1″ x 6″, unless otherwise Specified.
the thawing treatment, the crate of specimens shall be cooled down rapidly in water to 10 to 15° C. (50 to 59° F.) and then inspected. The condition of each sample after each thawing shall be noted in the records.

31. Failure under the freezing and thawing treatment shall be considered to be reached when:

(a) The specimens show superficial disintegration or spalling with loss of weight of more than 5 per cent of the initial dry weight; or,

(b) The specimens are badly cracked in other than lamination planes; or,

(c) The specimens show evident serious loss of structural strength.

IV. PHYSICAL TEST REQUIREMENTS.

32. The physical test requirements for the different classes of drain tile shall be as given in Table I.

33. Drain tile made of mixtures of surface clays with other clays shall conform to the absorption requirements for surface-clay tile in Table I, when the proportion of surface clay is 75 per cent or more, and to the requirements for shale and fire clay tile for all other proportions.

34. In the event that a standard sample (Section 21) of tile fails to meet the requirements of the absorption test, the manufacturer or other seller may demand recourse to the freezing and thawing test, to be made at his expense. In such recourse, the number of tiles tested shall be four times the number represented by the standard sample (Section 21). If the material passes the freezing and thawing test satisfactorily, it shall not be rejected on account of its failure to meet the absorption requirements specified in Table I, but the average percentage of absorption of the specimens used in the freezing and thawing test shall be adopted as the maximum allowable mean absorption for the contract in question.

35. In the strength tests, individual tiles of a standard test whose mean strength is satisfactory may fall 25 per cent below the requirement for the average without causing rejection. In the absorption test, the absorption of individual tiles of a standard sample (Section 21), which gives a satisfactory mean
Specifications for Drain Tile.

absorption percentage, may exceed the average by 25 per cent without causing rejection. In the freezing and thawing test, at least 95 per cent of all the tiles tested shall meet the requirement.

In the event of the failure of a standard sample (Sections 9, 21 and 26) to meet the above requirements, the manufacturer

Table I.—Physical-Test Requirements for Different Classes of Drain Tile.

<table>
<thead>
<tr>
<th>Internal Diameter of Tile, in.</th>
<th>Farm Drain Tile</th>
<th>Standard Drain Tile</th>
<th>Extra-Quality Drain Tile</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>800</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>6</td>
<td>800</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>8</td>
<td>800</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>10</td>
<td>500</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>12</td>
<td>500</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>14</td>
<td>900</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>16</td>
<td>1000</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>18</td>
<td>1400</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>20</td>
<td>1500</td>
<td>11 14 12</td>
<td>1200 9 13 11 1600 7 11 10</td>
</tr>
<tr>
<td>22</td>
<td>1100</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>24</td>
<td>1700</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>26</td>
<td>1800</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>28</td>
<td>1900</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>30</td>
<td>2000</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>32</td>
<td>2100</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>34</td>
<td>2200</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>36</td>
<td>2300</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>38</td>
<td>2400</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>40</td>
<td>2500</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
<tr>
<td>42</td>
<td>2600</td>
<td>(Not Permitted)</td>
<td>(Not Permitted)</td>
</tr>
</tbody>
</table>

Note.—When the freezing and thawing test is specified or demanded, as provided in Section 7, the number of freezings and thawings to be endured shall be as follows: For farm drain tile, 8; for standard drain tile, 12; for extra-quality drain tile 16.

or other seller may thoroughly cull the material and submit a portion of retest at his own expense, and for such retest the number of tiles per sample shall be 10 for the strength and absorption tests and 20 for the freezing and thawing test. In the event of the failure of the material after culling to pass the requirements, it shall be rejected without further test.
### Table II.—Standard Ordinary Supporting Strengths of Drain Tile for Ordinary Sand and for Thoroughly Wet Clay Ditch Filling Material.

**Strengths in Pounds per Linear Foot.**

<table>
<thead>
<tr>
<th>Height of Fill above Top of Tile, ft.</th>
<th>1 ft.</th>
<th>2 ft.</th>
<th>3 ft.</th>
<th>4 ft.</th>
<th>5 ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>265</td>
<td>280</td>
<td>220</td>
<td>235</td>
<td>615</td>
</tr>
<tr>
<td>4</td>
<td>400</td>
<td>450</td>
<td>335</td>
<td>375</td>
<td>1,050</td>
</tr>
<tr>
<td>6</td>
<td>470</td>
<td>545</td>
<td>390</td>
<td>455</td>
<td>1,370</td>
</tr>
<tr>
<td>8</td>
<td>565</td>
<td>665</td>
<td>450</td>
<td>565</td>
<td>1,600</td>
</tr>
<tr>
<td>10</td>
<td>525</td>
<td>640</td>
<td>440</td>
<td>535</td>
<td>1,760</td>
</tr>
<tr>
<td>12</td>
<td>535</td>
<td>660</td>
<td>445</td>
<td>550</td>
<td>1,880</td>
</tr>
<tr>
<td>14</td>
<td>540</td>
<td>675</td>
<td>450</td>
<td>560</td>
<td>1,960</td>
</tr>
<tr>
<td>16</td>
<td>545</td>
<td>685</td>
<td>455</td>
<td>565</td>
<td>2,050</td>
</tr>
<tr>
<td>18</td>
<td>545</td>
<td>685</td>
<td>455</td>
<td>570</td>
<td>2,070</td>
</tr>
<tr>
<td>20</td>
<td>545</td>
<td>695</td>
<td>460</td>
<td>575</td>
<td>2,100</td>
</tr>
<tr>
<td>22</td>
<td>545</td>
<td>690</td>
<td>455</td>
<td>575</td>
<td>2,120</td>
</tr>
<tr>
<td>24</td>
<td>545</td>
<td>690</td>
<td>455</td>
<td>575</td>
<td>2,140</td>
</tr>
<tr>
<td>26</td>
<td>545</td>
<td>690</td>
<td>455</td>
<td>575</td>
<td>2,150</td>
</tr>
<tr>
<td>28</td>
<td>545</td>
<td>690</td>
<td>455</td>
<td>575</td>
<td>2,160</td>
</tr>
<tr>
<td>30</td>
<td>545</td>
<td>690</td>
<td>455</td>
<td>575</td>
<td>2,170</td>
</tr>
<tr>
<td><strong>Very great...</strong></td>
<td>545</td>
<td>690</td>
<td>455</td>
<td>575</td>
<td>2,180</td>
</tr>
</tbody>
</table>

**Breadth of Ditch at Top of Tile.**

- First-Class Pipe Laying is pipe laying in accordance with the best customary practice in pipe-sewer construction, whereby the entire underside of the pipe is very thoroughly bedded on soil and the entire pipe is surrounded by well-compacted soil, under the direction of an inspector constantly present on the work.

When pipe is laid in a concrete or other permanent masonry cradle, strong enough to carry the entire load to the sub-base without breaking and large enough to prevent material settlement, the standard strengths for all dimensions of ditches and all filling materials shall be those specified for Standard Drain Tile in Table I.
36. The manufacturer or other seller shall not be held responsible for cracking of drain tile in ditches unless by special agreement in advance, and in any event his obligation shall be held to be discharged by the delivery of drain tile having the minimum ordinary supporting strengths specified in Table II; and, if it is not otherwise specified in advance by the purchaser, tile shall be supplied of the strengths specified for clay ditch filling, for "ordinary" pipe laying and for widths of ditch at the level of the top of the tile equal to 0.5 ft. greater than the outside diameters of the tile. The purchaser shall furnish to the manufacturer or other seller complete information, in advance of receiving bids, as to the number of linear feet of drain tile of each diameter required for each different depth of ditch, measured to the nearest foot from the surface of the ground to the top of the tile.

V. VISUAL INSPECTION.

37. All drain tile shall be given a thorough visual inspection at the trench by a competent inspector employed by the purchaser. The purposes of the visual inspection shall be: (1) to cull and reject imperfect individual tiles; and (2) to determine whether the tiles, independently of meeting the chemical and the physical test requirements, comply with the specifications of general properties, especially as stated hereinafter.

38. All drain tile shall be of approximately circular cross-section, except when otherwise specified in advance. They shall be approximately straight, except in the case of special connections. The ends shall be so regular and smooth as readily to admit of making close joints by turning and pressing together adjoining tile.

39. The sizes of drain tile shall be designated by their interior diameters.

40. Drain tile smaller than 12 in. in diameter shall have a minimum length of 12 in. Tile of from 12 to 30 in. in diameter, inclusive, shall have lengths not less than the diameters. Tile larger than 30 in. in diameter shall have a minimum length of 30 in.

41. Drain tile shall be substantially uniform in structure throughout, and the inspector shall investigate this property by examining fractured surfaces.
42. Drain tile shall give a clear ring when stood on end and while dry tapped with a light hammer.

43. The inspector may use the color of drain tile as a general guide in sorting and inspecting, but he shall first so familiarize himself with the raw materials and the processes used in the manufacture of the particular tile in question as to be competent to interpret the true meaning of variations in their color.

44. Drain tile shall be reasonably smooth on the inside.

45. Drain tile shall be free from cracks and checks extending into the body of the tile in such a manner as to decrease the strength appreciably. Tile shall not be chipped or broken in such a manner as to decrease their strength materially or to admit earth into the drain.

46. All drain tile shall be sufficiently "vitrified" or "hard-burned" to afford the degree of supporting strength, percentage of absorption, and resistance to freezing and thawing specified in the physical test requirements prescribed in Table I.

47. The manufacturer or other seller may appeal from decisions of the inspector on questions of strength or structure when such decisions are based on visual inspection alone, in which case the point at issue shall be determined by standard physical tests, the cost of which shall be paid by the appellant, if the inspector was right, or by the purchaser if his inspector was in error.

Table III.—Distinctive General Physical Properties of Different Classes of Drain Tile.

<table>
<thead>
<tr>
<th>Physical Properties Specified</th>
<th>Farm Drain Tile</th>
<th>Standard Drain Tile</th>
<th>Extra-Quality Drain Tile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable variation of average diameter below specified diameter, per cent.</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Allowable variation between maximum and minimum diameters of same tile, or average diameters of adjoining tile, percentage of thickness of wall</td>
<td>65</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td>Allowable variation from straightness, percentage of length</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Allowable thickness of exterior blisters, lumps and flakes which do not weaken tile and are few in number, percentage of thickness of wall</td>
<td>25</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Allowable diameters of above blisters, lumps and flakes, percentage of internal diameter</td>
<td>20</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>General Inspection</td>
<td>Careful</td>
<td>Rigid</td>
<td>Very rigid</td>
</tr>
</tbody>
</table>
48. Drain tile of the different classes shall, in addition to all requirements heretofore specified, have the distinctive physical characteristic prescribed in Table III.

VI. TESTING, INSPECTION AND REJECTION.

49. All tests shall be made by experts employed by the purchaser. Full reports of all tests shall be furnished the manufacturer or other seller on his request. Tests shall be made and reported promptly.

50. The purchaser shall pay the expense of making all tests except as otherwise specified in Sections 9, 34, 35, 47 and 52.

51. The number of standard tests to be made shall be determined by the purchaser.

52. In all contracts for ten or more carloads of tile, preliminary general tests and inspection shall be made at the factory by the purchaser upon demand of the manufacturer or other seller. The expense of such tests and inspection shall be paid by the manufacturer or other seller.

53. The inspector shall be employed by the purchaser.

54. The manufacturer or other seller of the drain tile shall afford the inspector all reasonable facilities for his work, both as to the selection of specimens for tests, and as to visual inspection. Inspection shall be completed promptly.

55. The inspector shall plainly mark all drain tile which he rejects, and such rejected tile shall be removed promptly by the manufacturer or other seller. Upon request of the purchaser, the manufacturer or other seller shall give full account of the removal of rejected tile.
STANDARD SPECIFICATIONS
FOR
QUICKLIME.


The specifications for this material are issued under the fixed designation C 5; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1915.

1. Quicklime is a material the major part of which is calcium oxide or calcium and magnesium oxides, which will slake on the addition of water.

2. Quicklime is divided into two grades:
   (a) Selected.—Shall be well-burned, picked free from ashes, core, clinker or other foreign material.
   (b) Run-of-Kiln.—Shall be well-burned, without selection.

3. Quicklime is shipped in two forms:
   (a) Lump.—Shall be kiln size.
   (b) Pulverized.—Shall be reduced in size to pass a \( \frac{1}{4} \)-in. screen.

4. Quicklime is divided into four classes:
   (a) High-Calcium; (b) Calcium; (c) Magnesian; (d) High-Magnesian.

5. The particular grade, form and class of quicklime desired shall be specified in advance by the purchaser.
Specifications for Quicklime.

I. CHEMICAL PROPERTIES AND TESTS.

(A) Sampling.

6. When quicklime is shipped in bulk, the sample shall be so taken that it will represent an average of all parts of the shipment from top to bottom, and shall not contain a disproportionate share of the top and bottom layers, which are most subject to changes. The samples shall comprise at least 10 shovelsful taken from different parts of the shipment. The total sample taken shall weigh at least 100 lb. and shall be crushed to pass a 1-in. ring, and quartered to provide a 15-lb. sample for the laboratory.

7. When quicklime is shipped in barrels, at least 3 per cent of the number of barrels shall be sampled. They shall be taken from various parts of the shipment, dumped, mixed and sampled as specified in Section 6.

8. All samples to be sent to the laboratory shall be immediately transferred to an air-tight container in which the unused portion shall be stored until the quicklime shall finally be accepted or rejected by the purchaser.

(B) Chemical Tests.

9. (a) The classes and chemical properties of quicklime shall be determined by standard methods of chemical analysis.

(b) Samples shall be taken as specified in Sections 6, 7 and 8.

(c) Quicklime shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Oxide, per cent.</td>
<td>90 (min.)</td>
<td>90</td>
<td>85-90</td>
<td>85-90</td>
</tr>
<tr>
<td>Magnesium Oxide, per cent.</td>
<td>85</td>
<td>85</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Calcium Oxide plus Magnesium Oxide, min., per cent.</td>
<td>90</td>
<td>85</td>
<td>90</td>
<td>85</td>
</tr>
<tr>
<td>Carbon Dioxide, max., per cent.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Silica plus Alumina plus Oxide of Iron, max., per cent.</td>
<td>5</td>
<td>7.5</td>
<td>5</td>
<td>7.5</td>
</tr>
</tbody>
</table>
II. PHYSICAL PROPERTIES AND TESTS.

10. An average 5-lb. sample shall be put into a box and slaked by an experienced operator with sufficient water to produce the maximum quantity of lime putty, care being taken to avoid "burning" or "drowning" the lime. It shall be allowed to stand for 24 hours and then washed through a 20-mesh sieve by a stream of water having a moderate pressure. No material shall be rubbed through the screens. Not over 3 per cent of the weight of the selected quicklime nor over 5 per cent of the weight of the run-of-kiln quicklime shall be retained on the sieve. The sample of lump lime taken for this test shall be broken to all pass a 1-in. screen and be retained on a ¾-in. screen. Pulverized lime shall be tested as received.

III. INSPECTION AND REJECTION.

11. (a) All quicklime shall be subject to inspection.

(b) The quicklime may be inspected either at the place of manufacture or the point of delivery as arranged at the time of purchase.

(c) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the quicklime ordered. The manufacturer shall afford the inspector all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the operation of the works.

(d) The purchaser may make the tests to govern the acceptance or rejection of the quicklime in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

12. Unless otherwise specified, any rejection based on failure to pass tests prescribed in these specifications shall be reported within five days from the taking of samples.

13. Samples which represent rejected quicklime shall be preserved in air-tight containers for five days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS
FOR
HYDRATED LIME.


The specifications for this material are issued under the fixed designation C 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

Definition.

1. Hydrated lime is a dry flocculent powder resulting from the hydration of quicklime.

Classes.

2. Hydrated lime is commercially divided into four classes:
   (a) High-Calcium; (b) Calcium; (c) Magnesian; (d) High-Magnesian.

Basis of Purchase.

3. The particular class of hydrated lime desired shall be specified in advance by the purchaser.

I. CHEMICAL PROPERTIES AND TESTS.

Sampling.

4. The sample shall be a fair average of the shipment. Three per cent of the packages shall be sampled. The sample shall be taken from the surface to the center of the package. A 2-lb. sample to be sent to the laboratory shall immediately be transferred to an air-tight container, in which the unused portion shall be stored until the hydrated lime has been finally accepted or rejected by the purchaser.
5. (a) The classes and chemical properties of hydrated lime shall be determined by standard methods of chemical analysis. (b) The non-volatile portion of hydrated lime shall conform to the following requirements as to chemical composition:

<table>
<thead>
<tr>
<th>Chemical Composition.</th>
<th>High-Calcium</th>
<th>Calcium</th>
<th>Magnesian</th>
<th>High-Magnesian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Oxide, per cent</td>
<td>90 (min.)</td>
<td>85-90</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Magnesium Oxide, per cent</td>
<td>...</td>
<td>...</td>
<td>10-25</td>
<td>25 (min.)</td>
</tr>
<tr>
<td>Silica plus Alumina plus Oxide of Iron, max., per cent</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Carbon Dioxide, max., per cent</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Water</td>
<td>Sufficient to hydrate the Calcium-oxide Content</td>
<td>Sufficient to hydrate the Calcium-oxide Content</td>
<td>Sufficient to hydrate the Calcium-oxide Content</td>
<td>Sufficient to hydrate the Calcium-oxide Content</td>
</tr>
</tbody>
</table>

II. PHYSICAL PROPERTIES AND TESTS.

6. A 100-g. sample shall leave by weight a residue of not over 5 per cent on a standard 100-mesh sieve and not over 0.5 per cent on a standard 30-mesh sieve.

7. Hydrated lime shall be tested to determine its constancy of volume in the following manner:

Equal parts of hydrated lime under test and volume-constant Portland cement shall be thoroughly mixed together and gaged with water to a paste. Only sufficient water shall be used to make the mixture workable. From this paste a pat about 3 in. in diameter and ½ in. thick at the center, tapering to a thin edge shall be made on a clean glass plate about 4 in. square. This pat shall be allowed to harden 24 hours in moist air and shall be without popping, checking, cracking, warping or disintegration after 5 hours' exposure to steam above boiling water in a loosely closed vessel.

III. PACKING AND MARKING.

8. Hydrated lime shall be packed either in cloth or in paper bags and the weight shall be plainly marked on each package.
Specifications for Hydrated Lime.

Marking. 9. The name of the manufacturer shall be legibly marked or tagged on each package.

IV. INSPECTION AND REJECTION.

Inspection. 10. (a) All hydrated lime shall be subject to inspection.
(b) The hydrated lime may be inspected either at the place of manufacture or the point of delivery, as arranged at the time of purchase.
(c) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the hydrated lime ordered. The manufacturer shall afford the inspector all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the operation of the works.
(d) The purchaser may make the tests to govern the acceptance or rejection of the hydrated lime in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection. 11. Unless otherwise specified, any rejection based on failure to pass tests prescribed in these specifications shall be reported within five working days from the taking of samples.

Rehearing. 12. Samples which represent rejected hydrated lime shall be preserved in air-tight containers for five days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.
STANDARD SPECIFICATIONS

FOR

PAVING BRICK.

Serial Designation: C 7-15.

The specifications for this material are issued under the fixed designation C 7; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

The quality and acceptability of paving brick, in the absence of other special tests mutually agreed upon in advance by the seller on the one side and the buyer on the other side shall be determined by the following procedure:

I. The Rattler Test, for the purpose of determining whether the material as a whole possesses to a sufficient degree strength, toughness and hardness.

II. Visual Inspection, for the purpose of determining whether the physical properties of the material as to dimensions, accuracy and uniformity of shape and color, are in general satisfactory, and for the purpose of culling out from the shipment individually imperfect or unsatisfactory brick.

The acceptance of paving brick as satisfactorily meeting one of these tests shall not be construed as in any way waiving the other.
I. The Rattler Test.

The selection of samples for test.

1. Place of Sampling.—In general, where a shipment of bricks involving a quantity of less than 100,000 is under consideration, the sampling may be done either at the brick factory prior to shipment, or on cars at their destination or on the street, when delivered ready for use. When the quantity under consideration exceeds 100,000 the sampling shall be done at the factory prior to shipment. Bricks accepted as the result of test prior to shipment, shall not be liable to subsequent rejection as a whole, but are subject to such culling as is provided for under Part II, Visual Inspection.

2. Method of Selecting Samples.—In general, the buyer shall select his own samples from the material which the seller proposes to furnish. The seller shall have the right to be present during the selection of a sample. The sampler shall endeavor, to the best of his judgment, to select brick representing the average of the lot. No samples shall include bricks which would be rejected by visual inspection as provided in Part II, except that where controversy arises, whole tests may be selected to determine the admissibility of certain types or portions of the lot having a characteristic appearance in common. In cases where prolonged controversy occurs between buyer and seller and samples selected by each party fail to show reasonable concurrence, then both parties shall unite in the selection of a disinterested person to select the samples, and both parties shall be bound by the results of samples thus selected.

3. Number of Samples per Lot.—In general, one sample of ten bricks shall be tested for every 10,000 bricks contained in the lot under consideration; but where the total quantity exceeds 100,000, the number of samples tested may be fewer than one per 10,000, provided that they shall be distributed as uniformly as practicable over the entire lot.

4. Shipment of Samples.—Samples which must be transported long distances by freight or express shall be carefully put up in packages holding not more than twelve bricks each. When more than six bricks are shipped in one package, it shall be so arranged as to carry two parallel rows of bricks side by
side, and these rows shall be separated by a partition. In event of some of the bricks being cracked or broken in transit, the sample shall be disqualified if there are not remaining ten sound undamaged bricks.

5. Storage and Care of Samples.—Samples shall be carefully handled to avoid breakage or injury. They shall be kept in the dry so far as practicable. If wet when received, or known to have been immersed or subjected to recent prolonged wetting, they shall be dried for at least six hours in a temperature of 100° F. before testing.

THE CONSTRUCTION OF THE RATTLER.

6. General Design.—The machine shall be of good mechanical construction, self-contained, and shall conform to the following details of material and dimensions, and shall consist of barrel, frame, and driving mechanism as herein described. Accompanying these specifications is a complete drawing of a rattler which will meet the requirements, and to which reference should be made (Plate II).

7. The Barrel.—The barrel of the machine shall be made up of the heads, headliners, staves and stave-liners.

The heads may be cast in one piece with the trunnions, which shall be 2\(\frac{1}{2}\) in. in diameter, and shall have a bearing 6 in. in length, or they may be cast with heavy hubs, which shall be bored out for 2\(\frac{7}{16}\)-in. shafts, and shall be keyseated for two keys, each \(\frac{1}{2}\) by \(\frac{3}{8}\) in. and spaced 90 deg. apart. The shaft shall be a snug fit and when keyed shall be entirely free from lost motion. The distance from the end of the shaft or trunnion to the inside face of the head shall be 15\(\frac{3}{8}\) in. in the head for the driving end of the rattler, and 11\(\frac{3}{8}\) in. for the other head, and the distance from the face of the hubs to the inside face of the heads shall be 5\(\frac{1}{8}\) in.

The heads shall be not less than \(\frac{3}{4}\) in. thick, nor more than \(\frac{7}{8}\) in. thick. In outline, each head shall be a regular 14-sided polygon inscribed in a circle 28\(\frac{3}{8}\) in. in diameter. Each head shall be provided with flanges not less than \(\frac{3}{4}\) in. thick and extending outward 2\(\frac{3}{4}\) in. from the inside face of the head to afford a means of fastening the staves. The surface of the flanges of the head shall be smooth and give a true and uniform bearing
Specifications for Paving Brick.

for the staves. To secure the desired true and uniform bearing the surfaces of the flanges of the head shall be either ground or machined. The flanges shall be slotted on the outer edge, so as to provide for two \( \frac{3}{4} \)-in. bolts at each end of each stave, said slots to be \( \frac{1}{4} \) in. wide and \( 2\frac{3}{4} \) in., center to center. Each slot shall be provided with a recess for the bolt head, which shall act to prevent the turning of the same. Between each two slots there shall be a brace \( \frac{3}{8} \) in. thick, extending down the outward side of the head not less than 2 in.

There shall be for each head a cast-iron headliner 1 in. in thickness and conforming to the outline of the head, but inscribed in a circle \( 28\frac{\alpha}{\beta} \) in. in diameter. This headliner shall be fastened to the head by seven \( \frac{5}{6} \)-in. cap-screws, through the head from the outside. Whenever these headliners become worn down \( \frac{1}{5} \) in. below their initial surface level at any point of their surface, they shall be replaced with new ones. The metal of these headliners shall be hard machinery iron and should contain not less than one per cent of combined carbon.

The staves shall be made of 6-in. medium-steel structural channels, \( 27\frac{1}{2} \) in. long and weighing 15.5 lb. per lineal foot. The staves shall have two holes \( \frac{1}{4} \)-in. in diameter, drilled in each end, the center line of the holes being 1 in. from the end and \( 1\frac{6}{8} \) in. either way from the longitudinal center line. The spaces between the staves shall be as uniform as practicable, but shall not exceed \( \frac{1}{5} \) in.

The interior or flat side of each stave shall be protected by a liner \( \frac{3}{8} \) in. thick by \( 5\frac{1}{2} \) in. wide by \( 19\frac{5}{6} \) in. long. The liner shall consist of medium-steel plate, and shall be riveted to the channel by three \( \frac{1}{2} \)-in. rivets, one of which shall be on the center line both ways and the other two on the longitudinal center line and spaced 7 in. from the center each way. The rivet holes shall be countersunk on the face of the liner and the rivets shall be driven hot and chipped off flush with the surface of the liners. These liners shall be inspected from time to time, and if found loose shall be at once re-riveted.

Any test at the expiration of which a stave-liner is found detached from the stave or seriously out of position shall be rejected. When a new rattler, in which a complete set of new staves is furnished, is first put into operation, it shall be charged
STANDARD RATTLER
FOR TESTING PAVING BRICK
PROPOSED BY
THE NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION
December 1, 1916
with 400 lb. of shot of the same sizes, and in the same proportions as provided in Section 9, and shall then be run for 18,000 revolutions at the usual prescribed rate of speed. The shot shall then be removed and a standard shot charge inserted, after which the rattler may be charged with brick for a test.

No stave shall be used for more than 70 consecutive tests without renewing its lining. Two of the 14 staves shall be removed and relined at a time in such a way that of each pair, one falls upon one side of the barrel and the other upon the opposite side, and also so that the staves changed shall be consecutive but not contiguous; for example, 1 and 8, 3 and 10, 5 and 12, 7 and 14, 2 and 9, 4 and 11, 6 and 13, etc., to the end that the interior of the barrel at all times shall present the same relative condition of repair. The changes in the staves should be made at the time when the shot charges are being corrected, and the record must show the number of charges run since the last pair of new lined staves was placed in position.

The staves when bolted to the heads shall form a barrel 20 in. long, inside measurement, between head liners. The liners of the staves shall be so placed as to drop between the head-liners. The staves shall be bolted tightly to the heads by four 3⁄4-in. bolts, and each bolt shall be provided with a lock nut, and shall be inspected at not less frequent intervals than every fifth test and all nuts kept tight. A record shall be made after each inspection showing in what condition the bolts were found.

8. The Frame and Driving Mechanism.—The barrel shall be mounted on a cast-iron frame of sufficient strength and rigidity to support it without undue vibration. It shall rest on a rigid foundation with or without the interposition of wooden plates, and shall be fastened thereto by bolts at not less than four points.

It shall be driven by gearing whose ratio of driver to driven is not less than one to four. The counter shaft upon which the driving pinion is mounted shall not be less than 1 5⁄8 in. in diameter, with bearing not less than 6 in. in length. If a belt drive is used the pulley shall not be less than 18 in. in diameter and 6 1⁄2 in. in face. A belt at least 6 in. in width properly adjusted, to avoid unnecessary slipping, should be used.
9. The Abrasive Charge.—The abrasive charge shall consist of cast-iron spheres of two sizes. When new, the larger spheres shall be 3.75 in. in diameter and shall weigh approximately 7.5 lb. (3.40 kg.) each. Ten spheres of this size shall be used.

These shall be weighed separately after each ten tests, and if the weight of any large sphere falls to 7 lb. (3.175 kg.) it shall be discarded and a new one substituted; provided, however, that all of the large spheres shall not be discarded and substituted by new ones at any single time, and that so far as possible the large spheres shall compose a graduated series in various stages of wear.

When new, the smaller spheres shall be 1.875 in. in diameter and shall weigh approximately 0.95 lb. (0.43 kg.) each. In general, the number of small spheres in a charge shall not fall below 245 nor exceed 260. The collective weight of the large and small spheres shall be as nearly 300 lb. as possible. No small sphere shall be retained in use after it has been worn down so that it will pass a circular hole 1.75 in. in diameter, drilled in an iron plate 1 in. in thickness, or weigh less than 0.75 lb. (0.34 kg.). Further, the small spheres shall be tested, by passing them over the above plate or by weighing, after every ten tests, and any which pass through or fall below the specified weight, shall be replaced by new spheres; provided, further, that all of the small spheres shall not be rejected and replaced by new ones at any one time, and that so far as possible the small spheres shall compose a graduated series in various stages of wear. At any time that any sphere is found to be broken or defective it shall at once be replaced.

The iron composing these spheres shall have a chemical composition within the following limits:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined carbon</td>
<td>not under 2.50%</td>
</tr>
<tr>
<td>Graphitic carbon</td>
<td>over 0.25%</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.00%</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.25%</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.08%</td>
</tr>
</tbody>
</table>

For each new batch of spheres used, the chemical analysis shall be furnished by the maker or be obtained by the user,
before introducing into the charge, and unless the analysis meets the above specifications, the batch of spheres shall be rejected.

THE OPERATION OF THE TEST.

10. The Brick Charge.—The number of bricks per test shall be ten for all bricks of so-called "block-size," whose dimensions fall between 8 and 9 in. in length, 3 and 3 4 in. in breadth, and 3 3 and 4 1 in. in thickness.¹ No brick should be selected as part of a regular test that would be rejected by any other requirements of the specifications under which the purchase is made.

11. Speed and Duration of Revolution.—The rattler shall be rotated at a uniform rate of not less than 29.5 nor more than 30.5 revolutions per minute, and 1800 revolutions shall constitute the test. A counting machine shall be attached to the rattler for counting the revolutions. A margin not to exceed ten revolutions will be allowed for stopping. Only one start and stop per test is generally acceptable. If, from accidental causes, the rattler is stopped and started more than once during a test, and the loss exceeds the maximum permissible under the specifications, the test shall be disqualified and another made.

12. The Scales.—The scales must have a capacity of not less than 300 lb., and must be sensitive to 0.5 oz., and must be tested by a standard test weight at intervals of not less than every ten tests.

13. The Results.—The loss shall be calculated in percentage of the initial weight of the brick composing the charge. In weighing the rattled brick, any piece weighing less than 1 lb. shall be rejected.

14. The Records.—A complete and continuous record shall be kept of the operation of all rattlers working under these specifications. This record shall contain the following data concerning each test made:

1. The name of the person, firm or corporation furnishing each sample tested.

2. The name of the maker of the brick represented in each sample tested.

¹ Where brick of larger or smaller sizes than the dimensions given above for blocks are to be tested, the same number of bricks per charge should be used, but allowance for the difference in size should be made in setting the limits for average and maximum rattler loss.
3. The name of the street, or contract, which the sample represented.
4. The brands or marks upon the bricks by which they were identified.
5. The number of bricks furnished.
6. The date on which they were received for test.
7. The date on which they were tested.
8. The drying treatment given before testing, if any.
9. The length, breadth and thickness of the bricks.
10. The collective weight of the ten large spherical shot used in making the test at the time of their last standardization.
11. The number and collective weight of the small spherical shot used in making the test, at the time of their last standardization.
12. The total weight of the shot charge, after its last standardization.
13. Certificate of the operator that he examined the condition of the machine as to staves, liners, and any other parts affecting the barrel, and found them right at the beginning of the test.
14. Certificate of the operator of the number of charges tested since the last standardization of shot charge and last renewals of stave liners.
15. The time of the beginning and ending of each test, and the number of revolutions made by the barrel during the test, as shown by the indicator.
16. Certificate of the operator as to number of stops and starts made in each test.
17. The initial collective weight of the ten bricks composing the charge and their collective weight after rattling.
18. The loss calculated in percentage of the initial weight; and the calculation itself.
19. The number of broken bricks and remarks upon the portions which were included in the final weighing.
20. General remarks upon the test and any irregularities occurring in its execution.
21. The date upon which the test was made.
22. The location of the rattler and name of the owner, upon which the test was made.
23. The certificate of the operator that the test was made under the specifications of the American Society for Testing Materials and that the record is a true record.
24. The signature of the operator or person responsible for the test.
25. The serial number of the test.

In the event of more than one copy of the record of any test being required, they may be furnished on separate sheets, and marked duplicates, but the original record shall always be preserved intact and complete.

For the convenience of the public, the accompanying blank form, which provides space for the necessary data, is furnished and its use recommended.
REPORT OF STANDARD RATTLER TEST OF PAVING BRICK.

IDENTIFICATION DATA.

Name of the firm furnishing sample..........................................................
Name of the firm manufacturing sample......................................................
Street or job which sample represents.....................................................
Brands or marks on the brick...........................................................................
Quantity furnished.........................................................................................
Drying treatment............................................................................................
Date received.................................................................................................
Date tested......................................................................................................
Length...............................................................................................................
Breadth...........................................................................................................
Thickness........................................................................................................

STANDARDIZATION DATA.

<table>
<thead>
<tr>
<th>Weight of Charge. (After Standardization.)</th>
<th>Condition of Locknuts on Staves</th>
<th>Condition of Scales</th>
<th>Number and Position of Fresh Stave Liners</th>
<th>Repairs. (Note any repairs affecting the condition of the barrel.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Large spheres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small spheres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of charges tested since last inspection........................................

RUNNING DATA.

<table>
<thead>
<tr>
<th>Time Readings.</th>
<th>Revolution Counter Readings.</th>
<th>Running Notes, Stops, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours. Minutes. Seconds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beginning of Test.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Reading</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WEIGHTS AND CALCULATIONS.

Percentage Loss.
(Note.—The Calculation Must Appear.)

Initial Weight of Ten Bricks.................................................................
Final Weight of Same..............................................................................
Loss of Weight..........................................................................................

Number of broken bricks and remarks on same........................................

I certify that the foregoing test was made under the specifications of the American Society for Testing Materials, and is a true record.
(Signature of Tester)..............................................................................

Date............................................................................................................

Location of Laboratory.............................................................................
Specifications for Paving Brick.

Acceptance and Rejection of Material.

15. Basis of Acceptance or Rejection.—Paving bricks shall not be judged for acceptance or rejection by the results of individual tests, but by the average of no less than five tests. Where a lot of bricks fail to meet the required average, it shall be optional with the buyer whether the bricks shall be definitely rejected or whether they may be regraded and a portion selected for further test as provided in Section 16.

16. Range of Fluctuation.—Some fluctuation in the results of the rattler test, both on account of variations in the bricks and in the machine used in testing, are unavoidable, and a reasonable allowance for such fluctuations should be made, wherever the standard may be fixed.

In any lot of paving brick, if the loss on a test computed upon its initial weight exceeds the standard loss by more than two per cent, then the portion of the lot represented by that test shall at once be resampled and three more tests executed upon it, and if any of these three tests shall again exceed by more than two per cent the required standard, then that portion of the lot shall be rejected.

If in any lot of brick, two or more tests exceed the permissible maximum, then the buyer may at his option reject the entire lot, even though the average of all the tests executed may be within the required limits.

17. Fixing of Standards.—The percentage of loss which may be taken as the standard, will not be fixed in these specifications, and shall remain within the province of the contracting parties. For the information of the public, the following scale of average losses is given, representing what may be expected of tests executed under the foregoing specifications:

<table>
<thead>
<tr>
<th>General Maximum</th>
<th>Average Loss, Per Cent.</th>
<th>Permissible Loss, Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>For bricks suitable for heavy traffic</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>For bricks suitable for medium traffic</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>For bricks suitable for light traffic</td>
<td>26</td>
<td>28</td>
</tr>
</tbody>
</table>

Which of these grades should be specified in any given district and for any given purpose is a matter wholly within the province of the buyer, and should be governed by the kind
and amount of traffic to be carried, and the quality of paving bricks available.

18. *Culling and Retesting.*—Where, under Sections 15 and 16, a lot or portion of a lot of bricks is rejected, either by reason of failure to show a low enough average test or because of tests above the permissible maximum, the buyer may at his option permit the seller to regrade the rejected brick, separating out that portion which he considers at fault and retaining that which he considers good. When the regrading is complete, the good portion shall be then resampled and retested, under the original conditions, and if it fails again either in average or in permissible maximum, then the buyer may definitely and finally reject the entire lot or portion under test.

19. *Payment of Cost of Testing.*—Unless otherwise specified, the cost of testing the material as delivered or prepared for delivery, up to the prescribed number of tests for valid acceptance or rejection of the lot, shall be paid by the buyer. (See also Section 23.) The cost of testing extra samples made necessary by the failure of the whole lot or any portion of it, shall be paid by the seller, whether the material is finally accepted or rejected.

II. *Visual Inspection.*

It shall be the right of the buyer to inspect the bricks, subsequent to their delivery at the place of use, and prior to or during laying, to cull out and reject upon the following grounds:

20. All bricks which are broken in two or chipped in such a manner that neither wearing surface remains substantially intact, or that the lower or bearing surface is reduced in area by more than one-fifth. Where bricks are rejected upon this ground, it shall be the duty of the purchaser to use them so far as practicable in obtaining the necessary half-bricks for breaking courses and making closures, instead of breaking otherwise whole and sound bricks for this purpose.

21. All bricks which are cracked in such a degree as to produce defects such as are defined in Section 20, either from shocks received in shipment and handling, or from defective conditions of manufacture, especially in drying, burning or cooling, unless
such cracks are plainly superficial and not such as to percep-
tively weaken the resistance of the brick to its conditions of use.

22. All bricks which are so off-size, or so misshapen, bent, twisted or kiln-marked, that they will not form a proper sur-
face as defined by the paving specifications, or align with other bricks without making joints other than those permitted in
the paving specifications.

23. All bricks which are obviously too soft and too poorly vitrified to endure street wear. When any disagreement arises
between buyer and seller under this item, it shall be the right
of the buyer to make two or more rattler tests of the brick which
he wishes to exclude, as provided in Section 2, and if in either
or both tests, the bricks fall beyond the maximum rattler losses
permitted under the specifications, then all bricks having the
same objectionable appearance may be excluded, and the seller
shall pay for the cost of the test. But if under such procedure,
the bricks which have been tested as objectionable, shall pass
the rattler test, both tests falling within the permitted maximum,
then the buyer cannot exclude the class of material represented
by this test and he shall pay for the cost of the test.

24. All bricks which differ so markedly in color from the
type or average of the shipment, as to make the resultant
pavement checkered or disagreeably mottled in appearance.
This Section shall not be held to apply to the normal variations in
color which may occur in the product of one plant among bricks
which will meet the rattler test as referred to in Sections 15, 16, and 17, but shall apply only to differences of color which
imply differences in the material of which the bricks are made, or extreme differences in manufacture.
STANDARD TEST
FOR
FIREPROOF FLOOR CONSTRUCTION.

Serial Designation: C 2 - 08.

This test is issued under the fixed designation C 2; the final number
indicates the year of original issue, or in the case of revision, the year of last
revision.

ADOPTED, 1907; REVISED, 1908.

The test structure may be located at any place convenient
to the applicant, where all the necessary facilities for properly
conducting the test are provided.

The test structure may be constructed of walls of any
material not less than 12 in. thick, properly buttressed on all
sides.

The floor construction to be tested shall form the roof of the
test structure.

At a height of not less than 2 ft. 6 in., nor more than 3 ft.,
above the ground level, a metal grate, properly supported, shall
be provided, covering the whole inside area of the building.

In the walls below this grate level, draught openings shall
be provided, as many as possible, furnishing openings with an
aggregate area of not less than one square foot for every ten square
feet of grate surface. Means for temporarily closing these open-
ings shall be provided.

In the wall, immediately above the grate level, a firing door,
3 ft. 6 in. by 5 ft. high, shall be provided in the side of the build-
ing at right angles to the floor beams. A second door shall be added when the span of the floor slab under test exceeds 10 ft.

Flues should be supplied at each of the corners, and oftener in case of a test structure exceeding 250 sq. ft. of grate surface, with sufficient opening to insure a proper draught, securely supported and disposed at the sides of the structure in such manner as not to rest on the floor under test. In no case should a flue area be less than 180 sq. in.

The horizontal dimensions of the test structure will depend upon the number and the span of the system under consideration. The clear span of the floor beams is to be 14 ft. The distance between floor beams, or span of slab, may be varied according to the design of the system to be tested, and should be as near as possible to usual practice. The underside of the construction under test shall be not less than 9 ft. 6 in. nor more than 10 ft. above the grate level.

The construction to be tested should be designed for a working load of 150 lb. per sq. ft., and no more. This load is to be uniformly distributed without arching effect, and is to be carried on the floor during the fire test.

The floor may be tested as soon after construction as desired, but within forty days. Artificial drying will be allowed if desired.

No plastering shall be applied to the underside of the floor construction under test.

The floor shall be subjected for four hours to the continuous heat of a fire of an average temperature of not less than 1700° F.; the fuel used being either wood or gas, so introduced as to cause an even distribution of heat throughout the test structure.

The heat obtained shall be measured by means of standard pyrometers, under the direction of an experienced person. The type of pyrometer is immaterial so long as its accuracy is secured by proper standardization. The heat should be measured at not less than two points when the main floor span is not more than 10 ft., and at one additional point when it exceeds 10 ft. Temperature readings at each point are to be taken every three minutes. The heat determination shall be made at points directly beneath the floor so as to secure a fair average.

At the end of the heat test a stream of water shall be directed
against the underside of the floor, discharged through a 1\(\frac{1}{2}\)-in. nozzle, under 60 lb. nozzle pressure, for ten minutes, the nozzle being held not more than 3 ft. from the firing door during the application of the water.

After the floor has sufficiently cooled the load on the same shall be increased to 600 lb. per sq. ft., uniformly distributed.

The test shall not be regarded as successful unless the following conditions are met: No fire or smoke shall pass through the floor during the fire test; the floor shall safely sustain the loads prescribed; the permanent deflection shall not exceed \(\frac{1}{8}\) in. for each foot of span in either slab or beam.
stream being played backward and forward over the entire surface of the partition under test.

The test shall not be regarded as successful unless the following conditions are met: No fire or smoke shall pass through the partition during the fire test; the partition shall safely sustain the pressure of the hose stream; the partition shall not warp or bulge, or disintegrate under the action of the fire or water to such an extent as to be unsafe.
STANDARD DEFINITIONS
OF
TERMS RELATING TO SEWER PIPE.

Serial Designation: C 8-15.

These definitions are issued under the fixed designation C 8-15, the final number indicates the year of original issue or in the case of revision, the year of last revision.

ADOPTED 1915.

I. FORCES ACTING UPON SEWER PIPE.

External Forces.—Forces resulting from pressures or impact acting from the outside upon the pipe.

Internal Forces.—Forces resulting from interior fluid pressure.

Abrasion.—Wearing away of surface material by friction.

II. RAW MATERIALS

Physical Properties.—Those sensible properties of raw materials, which in their combinations affect the manufacture and use of the product.

Chemical Properties.—Those properties resulting from combinations of elements in the raw materials, which in their composition affect the manufacture and use of the product.
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Chemical Properties.—Those properties resulting from combinations of elements in the raw materials, which in their composition affect the manufacture and use of the product.
III. Pipe.

(a) Sewer Pipe.—Separate pipe suitable for the conveyance of domestic and industrial sewage and storm water and capable of being properly joined to form a conduit.

Clay Pipe.—Made from red burning plastic clay devoid of fissile structure. Maturing temperature about 1170° C. Vitrification not ordinarily produced, and salt glazing not always effective.

Fire-Clay Pipe.—Made from buff, gray or reddish burning fire clay showing conchoidal structure. Maturing temperature about 1250° C. Complete stony vitrification may be produced, but an absorption lower than 3 per cent is not general, nor desirable for maximum strength.

Shale Pipe.—Made from red burning hard clay with a distinct fissile structure. Vitrification at from 1050 to 1250° C., and salt glazing successful only at highest temperature.

Cement-Concrete Pipe.—Pipe formed by consolidating in a mold a mixture of Portland cement, water, sand, stone or other hard material, and permitting it to harden by natural process prior to handling and use.

Special.—A pipe other than a straight pipe.

Branch.—A pipe attached to and diverging from the barrel of another pipe, such as Y-branches, T-branches, etc.

(b) Demands upon Sewer Pipes.—Requirements of qualities which are desirable and attainable under conditions of actual practice.

IV. Parts of Sewer Pipe.

Barrel or Shell.—Main body of a pipe, exclusive of differently formed ends.

Ends.—Those parts of a pipe which terminate it and are so formed as to permit of making a proper joint.

Beveled End.—End surfaces of pipes inclined at an angle with the pipe axis so formed that the end of one pipe can enter the end of the adjoining pipe with a close fit.

Hub or Bell.—That end of a pipe which is sufficiently enlarged for a short distance to receive and enclose the spigot end of the adjoining pipe, to form a joint.
Spigot.—That end of a pipe which enters and is formed to fit the hub or bell of the adjoining pipe; it is sometimes scored or has a head.

Butt.—Plain end of a pipe sometimes scored on the outside, to close up against a similar end of an adjoining pipe for the purpose of forming a joint, the two ends being surrounded and covered by a collar.

Collar.—A flat band to surround and cover a butt joint.

Base, form of.—Shape of that part of a pipe which rests upon a foundation.

V. JOINTS.

Beveled.—Formed by joining pipes with beveled ends and applying the jointing material.

Hub and Spigot.—Formed by inserting the spigot end of one pipe into the hub of another and applying the jointing material.

Butt and Collar.—Formed by abutting the butt ends of two adjacent pipes and, after applying the jointing material, surrounding the joint with a collar.

Jointing Materials.—The materials which are inserted between the ends of adjoining pipes for the purpose of forming a continuous closed conduit.

Elasticity of Joints.—Ability of jointed pipes to resist strains caused by bending and returning to original position.

VI. FINISHED PRODUCT.

(a) Material.

Durability.—Resistance to disintegration or deterioration.

Serviceability.—Ability to readily and effectively render satisfactory service.

Thickness.—Distance between outside and inside surfaces.

Strength.—Ability to resist physical forces imposed during handling and after pipe has been put in use.

Toughness.—Relative degree of resistance to impact without fracture as opposed to brittleness.

Hardness.—Intensity of molecular cohesion as measured by resistance to penetration by a standard tool.
Definitions of Terms Relating to Sewer Pipe.

Smoothness.—Evenness of surface without projections or irregularities.

Vitrification.—The consolidation of material under high heat.

Shrinkage.—Diminution of dimensions and mass of the material.

Porosity.—Ratio of the volume of interstices of the material to the volume of its mass.

Percolation.—Passage of water through the interstices of the material.

(b) Covering.

Coating.—A covering of other materials applied in liquid form.

Glazing.—Hard glassy surface covering.

Salt Glazing.—Glazing produced by application of salt during vitrification.

Lining.—A covering of other material applied in solid form to inside surfaces.

Waterproofing.—Materials resistant to penetration by water.

(c) Defects.

Warp.—Twisted out of normal shape.

Fracture.—Rupture of the material by a break through its entire thickness.

Crack.—Fissure or open seam not necessarily extending through body of material.

Fire Crack.—A crack resulting from lack of uniformity in shrinkage after the application of excessive heat.

Hair Crack.—Irregularly running, fine, narrow crevice or fissure at the surface of a pipe not penetrating deeply, and caused by a shrinkage of material during manufacture.

Blister.—Convex hollow prominence formed by separation and raising of a film in the process of burning.

Leakage.—Passage of water contrary to intention.

Lamination.—Division of material into thin layers or sheets.

VII. Identification.

Marking and Imprints.—Impressions made upon pipe at the place and time of manufacture for the purpose of identification.
STANDARD SPECIFICATIONS
FOR
PURITY OF RAW LINSEED OIL FROM NORTH AMERICAN SEED.

Serial Designation: D 1-15.

The specifications for this material are issued under the fixed designation D 1; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1913; REVISED, 1915.

I. PROPERTIES AND TESTS.

1. Raw linseed oil from North American seed shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity at 15°.5 C.</td>
<td>0.936</td>
<td>0.932</td>
</tr>
<tr>
<td>or Specific Gravity at 25° C.</td>
<td>0.931</td>
<td>0.927</td>
</tr>
<tr>
<td>Acid Number</td>
<td>6.00</td>
<td>....</td>
</tr>
<tr>
<td>Saponification Number</td>
<td>195</td>
<td>189</td>
</tr>
<tr>
<td>Unsaponifiable matter, per cent.</td>
<td>1.50</td>
<td>....</td>
</tr>
<tr>
<td>Refractive Index at 25° C.</td>
<td>1.4805</td>
<td>1.4790</td>
</tr>
<tr>
<td>Iodine Number (Hanus)</td>
<td>....</td>
<td>180</td>
</tr>
</tbody>
</table>

II. METHODS OF TESTING.

2. The recommended methods of testing are as follows:

General.—All tests are to be made on oil which has been filtered at a temperature of between 60 and 80° F. through
paper in the laboratory immediately before weighing out. The sample should be thoroughly agitated before the removal of a portion for filtration or analysis.

Specific Gravity.—Use a pyknometer, accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making a test at 15°.5 C., water being 1 at 15°.5 C., or a test at 25° C., water being 1 at 25° C.

Acid Number.—Expressed in milligrams of KOH per gram of oil. Follow the method described in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, page 142.

Saponification Number.—Expressed as with Acid Number. Blanks should also be run to cover effect of alkali in glass. Follow method given in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, pages 137–138.

Unsaponifiable Matter.—Follow Boemer’s method taken from his Ubbelohde Handbuch Der Ole u. Fette, pages 261–262.

"To 100 g. of oil in a 1000 to 1500-cc. Erlenmeyer flask add 60 cc. of an aqueous solution of potassium hydroxide (200 g. KOH dissolved in water and made up to 300 cc.) and 140 cc. of 95-per cent alcohol. Connect with a reflux condenser and heat on the water bath, shaking at first until the liquid becomes clear. Then heat for one hour with occasional shaking. Transfer while yet warm to a 2000-cc. separatory funnel to which some water has been added, wash out the Erlenmeyer with water using in all 600 cc. Cool, add 800 cc. of ether and shake vigorously one minute. In a few minutes the ether solution separates perfectly clear. Draw off the soap and filter the ether (to remove last traces of soap) into a large Erlenmeyer and distill off the ether, adding if necessary one or two pieces of pumice stone. Shake the soap solution three times with 400 cc. of ether, which add to the first ether extract. To the residue left after distilling the ether add 3 cc. of the above KOH solution, and 7 cc. of the 95-per cent alcohol, and heat under reflux condenser for 10 minutes on the water bath. Transfer to a small separatory funnel, using 20 to 30 cc. of water, and after cooling shake out with two portions of 100 cc. of ether; wash the ether three times with 10 cc. of water. After drawing off the last of the water, filter the ethereal solution so as to remove the last drops of water, distill off the ether, dry residue in water oven and weigh."
Or, any accurate method involving the extraction of the dried soap may be used.

*Refractive Index.*—Use a properly standardized Abbé Refractometer at 25° C., or any other equally accurate instrument.

*Iodine Number (Hanus).*—Follow the Hanus method as described in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, page 136.
STANDARD SPECIFICATIONS

FOR

PURITY OF BOILED LINSEED OIL FROM
NORTH AMERICAN SEED.


The specifications for this material are issued under the fixed designation D 11; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

I. PROPERTIES AND TESTS.

Properties.

1. Boiled linseed oil from North American seed shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>MAXIMUM</th>
<th>MINIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity at $15^\circ C$</td>
<td>0.945</td>
<td>0.937</td>
</tr>
<tr>
<td>Acid Number</td>
<td>8</td>
<td>....</td>
</tr>
<tr>
<td>Saponification Number</td>
<td>195</td>
<td>189</td>
</tr>
<tr>
<td>Unsaponifiable Matter, per cent.</td>
<td>1.5</td>
<td>....</td>
</tr>
<tr>
<td>Refractive Index at $25^\circ C$</td>
<td>1.484</td>
<td>1.479</td>
</tr>
<tr>
<td>Iodine Number (Hanus)</td>
<td>....</td>
<td>178</td>
</tr>
<tr>
<td>Ash, per cent.</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Manganese, per cent.</td>
<td>....</td>
<td>0.03</td>
</tr>
<tr>
<td>Calcium, per cent.</td>
<td>0.3</td>
<td>....</td>
</tr>
<tr>
<td>Lead, per cent.</td>
<td>....</td>
<td>0.1</td>
</tr>
</tbody>
</table>

(500)
II. METHODS OF TESTING.

2. The recommended methods of testing are as follows:

*General.*—The sample should be thoroughly agitated before the removal of a portion for analysis.

*Specific Gravity.*—Use a pyknometer, accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making a test at 15°.5 C., water being 1 at 15°.5 C.

*Acid Number.*—Expressed in milligrams of KOH per gram of oil. Follow the method described in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, page 142.

*Saponification Number.*—Expressed as with Acid Number. Blanks should also be run to cover effect of alkali in glass. Follow method given in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, pages 137-138.

*Unsaponifiable Matter.*—Follow Boemer's method taken from his Ubbelohde Handbuch Der Öle u. Fette, pages 261-262. "To 100 g. of oil in a 1000 to 1500-cc. Erlenmeyer flask add 60 cc. of an aqueous solution of potassium hydroxide (200 g. KOH dissolved in water and made up to 300 cc.) and 140 cc. of 95-per-cent alcohol. Connect with a reflux condenser and heat on the water bath, shaking at first until the liquid becomes clear. Then heat for one hour with occasional shaking. Transfer while yet warm to a 2000-cc. separatory funnel to which some water has been added, wash out the Erlenmeyer with water using in all 600 cc. Cool, add 800 cc. of ether and shake vigorously one minute. In a few minutes the ether solution separates perfectly clear. Draw off the soap and filter the ether (to remove last traces of soap) into a large Erlenmeyer and distill off the ether, adding if necessary one or two pieces of pumice stone. Shake the soap solution three times with 400 cc. of ether, which add to the first ether extract. To the residue left after distilling the ether add 3 cc. of the above KOH solution, and 7 cc. of the 95-per-cent alcohol, and heat under reflux condenser for 10 minutes on the water bath. Transfer to a small separatory funnel, using 20 to 30 cc. of water, and after cooling shake out with two portions of 100 cc. of ether; wash the ether three times with 10 cc. of water. After drawing off the last of the
water, filter the ethereal solution so as to remove the last drops of water, distill off the ether, dry residue in water oven and weigh."

Or, any accurate method involving the extraction of the dried soap may be used.

Refractive Index.—Use a properly standardized Abbé Refractometer at 25° C., or any other equally accurate instrument.

Iodine Number (Hanus).—Follow the Hanus method as described in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, page 136.

Ash.—The determination of the percentage of ash and the constituents thereof may be made by any method which gives accurate results.
STANDARD SPECIFICATIONS
FOR
PURITY OF RAW TUNG OIL.

Serial Designation: D 12-16.

The specifications for this material are issued under the fixed designation D 12; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915; REVISED, 1916.

I. PROPERTIES AND TESTS.

1. Raw tung oil shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Properties</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity at 15°.5 C</td>
<td>0.943</td>
<td>0.939</td>
</tr>
<tr>
<td>Acid Number</td>
<td>6</td>
<td>....</td>
</tr>
<tr>
<td>Saponification Number</td>
<td>195</td>
<td>190</td>
</tr>
<tr>
<td>Unsaponifiable Matter, per cent</td>
<td>0.75</td>
<td>....</td>
</tr>
<tr>
<td>Refractive Index at 25° C</td>
<td>1.520</td>
<td>1.515</td>
</tr>
<tr>
<td>Iodine Number (Hübli 18 hours)</td>
<td>....</td>
<td>165</td>
</tr>
<tr>
<td>Heating Test (Browne's Method), minutes</td>
<td>....</td>
<td>12</td>
</tr>
<tr>
<td>Iodine Jelly Test, minutes</td>
<td>....</td>
<td>4</td>
</tr>
</tbody>
</table>

II. METHODS OF TESTING.

2. The recommended methods of testing are as follows:

Methods of Testing.—Use a pyknometer accurately standardized and having a capacity of at least 25 cc., or any other equally (503)
Specifications for Purity of Raw Tung Oil.

accurate method, making the test at 15°.5 C., water being 1 at 15°.5 C.

**Acid Number.**—Weigh 10 g. of oil in a 200-cc. Erlenmeyer flask, add 50 cc. of neutral alcohol, connect with a reflux air condenser (or place small funnel in neck of flask), and heat on a steam bath for \( \frac{1}{2} \) hour. Remove from the bath, cool, add phenolphthalein, and titrate the free acid with N/5 sodium hydroxide. Calculate as the acid number (milligrams of potassium hydroxide to 1 g. oil).

**Saponification Number.**—Weigh from 2 to 3 g. of oil in a 200-cc. Erlenmeyer flask, add 30 cc. of a N/2 alcoholic solution of potassium hydroxide, connect with a reflux condenser, heat on a steam bath for 1 hour, then titrate with N/2 sulfuric acid, using phenolphthalein as indicator. Always run two blanks with the alcoholic potash. From the difference between the number of cubic centimeters of acid required by the blanks and the determinations, calculate the saponification number (milligrams of potassium hydroxide to 1 g. of oil).

**Unsaponifiable Matter.**—To 25 g. of oil add 15 cc. of an aqueous solution of KOH (200 g. of KOH dissolved in water and made up to 300 cc.) and 35 cc. of 95-per-cent alcohol. Connect with a reflux condenser and heat on the water bath for 1 hour with occasional shaking. Transfer to a separatory funnel containing a little water and wash out flask with water, using in all 125 cc. Cool, add 200 cc. of ether and shake vigorously for 1 minute. In a few minutes the ether solution will separate perfectly clear. Draw off the soap solution into another separatory funnel. Shake the soap solution with three 100-cc. portions of ether. Unite all the ether portions and wash with three 30-cc. portions of water. Filter the ether solution (small portions at a time) into a tared flask, distill off the ether and dry flask and contents to constant weight at 95 to 100° C. in a steam oven. Report the percentage of unsaponifiable matter.

**Refractive Index.**—Use a properly standardized Abbé refractometer at 25° C., or any other equally accurate instrument.

**Iodine Number (Hübl).**—Place a small quantity of oil into a small weighing bottle or beaker. Weigh carefully. Transfer by dropping from 0.2 to 0.3 g. to a 500-cc. bottle having a well-ground stopper, or a specially flanged neck, iodine-test
Erlenmeyer flask. Reweigh the weighing bottle or beaker to determine the amount of oil used in the test. Then dissolve the oil in 10 cc. of chloroform and add an amount of Hübli solution containing twice the amount of iodine that will be absorbed by the oil. Stopper the flask, shake well, and place in a dark closet for 18 hours. Add 20 cc. of a 10-per-cent solution of potassium iodide and 100 cc. of distilled water. Titrate with N/10 sodium thiosulfate, using starch as an indicator. Blank tests must be made. From the difference between the amounts of sodium thiosulfate required by the blanks and the determination, calculate the iodine number (centigrams of iodine to 1 g. of oil).

On account of the fact that Hübli solution after preparation is apt to deteriorate in strength, it is considered advisable to have prepared the two component parts of Hübli solution, namely, a solution of mercuric chloride in alcohol and a solution of iodine in alcohol, of the proper strength, as outlined in text-books. The proper amounts of these solutions may be mixed on the day of use.

Heating Test (Browne's Method).—Test tubes for containing the oil should be 16 cm. by 15 mm., with a mark near the bottom to indicate 5 cc., and closed by a cork so perforated that a glass rod 3 mm. in diameter could move freely.

Fill a copper beaker (height, 12 cm.; internal diameter, 6 cm.) with cotton-seed oil to a height of 7.5 cm. Place a thermometer so as to be 1.5 cm. from the bottom of the bath.

Use a nitrogen-filled, immersed-stem chemical thermometer, engraved stem; total length 4 to 4 1/2 in.; graduated from 210 to 310° C. in 2° intervals; the length between 210 and 310° C. not less than 2 1/2 in. If preferred, use emergent-stem thermometer 30 cm. long, with graduations from 100 to 400° C., making correction for emergent stem according to the method outlined in Stem Correction Sheet No. 44 of the U. S. Bureau of Standards.

When the bath temperature is 293° C. (560° F.) and very slowly rising at this point, place the tube containing 5 cc. of the oil to be tested so that its bottom is level with the lowest part of the bulb of the thermometer. Note the time, remove the source of heat for about 45 seconds and then reapply. Before 2 minutes have elapsed the temperature of the bath will have fallen to 282° C. (540° F.), at which point it should be kept as
Specifications for Purity of Raw Tung Oil.

steady as possible. When the tung oil has been in the bath about 9 minutes, raise the glass rod at intervals of \(\frac{1}{4}\) minute, and when the rod is firmly set note the time. As setting or jellying takes place within a few seconds of fluidity, a good end determination is afforded. Remove the specimen at once, heat the bath again to 293° C., and repeat the experiment with another portion of the sample.

No stirrer is used in the bath. A screen around the bath enables the temperature to be more easily reached. When the cotton-seed oil has become tarry and viscid, it should be renewed; otherwise heating may be irregular.

_Iodine Jelly Test._—In a wide-necked 200-cc. Erlenmeyer flask, place 2.5 g. (weight correct to 1 mg.) of the oil. Add 10 cc. of chloroform from a pipette and stopper the flask immediately. Carefully insert a small glass vial into the flask so that the vial stands upright. Into the vial from a pipette run 10 cc. of a solution of iodine in chloroform, containing 0.035 to 0.036 g. of iodine per cubic centimeter. Place the flask in a bath containing water at 25 to 26° C. and allow it to stand there for a few minutes. Keep the flask stoppered, except when it is necessary to remove it to insert the vial and to add the iodine solution. Tilt and rotate the flask so that the vial is upset and the contents of the flask are thoroughly mixed, at the same time starting a stop watch. Keep the flask in the bath at 25 to 26° C. and at the end of every quarter minute, tilt the flask towards a horizontal position. Note the time required for the formation of a jelly that does not flow, but sticks to the bottom of the flask or slides as a mass. Record time in minutes and quarters.
thereof. Pure tung oil should require $2\frac{3}{4}$ to $3\frac{1}{4}$ minutes for the formation of the jelly. If the temperature of the laboratory is more than 2 or 3° C. above or below 25° C., place the flask containing the iodine solution in the bath and allow it to remain there for several minutes before pipetting out the 10 cc. for the test. The arrangement of the apparatus is shown in Fig. 1. The chloroform used to dissolve the oil and to prepare the iodine solution shall conform to the requirements of the United States Pharmacopoeia and shall have a specific gravity at 25°/25° C. of not more than 1.481 and not less than 1.480. The proper density can be obtained by washing with water if the specific gravity is too low or by adding 95-per-cent ethyl alcohol if too high.

A convenient procedure for preparing the iodine solution is as follows: Treat an excess of iodine with warm chloroform and after shaking for a few minutes, cool the contents to about 20° C. and filter through glass wool. Pipette 10 cc. of the solution into a flask containing 10 cc. of 10-per-cent potassium-iodide solution and titrate with 0.1 normal sodium-thiosulfate solution. Calculate the iodine content and dilute with chloroform so as to obtain an iodine content of 0.035 to 0.036 g. per cc. After dilution, titrate again against the thiosulfate to be sure that the solution is of required strength.

All the details of the above method shall be followed exactly.
STANDARD SPECIFICATIONS
FOR
TURPENTINE.


The specifications for this material are issued under the fixed designation D 13; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

1. These specifications apply both to the turpentine that is distilled from pine oleoresins, and commonly known as “gum turpentine” or “spirits turpentine,” and to the turpentine commonly known as “wood turpentine” that is obtained from resinous wood, whether by extraction with volatile solvents, or by steam, or by destructive distillation.

2. The purchaser, when ordering under these specifications, may specify whether gum spirits or wood turpentine is desired. The turpentine shall be clear and free from suspended matter and water.

3. The color shall be “Standard”\[1\] or better.

4. The specific gravity shall be not less than 0.862 nor more than 0.872 at 15°.5 C.

\[1\] The term “Standard” refers to the color recognized as standard by the “Naval Stores Trade.” Turpentine is of “Standard” color when a depth of 50 mm. in a perfectly flat polished bottom tube, approximately matches a No. 1 yellow Lovibond glass.
5. The refractive index at 15°.5 C. shall be not less than 1.468 nor more than 1.478.

6. The initial boiling point shall be not less than 150 nor more than 160° C.

7. Ninety per cent of the turpentine shall distill below 170° C.

8. The polymerization residue shall not exceed 2 per cent and its refractive index at 15°.5 C. shall not be less than 1.500.

Methods of Analysis.

9. Color.—Fill a 200-mm., perfectly flat bottom colorimetric tube graduated in millimeters to a depth of from 40 to 50 mm. with the turpentine to be examined. Place the tube in a colorimeter and place on or under it a No. 2 yellow Lovibond glass. Over or under a second graduated tube in the colorimeter, place a No. 1 yellow Lovibond glass and run in the same turpentine until the color matches as nearly as possible the color in the first tube. Read the difference in depth of the turpentine in the two tubes. If this difference is 50 mm. or more, the turpentine is "Standard" or better.

10. Specific Gravity.—Determine specific gravity at any convenient temperature with a plummet, the displacement of which has been accurately determined for that temperature, or by an equally accurate method, using the factor 0.00082 for each degree centigrade that the temperature of determination differs from 15°.5 C.

11. Refractive Index.—Determine refractive index at any convenient temperature with an accurate instrument, and calculate the results to 15°.5 C., using the factor 0.00045 for each degree that the temperature of determination differs from 15°.5 C.

12. Distillation.—Use an ordinary Engler flask and condenser, and heat the flask by placing it in a glycerin or oil bath of the general type described in Bulletin No. 135, Bureau of Chemistry. Fit the flask with a thermometer reading from 145 to 200° C. in such a way that the mercury bulb shall be opposite the side tube of the flask and the 175° mark below

Specifications for Turpentine.

the cork. Place 100 cc. of the turpentine to be examined in the flask, connect with the condenser, insert stopper bearing thermometer, and heat until distillation of the turpentine begins. Conduct the distillation so that the distillate passes over at the rate of 2 drops per second. Note the initial distilling temperature and the percentage distilling below 170° C.

13. Polymerization.—Place 20 cc. of exactly 38/N (100.92 per cent) sulfuric acid in a graduated, narrow-neck Babcock flask, stoppered, and place in ice water and cool. Add slowly 5 cc. of the turpentine to be tested. Gradually mix the contents, cooling from time to time, and not allowing the temperature to rise above about 60° C. When the mixture no longer warms up on shaking, agitate thoroughly and place the bottle in a water bath and heat from 60 to 65° C. for about 10 minutes, keeping the contents of the flask thoroughly mixed by vigorous shaking five or six times during the period. Do not stopper the flask after the turpentine has been added, as it may explode. Cool to room temperature, fill the flask with concentrated sulfuric acid until the unpolymerized oil rises into the graduated neck. Centrifuge at about 1200 r. p. m. from 4 to 5 minutes, or allow to stand for 12 hours. Read unpolymerized residue, notice its consistency and color, and determine its refractive index.
STANDARD SPECIFICATIONS
FOR
FOUNDRY COKE.

Serial Designation: D 17–16.

The specifications for this material are issued under the fixed designation D 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

I. CHEMICAL PROPERTIES AND TESTS.

(A) Sampling.

1. Each carload, or its equivalent, shall be considered as a unit.

2. (a) The sample shall be taken from the exposed surface of the car, by knocking off with a hammer a piece approximately the size of a walnut, at regular intervals of 18 in. along three lines running from one end of the car to the other. One of these lines shall pass through the center of the car and the other two lines shall be 2 ft. from the respective sides of the car.

(b) The intervals of sampling along the three lines may be measured by using a hammer with a handle 18 in. long, breaking off a piece of coke the size of a walnut at each point where the head of the hammer rests, regardless of the appearance of the particular piece that happens to occur under the head of the hammer.

3. The total quantity of sample collected in the above manner shall not be less than 2 pecks.
4. When the total moisture content is not to be determined, the entire gross sample shall be crushed to pass through a screen having 4 meshes to the linear inch, under such conditions as shall prevent loss or the accidental admixture of foreign matter. The crushing shall be done mechanically with a jaw crusher, or by hand on a chilled iron or hard steel plate by impact of a chilled iron or hard steel tamping bar, hammer or sledge, avoiding all rubbing action, otherwise the ash content of the sample will be materially increased by the addition of iron from the crushing apparatus, even though hardened steel or chilled iron is used.

After all the gross sample has been passed through the 4-mesh screen, it shall be mixed on a strong, closely woven cloth about 5 ft. square by raising successively the four sides of the cloth, thus rolling the sample about until thoroughly mixed. The four corners of the cloth shall then be gathered up, and the sample shall be formed in a conical pile and reduced in quantity by quartering as follows:

The cone shall be flattened, its apex being pressed down so that each quarter contains the material originally in it. The flattened mass shall then be divided into four equal quarters. The diagonally opposite quarters shall then be removed and discarded and the space that they occupied brushed clean. The two remaining quarters shall be successively mixed, coned and quartered on the cloth as before, until two opposite quarters shall weigh not less than 5 lb., which shall then be placed in a suitable container for transportation to the laboratory. In case duplicate laboratory samples are desired, the rejected portions of the original 4-mesh sample shall be combined, mixed and quartered down to a similar 5-lb. sample.

5. The sample prepared by the above method may, at the option of the purchaser, be used for an approximate moisture determination. In such cases the gross sample shall be immediately crushed and reduced to the 5-lb. laboratory sample as rapidly as possible, to minimize the loss of moisture. The container for shipment to the laboratory shall be moisture-tight. Since the sample obtained by this method will usually show less than the true moisture content of the gross sample, the purchaser shall have the privilege of a special moisture sample as hereinafter
provided, if the standard sample shows more than 3 per cent moisture.

6. The special moisture sample shall consist of not less than 2 pecks of walnut size. It shall be taken in the manner described in Section 2, and shall be placed, immediately after collection, in a moisture-tight container for transportation to the laboratory. The car shall be weighed at the time the special moisture sample is collected.

7. In case of disagreement between buyer and seller, an independent chemist, mutually agreed upon, shall be employed to sample and analyze the coke, the cost to be borne by the party at fault.

The resample shall be taken and prepared as prescribed in the foregoing sections, except that the minimum quantity of gross sample shall be not less than 1 bushel in volume, taken at intervals of 18 in. on six equidistant lines parallel to the side of the car.

(B) Chemical Analysis.

8. The sample received at the laboratory shall be prepared for analysis, and the percentage of moisture, volatile matter, fixed carbon, ash, and sulfur shall be determined as specified in the Tentative Methods for Laboratory Sampling and Analysis of Coke (Serial Designation: D 37–16 T) of the American Society for Testing Materials.¹

9. The dry coke shall not exceed the following limits in chemical composition:

<table>
<thead>
<tr>
<th>Component</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile matter</td>
<td>not over 2.0 %</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>not under 86.0%</td>
</tr>
<tr>
<td>Ash</td>
<td>not over 12.0%</td>
</tr>
<tr>
<td>Sulfur</td>
<td>not over 1.0%</td>
</tr>
</tbody>
</table>

II. REJECTION.

10. (a) In case the original standard sample was taken in accordance with Section 5 and showed more than 3 per cent moisture, the purchaser shall have the option of taking a special moisture sample according to Section 6, and of deducting the

moisture found in excess of 3 per cent, from the weight of coke found on reweighing the car at the time the special moisture sample was taken.

(b) In case the original standard sample was taken with special regard to moisture in accordance with Section 6, the purchaser shall have the option of deducting the moisture in excess of 3 per cent from the weight of coke, provided that the car was weighed at the time of sampling.

Rejection. 11. Coke which fails to conform to the limits of chemical composition given in Section 9 will be rejected, and the seller shall be notified within 5 working days from the date of sampling.
STANDARD SPECIFICATIONS
FOR
YELLOW-PINE BRIDGE AND TRESTLE TIMBERS.

To be Applied to Solid Members and not to Composite Members.


The specifications for this material are issued under the fixed designation D 10; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1910; Revised, 1915.

I. GENERAL REQUIREMENTS.

1. Except as noted, all timber shall be cut from sound trees and sawed standard size; close-grained and solid; free from defects such as injurious ring shakes and crooked grain; unsound knots; knots in groups; decay; large pitch pockets, or other defects that will materially impair its strength.

2. (a) Dense southern yellow pine shall show on either end an average of at least six annual rings per inch and at least one-third summer wood, or else the greater number of the rings shall show at least one-third summer wood, all as measured over the third, fourth, and fifth inches on a radial line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided that the amount of summer wood as above measured shall be at least one-half.
Specifications for Yellow-Pine Bridge Timbers.

(b) The contrast in color between summer wood and spring wood shall be sharp and the summer wood shall be dark in color, except in pieces having considerably above the minimum requirement for summer wood.

(c) In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over 3 in. on an approximate radial line beginning at the edge nearest the pith in timbers over 3 in. in thickness and on the second inch (on the piece) nearest to the pith in timbers 3 in. or less in thickness.

(d) In dimension material containing the pith but not a 5-in. radial line, which is less than 2 by 8 in. in section or less than 8 in. in width, that does not show over 16 sq. in. on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-in. radial line the inspection shall apply to the three inches farthest from the pith.

(e) The radial line chosen shall be representative. In case of disagreement between purchaser and seller the average summer wood and number of rings shall be the average of the two radial lines chosen.

3. Sound southern yellow pine shall include pieces of southern pine without any ring or summer-wood requirement.

4. Rough timbers when sawed to standard size, shall mean that they shall not be over \( \frac{1}{4} \) in. scant from actual size specified. For instance, a 12 by 12-in. timber shall measure not less than \( 11\frac{3}{4} \) by \( 11\frac{3}{4} \) in.

5. Standard dressing means that not more than \( \frac{1}{4} \) in. shall be allowed for dressing each surface. For instance, a 12 by 12-in. timber shall, after dressing four sides, not measure less than \( 11\frac{1}{2} \) by \( 11\frac{1}{2} \) in.

II. STRINGERS.

6. (a) Dense Southern Yellow Pine.—Dense southern yellow pine shall show not less than 80 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece; loose knots, or knots greater than \( 1\frac{1}{2} \) in. in diameter, will not be permitted at points within 4 in. of the edges of the piece.
(b) Sound Southern Yellow Pine.—Sound southern yellow pine shall be square-edged, except it may have 1 in. wane on one corner. Knots shall not exceed in their largest diameter one-fourth the width of the face of the stick in which they occur. Ring shakes extending not over one-eighth of the length of the piece are admissible.

III. CAPS AND SILLS.

7. (a) Dense Southern Yellow Pine.—Dense southern yellow pine shall show 85 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece, and shall be free from knots over 2½ in. in diameter. Knots shall not be in groups.

(b) Sound Southern Yellow Pine.—Sound southern yellow pine shall be square-edged, except it may have 1 in. wane on one corner, or ½ in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth the width of the face of the stick in which they occur. Ring shakes shall not extend over one-eighth of the length of the piece.

IV. POSTS.

8. (a) Dense Southern Yellow Pine.—Dense southern yellow pine shall show not less than 75 per cent of heart, measured across the face anywhere on the length of the piece, and shall be free from knots over 2½ in. in diameter. Knots shall not be in groups.

(b) Sound Southern Yellow Pine.—Sound southern yellow pine shall be square-edged, except it may have 1 in. wane on one corner, or ½ in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth the width of the face of the stick in which they occur. Ring shakes shall not extend over one-eighth of the length of the piece.

V. LONGITUDINAL STRUTS OR GIRTS.

9. (a) Dense Southern Yellow Pine.—Dense southern yellow pine shall show one face all heart; the other face and two sides shall show not less than 85 per cent of heart, measured across the face or side anywhere in the piece, and shall be free from knots 1½ in. or over in diameter.
(b) Sound Southern Yellow Pine.—Sound southern yellow pine shall be square-edged and sound, and shall be free from knots $1\frac{1}{2}$ in. or over in diameter.

VI. LONGITUDINAL X-BRACES, SASH BRACES AND SWAY BRACES.

10. (a) Dense Southern Yellow Pine.—Dense southern yellow pine shall show not less than 80 per cent of heart on two faces and four square edges, and shall be free from knots over $1\frac{1}{2}$ in. in diameter.

(b) Sound Southern Yellow Pine.—Sound southern yellow pine shall be square-edged and sound, and shall be free from knots $2\frac{1}{2}$ in. or over in diameter.
STANDARD SPECIFICATIONS
FOR
2½-IN. COTTON RUBBER-LINED FIRE HOSE FOR PRIVATE DEPARTMENT USE.


The specifications for this material are issued under the fixed designation D 14; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1915.

I. COTTON FABRIC.

1. (a) The cotton fabric shall be even and firm in texture throughout and free from all injurious or unsightly defects, except such trifling ones as are incident to the best manufacturing practice. The filling threads (or weft) shall be thoroughly covered by the warp in woven fabric, while in knit fabric both warp and filling shall be covered by the knitted loop.

(b) Woven fabric shall have not less than 7 picks of filling and 26 warp strands per square inch of weaving. It shall be guaranteed not to mildew, if properly cared for. Sizing or other treatment liable to cause mildew shall be avoided.

II. RUBBER LINING.

2. (a) The rubber lining shall be of uniform quality, free from defects, and as free from corrugations as may be possible with the best methods of manufacture.
Specifications for Cotton Rubber-Lined Fire Hose.

(b) It shall contain, exclusive of cement and backing, not less than 40 per cent by weight, as found by analysis, of pure fine Para rubber or its equivalent, and shall not contain any kind of rubber substitutes, old vulcanized, or reclaimed rubber.

(c) It shall be cemented to the cotton fabric with cement which will meet requirements of Section 3 (g).

(d) It shall be lap-jointed, and the lap shall be as small and as neat as is consistent with the best results.

(e) The lining (without cement and backing) shall be made up of not less than 3 calendered sheets, and shall be not less than 0.049 in. in thickness, and, including cement and other backing, shall not exceed 0.076 in. in thickness.

Tests of Rubber Lining.

3. (a) The tensile strength shall be not less than 1600 lb. per sq. in.

(b) The length at time of breaking shall be not less than 6 times the initial length.

(c) Mark two lines on the test specimen 2 in. apart and at right angles to the direction of pull. Stretch to 10 in. and hold in that position for 10 minutes. Ten minutes after release, the distance between the two lines shall not exceed 2.4 in.

(d) The compound used shall not contain more than 7.5 per cent of sulfur, exclusive of that which may be contained in the mineral matter, as barytes, and the free sulfur shall not exceed 3 per cent; both figures shall be based upon the amount of gum as found by chemical analysis.

(e) The organic-acetone extract shall not exceed 5 per cent of the gum as found by chemical analysis.

(f) The saponifiable matter extracted by alcoholic potash after the acetone extraction has been made shall not exceed 2 per cent of the gum as found by chemical analysis.

(g) The adhesion, or “friction,” between the cement backing and the cotton fabric, shall be such that when a 9-lb. weight is suspended from the free end of a 1-in. strip of the lining cut circumferentially from the hose, the lining shall not separate from the backing or fabric at a rate greater than 1 in. per minute.
3. The internal diameter of the hose shall be not less than 2\(\frac{3}{8}\) in.

4. (a) The weight of the finished hose without couplings shall be not less than 35 lb. per 50-ft. length, or with couplings, not less than 40 lb. per 50-ft. length.

5. (b) The hose shall be flexible and easily coiled.

6. (a) The hose shall meet the following requirements for minimum bursting pressure. Tests on 50-ft. lengths need not be made unless specified by the purchaser.

<table>
<thead>
<tr>
<th>Length of sample, ft.</th>
<th>Bursting pressure, min., lb. per sq. in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>50</td>
</tr>
</tbody>
</table>

(b) Every length of hose shall be tested by the manufacturer after coupling but before delivery, with 300 lb. pressure. It shall be carefully dried again before shipment.

7. The elongation between 10 and 100 lb. shall not exceed 5 per cent and between 10 and 300 lb., 13 per cent of the original length, as measured at 10 lb. pressure.

8. (a) The hose shall not twist more than 25 deg. per foot at 300 lb. pressure. The twist should be in such a direction as to tighten rather than loosen the couplings.

(b) When under 300 lb. pressure, a 50-ft. length of hose shall not warp more than 20 in. from a straight line drawn from center to center of couplings.

9. Each 50-ft. length of hose shall be stenciled twice in black letters 1 in. high beginning not more than 4 ft. from the couplings as follows: “A.S.T.M. Specification,” also with the name of the manufacturer, and the month and year of manufacture.
10. (a) Couplings shall be made, finished and fitted in a workmanlike manner throughout. The diameter through couplings shall be $2\frac{1}{2}$ in.

(b) They shall be of the expansion-ring pattern, of ample strength, and of the best form to resist the strain of expanding the binding ring in the coupling, and shall have a tail part sufficiently long to extend $\frac{1}{8}$ in. beyond the end of the expansion ring. The ring shall be at least $1\frac{1}{4}$ in. in length and the washer at least $\frac{3}{16}$ in. thick.

(c) They shall be made of an alloy of copper, tin and zinc (and lead if desired) of the following proportions:

<table>
<thead>
<tr>
<th>Element</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>not under 82 per cent</td>
</tr>
<tr>
<td>Tin</td>
<td>5%</td>
</tr>
<tr>
<td>Zinc</td>
<td>over 7%</td>
</tr>
<tr>
<td>Lead</td>
<td>3%</td>
</tr>
</tbody>
</table>

Couplings, including both male and female and expansion rings, shall weigh not less than 5 lb., and both male and female shall be stamped with the name of the maker of the couplings and the month and year of manufacture in letters and figures not less than $\frac{1}{8}$ in. high.

(d) They shall be provided with rubber gasket of the same quality as the rubber lining and accurately fitted.

(e) They shall have in the coupling, inside each expansion ring, a rubber washer at least $1\frac{3}{16}$ in. in thickness and with inside diameter not less than that of the coupling. Hose coupling threads of all equipments shall be interchangeable with those now in use in the city or town, but where practicable and not otherwise specified, the "National Standard" thread adopted in 1906 by the National Fire Protection Association should be used.

The essential features of the "National Standard" are a 60-deg. V-thread, outside diameter on the male threads of $3\frac{3}{16}$ in. and $7\frac{1}{2}$ threads per inch.

Note.

In private yards located in cities or towns where couplings having 7, $7\frac{1}{2}$ or 8 threads per inch, and outside diameters on the male ends of not less than $3\frac{3}{16}$ in. or more than $3\frac{7}{16}$ in. are in use, it is possible to render both male and female couplings adaptable for interchange with the Standard by the
use of an adjustable tap for the female end or an adjustable die for the male end of the coupling. This tap or die should have the same number of threads per inch as the coupling or nipple to be treated.

In cases where the thread in use does not come within the above limits both with respect to number of threads per inch and outside diameter of threads on male, the hydrant nipples can be equipped with adapters provided with spanner lugs and having a Standard male thread on the out-board end.
STANDARD TEST
FOR
ABRASION OF ROAD MATERIAL.

Serial Designation: D 2-08.

This test is issued under the fixed designation D 2; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1908.

This well-known test is similar in almost all respects to the Deval abrasion test of the French School of Roads and Bridges. It has been used since 1878, and is entirely satisfactory for the purpose for which it was designed.

ABRASION TEST.

The machine shall consist of one or more hollow iron cylinders; closed at one end and furnished with a tightly fitting iron cover at the other; the cylinders to be 20 cm. in diameter and 34 cm. in depth, inside. These cylinders are to be mounted on a shaft at an angle of 30 deg. with the axis of rotation of the shaft.

At least 30 lb. of coarsely broken stone shall be available for a test. The rock to be tested shall be broken in pieces as nearly uniform in size as possible, and as nearly 50 pieces as possible shall constitute a test sample. The total weight of

(524)
rock in a test shall be within 10 g. of 5 kg. All test pieces shall be washed and thoroughly dried before weighing. Ten thousand revolutions, at the rate of between 30 and 33 per minute, shall constitute a test. Only the percentage of material worn off which will pass through a 0.16-cm. (3/16-in.) mesh sieve shall be considered in determining the amount of wear. This may be expressed either as the percentage of the 5 kg. used in the test, or the French coefficient, which is in more general use, may be given; that is, coefficient of wear $= 20 \times \frac{20}{w} = \frac{400}{w}$, where $w$ is the weight in grams of the detritus under 0.16 cm. (3/16 in.) in size per kilogram of rock used.
STANDARD TEST
FOR
TOUGHNESS OF MACADAM ROCK.

Serial Designation: D 3 – 08.

This test is issued under the fixed designation D 3; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1908.

In the consideration of macadam road materials, toughness is understood to mean the power possessed by a material to resist fracture by impact.

In testing macadam rocks under impact, it has been found best to apply a number of blows of successively increasing energy and note the blow causing failure. The following test involving this principle is, therefore, recommended for determining the toughness of rock for macadam road building.

TOUGHNESS TEST.

1. Test pieces may be either cylinders or cubes, 25 mm. in diameter and 25 mm. in height, cut perpendicular to the cleavage of the rock. Cylinders are recommended as they are cheaper and more easily made.

2. The testing machine shall consist of an anvil of 50-kg. weight, and placed on a concrete foundation. The hammer (526)
shall be of 2-kg. weight, and dropped upon an intervening plunger of 1-kg. weight, which rests on the test piece. The lower or bearing surface of this plunger shall be of spherical shape having a radius of 1 cm. This plunger shall be made of hardened steel, and pressed firmly upon the test piece by suitable springs. The test piece shall be adjusted, so that the center of its upper surface is tangent to the spherical end of the plunger.

3. The test shall consist of a 1-cm. fall of the hammer for the first blow, and an increased fall of 1 cm. for each succeeding blow until failure of the test piece occurs. The number of blows necessary to destroy the test piece is used to represent the toughness, or the centimeter-grams of energy applied may be used.
STANDARD TEST
FOR
SOLUBLE BITUMEN.

Serial Designation: D 4—11.

This test is issued under the fixed designation D 4; the final number
indicates the year of original issue, or in the case of revision, the year of last
revision.

ADOPTED, 1911.

Drying the Sample and Preparing it for Analysis.—It was
decided, owing to the great variety of conditions met with in
bituminous compounds, that it is impossible to specify any one
method of drying that would be satisfactory in every case. It
is therefore supposed that the material for analysis has been
previously dried either in the laboratory or in the process of
refining or manufacture, and that water, if present, exists only
as moisture in the hydroscopic form.

The material to be analyzed, if hard and brittle, is ground
and spread in a thin layer in a suitable dish (iron or nickel will
answer every purpose) and kept at a temperature of 125° C. for
one hour. In the case of paving mixtures and road materials,
where it is not desirable to crush the rock or sand grains, a lump
may be placed in the drying oven until it is thoroughly heated

Committee D-4 on Road Materials, by whom this Standard Test was prepared, wish
it understood that they do not recommend it as the best for general use, as it is longer and
in many cases gives no better results than other more expeditious tests, but only as a test
to be resorted to in case of dispute, as it seems to have the widest range of applicability of
any of the tests considered. Moreover, they wish it to be understood that with some
classes of materials the test will show a lower percentage of soluble bitumen than many of
the shorter tests.
through, when it can be crushed down into a thin layer and dried as above. If the material under examination contains any hydrocarbons at all volatile at this temperature, it will of course be necessary to resort to other means of drying. Tar or oils may be dehydrated by distillation and the water-free distillate returned to the residue and thoroughly incorporated with it.

Analysis of Sample.—After drying, from 2 to 15 g. (as may be necessary to insure the presence of 1 to 2 g. of pure bitumen) is weighed into a 150-cc. tared Erlenmeyer flask, and treated with 100 cc. of carbon disulfide. The flask is then loosely corked and shaken from time to time until all large particles of the material have been broken up. It is then set aside for 48 hours to settle. The solution is decanted into a similar flask that has been previously weighed. As much of the solvent is poured off as possible without disturbing the residue. The contents of the first flask are again treated with fresh carbon disulfide, shaken as before, and then put away with the second flask for 48 hours to settle.

The liquid in the second flask is then carefully decanted upon a weighed Gooch crucible, 3.2 cm. in diameter at the bottom, fitted with an asbestos filter, and the contents of the first flask are similarly treated. The asbestos filter is made of ignited long-fiber amphibole, packed in the bottom of a Gooch crucible to the depth of not over 1/2 in. In filtering no vacuum is to be used and the temperature is to be kept between 20 and 25° C. After passing the liquid contents of both flasks through the filter, the residue on the filter is thoroughly washed and the residues remaining in them are shaken with more fresh carbon disulfide and allowed to settle for 24 hours, or until it is seen that a good subsidation has taken place. The solvent in both flasks is then again decanted through the filter and the residues remaining in them are washed until the washings are practically colorless. All washings are to be passed through the Gooch crucible.

The crucible and both flasks are then dried at 125° C. and weighed. The filtrate containing the bitumen is evaporated, the bituminous residue burned, and the weight of the ash thus obtained added to that of the residue in the two flasks and the crucible. The sum of these weights deducted from the weight of substance taken gives the weight of soluble bitumen.
STANDARD TEST
FOR
PENETRATION OF BITUMINOUS MATERIALS.

Serial Designation: D 5 – 16.

This test is issued under the fixed designation D 5; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Adopted, 1911; Revised, 1916.

I. DEFINITION.

Penetration. 1. Penetration is defined as the consistency of a bituminous material, expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature. Where the conditions of test are not specifically mentioned, the load, time and temperature are understood to be 100 g., 5 seconds, 25° C. (77° F.), respectively, and the units of penetration to indicate hundredths of a centimeter.

II. APPARATUS.

Container. 2. The container for holding the material to be tested shall be a flat-bottom, cylindrical dish, 55 mm. (2 3/16 in.) in diameter and 35 mm. (1 3/8 in.) deep.¹

¹ This requirement is fulfilled by the American Can Company’s Gill style ointment box, deep pattern, 3 oz. capacity.
3. The needle for this test shall be of cylindrical steel rod 50.8 mm. (2 in.) long and having a diameter of 1.016 mm. (0.04 in.) and turned on one end to a sharp point having a taper of 6.35 mm. (¼ in.).

4. The water bath shall be maintained at a temperature not varying more than 0.1° C. from 25° C. (77° F.). The volume of water shall be not less than 10 liters and the sample shall be immersed to a depth of not less than 10 cm. (4 in.) and shall be supported on a perforated shelf not less than 5 cm. (2 in.) from the bottom of the bath.

5. Any apparatus which will allow the needle to penetrate without appreciable friction, and which is accurately calibrated to yield results in accordance with the definition of penetration, will be acceptable.

6. The transfer dish for container shall be a small dish or tray of such capacity as will insure complete immersion of the container during the test. It shall be provided with some means which will insure a firm bearing and prevent rocking of the container.

III. PREPARATION OF SAMPLE.

7. The sample shall be completely melted at the lowest possible temperature and stirred thoroughly until it is homogeneous and free from air bubbles. It shall then be poured into the sample container to a depth of not less than 15 mm. (⅝ in.). The sample shall be protected from dust and allowed to cool in an atmosphere not lower than 18° C. (65° F.) for one hour. It shall then be placed in the water bath along with the transfer dish and allowed to remain one hour.

IV. TESTING.

8. (a) In making the test the sample shall be placed in the transfer dish filled with water from the water bath of sufficient depth to completely cover the container. The transfer dish containing the sample shall then be placed upon the stand of the penetration machine. The needle, loaded with specified weight, shall be adjusted to make contact with the surface of the sample. This may be accomplished by making contact of

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the actual needle point with its image reflected by the surface of the sample from a properly placed source of light. Either the reading of the dial shall then be noted or the needle brought to zero. The needle is then released for the specified period of time, after which the penetration machine is adjusted to measure the distance penetrated.

At least three tests shall be made at points on the surface of the sample not less than 1 cm. ($\frac{3}{8}$ in.) from the side of the container and not less than 1 cm. ($\frac{3}{8}$ in.) apart. After each test the sample and transfer dish shall be returned to the water bath and the needle shall be carefully wiped toward its point with a clean, dry cloth to remove all adhering bitumen. The reported penetration shall be the average of at least three tests whose values shall not differ more than four points between maximum and minimum.

(b) When desirable to vary the temperature, time and weight, and, in order to provide for a uniform method of reporting results when variations are made, the samples shall be melted and cooled in air as above directed. They shall then be immersed in water or brine, as the case may require, for one hour at the temperature desired. The following combinations are suggested:

At $0^\circ$ C. ($32^\circ$ F.) 200-g. weight, 60 seconds.
At $46.1^\circ$ C. ($115^\circ$ F.) 50-g. weight, 5 seconds.
STANDARD TEST
FOR
LOSS ON HEATING OF OIL AND ASPHALTIC COMPOUNDS.

Serial Designation: D 6 - 16.

This test is issued under the fixed designation D 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1911; REVISED, 1916.

The amount lost by oils and asphaltic compounds when they are heated in an oven at a temperature of 163° C. (325° F.), ± 1° C., shall be determined by heating 50 g. of the water-free substance contained in a flat-bottom dish, the inside dimensions of which are approximately 55 mm. (2 3/16 in.) in diameter, by 35 mm. (about 1 1/8 in.) deep (3-oz. Gill style ointment box, deep pattern) for 5 hours.

The oven in which the substance is to be heated shall be brought to the prescribed temperature before the sample is introduced, and the temperature of the sample under test shall be regarded as that of a similar quantity of the same material immediately adjoining it in the oven, in which the bulb of a standardized thermometer is immersed.

The oven may be either of circular or rectangular form and the source of heat either gas or electricity.

(533)
The samples under test shall rest in the same relative position in a single row upon a perforated circular shelf 24.8 cm. (9.75 in.) in diameter, as shown in Fig. 1, suspended by a vertical shaft midway in the oven, which is revolved by mechanical means at the rate of from 5 to 6 revolutions per minute.

![Diagram](image)

**Fig. 1.—Aluminum Shelf.**

**Note.**

If additional periods of heating are desired, it is recommended that they be made in successive increments of 5 hours each.

If the residue after heating is to be tested for penetration, the sample should be thoroughly mixed by stirring until it is cool, and thereafter manipulated in accordance with the directions of the Standard Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials.
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD METHOD
FOR
MAKING A MECHANICAL ANALYSIS OF SAND OR
OTHER FINE HIGHWAY MATERIAL, EXCEPT
FOR FINE AGGREGATES USED IN
CEMENT CONCRETE.

Serial Designation: D 7–16.

This method is issued under the fixed designation D 7; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1911; REVISED, 1916.

The method shall consist of (1) drying at not over 110° C. (230° F.) to a constant weight a sample weighing 50 g.; (2) passing the sample through each of the following mesh sieves (American Society for Testing Materials standard sieves):¹

<table>
<thead>
<tr>
<th>Meshes per Linear Inch (=2.54 cm.)</th>
<th>Diameter of Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In.</td>
</tr>
<tr>
<td>10</td>
<td>0.027</td>
</tr>
<tr>
<td>20</td>
<td>0.0165</td>
</tr>
<tr>
<td>30</td>
<td>0.01375</td>
</tr>
<tr>
<td>40</td>
<td>0.01025</td>
</tr>
<tr>
<td>50</td>
<td>0.009</td>
</tr>
<tr>
<td>80</td>
<td>0.00575</td>
</tr>
<tr>
<td>100</td>
<td>0.0045</td>
</tr>
<tr>
<td>200</td>
<td>0.00235</td>
</tr>
</tbody>
</table>

¹The order in which the sieves are to be used in the process of sifting is immaterial and shall be left optional; but in reporting results the order in which the sieves have been used shall be stated.

(535)
(3) determining the percentage by weight retained on each sieve, the sifting being continued on each sieve until less than 1 per cent of the weight retained on each sieve shall pass through the sieve during the last minute of sifting; and (4) recording the mechanical analysis in the following manner:

<table>
<thead>
<tr>
<th>Passing 200-mesh sieve</th>
<th>..........................</th>
<th>per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 100-mesh sieve and retained on a 200-mesh sieve</td>
<td>................</td>
<td>&quot;</td>
</tr>
<tr>
<td>Passing 80-mesh sieve and retained on a 100-mesh sieve</td>
<td>................</td>
<td>&quot;</td>
</tr>
<tr>
<td>Passing 50-mesh sieve and retained on an 80-mesh sieve</td>
<td>................</td>
<td>&quot;</td>
</tr>
<tr>
<td>..................................................................................</td>
<td>100.00</td>
<td>&quot;</td>
</tr>
</tbody>
</table>
AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD METHOD
FOR
MAKING A MECHANICAL ANALYSIS OF BROKEN
STONE OR BROKEN SLAG, EXCEPT FOR
AGGREGATES USED IN CEMENT
CONCRETE.

Serial Designation: D 18–16.
This method is issued under the fixed designation D 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

The method shall consist of (1) drying at not over 110° C. (230° F.) to a constant weight a sample weighing in pounds six times the diameter in inches of the largest holes required; (2) passing the sample through such of the following size screens having circular openings as are required or called for by the specifications, screens to be used in the order named: 8.89 cm. (3½ in.), 7.62 cm. (3 in.), 6.35 cm. (2½ in.), 5.08 cm. (2 in.), 3.81 cm. (1½ in.), 3.18 cm. (1¼ in.), 2.54 cm. (1 in.), 1.90 cm. (¾ in.), 1.27 cm. (½ in.), and 0.64 cm. (¼ in.); (3) determining the percentage by weight retained on each screen; and (4) recording the mechanical analysis in the following manner:

Passing 0.64-cm. (¼-in.) screen. ......................... . . . . . . . . per cent
Passing 1.27-cm. (½-in.) screen and retained on a 0.64-cm.
(¼-in.) screen. ............................................... "
Passing 1.90-cm. (¾-in.) screen and retained on a 1.27-cm.
(½-in.) screen. ............................................... "
Passing 2.54-cm. (1-in.) screen and retained on a 1.90-cm.
(¾-in.) screen. ............................................... "

................................................................. 100.00 "

(537)
STANDARD METHOD
FOR
MAKING A MECHANICAL ANALYSIS OF MIXTURES
OF SAND OR OTHER FINE MATERIAL WITH
BROKEN STONE OR BROKEN SLAG,
EXCEPT FOR AGGREGATES USED
IN CEMENT CONCRETE.

Serial Designation: D 19 – 16.

This method is issued under the fixed designation D 19; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

The method shall consist of (1) drying at not over 110° C. (230° F.) to a constant weight a sample weighing in pounds six times the diameter in inches of the largest holes required; (2) separating the sample by the use of a screen having circular openings 0.64 cm. (¼ in.) in diameter; (3) examining the portion retained on the screen in accordance with the Standard Method for Making a Mechanical Analysis of Broken Stone or Broken Slag, except for Aggregates Used in Cement Concrete (Serial Designation: D 18) of the American Society for Testing Materials; (4) examining the portion passing this screen in accordance with the Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, except for
Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials; and (5) recording the mechanical analysis in the following manner:

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 200-mesh sieve</td>
<td>\ldots per cent</td>
</tr>
<tr>
<td>Passing 100-mesh sieve and retained on a 200-mesh sieve</td>
<td>\ldots &quot;</td>
</tr>
<tr>
<td>Passing 80-mesh sieve and retained on a 100-mesh sieve</td>
<td>\ldots &quot;</td>
</tr>
<tr>
<td>Passing 10-mesh sieve and retained on a 20-mesh sieve</td>
<td>\ldots &quot;</td>
</tr>
<tr>
<td>Passing 0.64-cm. (\frac{1}{4}\text{-in.}) screen and retained on a 10-mesh sieve</td>
<td>\ldots &quot;</td>
</tr>
<tr>
<td>Passing 1.27-cm. (\frac{1}{2}\text{-in.}) screen and retained on a 0.64-cm. (\frac{1}{4}\text{-in.}) screen</td>
<td>\ldots &quot;</td>
</tr>
<tr>
<td>Passing 1.90-cm. (\frac{3}{4}\text{-in.}) screen and retained on a 1.27-cm. (\frac{1}{2}\text{-in.}) screen</td>
<td>\ldots &quot;</td>
</tr>
</tbody>
</table>

\[100.00\]
STANDARD METHOD
FOR
DISTILLATION OF BITUMINOUS MATERIALS
SUITABLE FOR ROAD TREATMENT.

Serial Designation: D 20 – 16.

This method is issued under the fixed designation D 20; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1916.

Sampling. 1. The sample as received shall be thoroughly stirred and agitated, warming, if necessary, to insure a complete mixture before the portion for analysis is removed.

Dehydration. 2. If the presence of water is suspected or known, the material shall be dehydrated before distillation. About 500 cc. of the material are placed in an 800-cc. copper still provided with a distilling head connected with a water-cooled condenser. A ring burner is used, starting with a small flame at the top of the still, and gradually lowering it, if necessary, until all the water has been driven off. The distillate is collected in a 200-cc. separatory funnel with the tube cut off close to the stopcock. When all the water has been driven over and the distillate has settled out, the water is drawn off and the oils returned to the residue in the still. The contents of the still shall have cooled to below 100° C. before the oils are returned, and they shall be well stirred and mixed with the residue.
3. The apparatus shall consist of the following standard parts:

(a) Flask.—The distillation flask shall be a 250-cc. Engler distilling flask, having the following dimensions:

- Diameter of bulb: 8.0 cm.
- Length of neck: 15.0 cm.
- Diameter of neck: 1.7 cm.
- Surface of material to lower side of tubulature: 11.0 cm.
- Length of tubulature: 15.0 cm.
- Diameter of tubulature: 0.9 cm.
- Angle of tubulature: 75 deg.

A variation of 3 per cent from the above measurements will be allowed.

(b) Thermometer.—(1) The thermometer shall be made of resistance glass (Jena 59... Jena 19... Verra dur are suggested); (2) it shall be filled with CO₂ under pressure of one atmosphere at 300° C., and shall be provided with expansion bulb at the top; (3) it shall be annealed at 400° C. for 96 hours and slowly cooled; (4) it shall be graduated in single degrees Centigrade from -5° C. to +400° C.; (5) the length of the graduations from 0 to 400° C. shall be 300 mm. (±10 mm.); (6) the diameter of stem shall be 7 mm. (±1 mm.); (7) when the thermometer is at a temperature of 26° C., and plunged into a free flow of steam, the meniscus shall pass the 90° mark in not less than 6 seconds.

The thermometer shall be set up as for the distillation test, using water, naphthalene and benzophenone as distilling liquids. The correctness of the thermometer shall be checked at 0 and 100° C. after each third distillation until seasoned.

(c) Condenser.—The condenser tube shall have the following dimensions:

- Adapter: 70 mm.
- Length of straight tube: " 185 "
- Width of tube: " 12-15 "
- Width of adapter end of tube: " 20-25 "

(d) Stands.—Two iron stands shall be provided, one with a universal clamp for holding the condenser, and one with a light grip arm with a cork-lined clamp for holding the flask.
Method for Distillation of Bituminous Materials.

(e) Burner and Shield.—A Bunsen burner shall be provided, with a tin shield 20 cm. long by 9 cm. in diameter. The shield shall have a small hole for observing the flame.

(f) Cylinders.—The cylinders used in collecting the distillate shall have a capacity of 25 cc., and shall be graduated in 0.1 cc.

Setting up the Apparatus.

4. The apparatus shall be set up as shown in Fig. 1, the thermometer being placed so that the top of the bulb is opposite the middle of the tubulation. All connections should be tight.

5. One hundred cubic centimeters of the dehydrated material to be tested shall be placed in a tared flask and weighed. After adjusting the thermometer, shield, condenser, etc., the dis-
Distillation is commenced, the rate being so regulated that 1 cc. passes over every minute. The receiver is changed as the mercury column just passes the fractionating point.

The following fractions should be reported:

Start of distillation to 110° C.
110 to 170° C.
170 to 235° C.
235 to 270° C.
270 to 300° C.
Residue

To determine the amount of residue, the flask is weighed again when distillation is complete. During the distillation the condenser tube shall be warmed when necessary to prevent the deposition of any sublimate. The percentages of fractions should be reported both by weight and by volume.
STANDARD METHOD
FOR
SAMPLING OF COAL.

Serial Designation: D 21 – 16.

This method is issued under the fixed designation D 21; the final number indicates the year of original issue, or in the case or revision, the year of last revision.

ADOPTED, 1916.

It is imperative that every sample be collected and prepared carefully and conscientiously and in strict accordance with the standard methods described herein, for if the sampling is improperly done, the sample will be in error, and it may be impossible or impracticable to take another sample; but if an analysis is in error, another analysis can easily be made of the original sample.

Gross samples of the quantities designated herein must be taken whether the coal to be sampled consists of a few tons or several hundred tons, because of the following cardinal principle in sampling coal that must be recognized and understood; that is, the effect of the chance inclusion or exclusion of too many or too few pieces of slate or other impurities in what, or from what, would otherwise have been a representative sample will cause the analysis to be in error accordingly, regardless of
the tonnage sampled. For example, the chance inclusion or exclusion of 10 lb. too much or too little of impurities in or from an otherwise representative sample of 100 lb. would cause the analysis to show an error in ash content and in heat units of approximately 10 per cent, whereas for a 1000-lb. sample, the effect would be approximately only 1 per cent, being the same whether the sample is collected from a 1-ton lot or from a lot consisting of several hundred tons.

When this method of sampling is to be employed as a part of any contract or agreement, the following provisions shall be specifically agreed to by the parties to such contract or agreement:

(a) The place at which the coal is to be sampled (see Section 1);
(b) The approximate size of the sample required when the standard conditions do not apply (see Section 3);
(c) The number of samples to be taken or the amount of coal to be represented by each sample when the standard conditions do not apply (see Section 4).

I. FOR ALL DETERMINATIONS EXCEPT TOTAL MOISTURE.

1. The coal shall be sampled when it is being loaded into or unloaded from railroad cars, ships, barges, or wagons, or when discharged from supply bins, or from industrial railway cars, or grab buckets, or from any coal-conveying equipment, as the case may be. If the coal is crushed as received, samples usually can be taken advantageously after the coal has passed through the crusher. Samples collected from the surface of coal in piles or bins, or in cars, ships or barges are generally unreliable.

2. To collect samples, a shovel or specially designed tool, or mechanical means shall be used for taking equal portions or increments. For slack or small sizes of anthracite, increments as small as 5 to 10 lb. may be taken, but for run-of-mine or lump coal, increments should be at least 10 to 30 lb.

3. The increments shall be regularly and systematically collected, so that the entire quantity of coal sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount shall be collected. The standard gross sample shall not be less than
1000 lb., except that for slack coal and small sizes of anthracite in which the impurities do not exist in abnormal quantities or in pieces larger than \( \frac{3}{4} \) in., a gross sample of approximately 500 lb. shall be considered sufficient. If the coal contains an unusual amount of impurities, such as slate, and if the pieces of such impurities are very large, a gross sample of 1500 lb. or more shall be collected. The gross sample should contain the same proportion of lump coal, fine coal, and impurities as is contained in the coal sampled. When coal is extremely lumpy, it is best to break a proportional amount of the lumps before taking the various increments of a sample. Provision should be made for the preservation of the integrity of the sample.

4. A gross sample shall be taken for each 500 tons or less, or in case of larger tonnages, for such quantities as may be agreed upon.

<table>
<thead>
<tr>
<th>Weight of Sample to be Divided, lb.</th>
<th>Largest Size of Coal and Impurities Allowable in Sample before Division, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 or over</td>
<td>1</td>
</tr>
<tr>
<td>500</td>
<td>( \frac{3}{4} )</td>
</tr>
<tr>
<td>250</td>
<td>( \frac{2}{3} )</td>
</tr>
<tr>
<td>125</td>
<td>( \frac{3}{8} )</td>
</tr>
<tr>
<td>60</td>
<td>( \frac{1}{4} )</td>
</tr>
<tr>
<td>30</td>
<td>( \frac{3}{16} ) or 4-mesh screen</td>
</tr>
</tbody>
</table>

5. After the gross sample has been collected, it shall be systematically crushed, mixed, and reduced in quantity to convenient size for transmittal to the laboratory. The sample may be crushed by hand or by any mechanical means, but under such conditions as shall prevent loss or the accidental admixture of foreign matter. Samples of the quantities indicated in Table I shall be crushed so that no pieces of coal and impurities will be greater in any dimension, as judged by eye, than specified for the sample before division into two approximately equal parts.

The method of reducing by hand the quantity of coal in a gross sample shall be carried out as prescribed in Section 6, even should the initial size of coal and impurities be less than indicated in Table I.
METHOD OF PREPARING A SAMPLE OF COAL BY HAND

FIRST STAGE IN THE PREPARATION OF A 1,000-POUND SAMPLE

 Crush 1,000-pound sample on hard, clean surface to 1" size

SECOND STAGE

 Crush 500-pound sample, (fig. 5, A) to 3/4" size

 Mix by forming long pile, A—spreading out first shovelful, B—long pile completed

 Halving by alternate shovel method, Shovelfuls 1, 3, 5, etc., reserved at A, B—4, 6, etc., rejected at B, B

 Long pile divided into two parts; A—reserve; B—reject

THIRD STAGE

 Crush 250-pound sample, (fig. 10, A) to 3/8" size

 Mix by forming new cone, A—quartering cone, B—long pile completed

 Quarter after flattening cone, Sample divided into quarters

 Retain opposite quarters A, B, Reject quarters B, B

FOURTH STAGE

 Crush 125-pound sample, (fig. 16, A) on blanket to 1/8" size

 Mix by rolling on blanket, A—forming cone after mixing

 Quarter after flattening cone, Sample divided into quarters

 Retain opposite quarters A, B, Reject quarters B, B

FIFTH STAGE

 Crush 60-pound sample, (fig. 22, A) to 1/4" size

 Mix by rolling on blanket, A—forming cone after mixing

 Quarter after flattening cone, Sample divided into quarters

 Retain opposite quarters A, B, Reject quarters B, B

SIXTH STAGE

 Crush 30-pound sample, (fig. 28, A) to 1/4" or 4-mesh size

 Mix by rolling on blanket, A—forming cone after mixing

 Quarter after flattening cone, Sample divided into quarters

 The laboratory sample to be taken from A, A

NOTE

SELECT A HARD, CLEAN SURFACE, FREE OF CRACKS AND PROTECTED FROM RAIN, SNOW, WIND, AND BEATING SUN. DO NOT LET CINDER, SAND, CHIPPINGS FROM FLOOR, OR ANY OTHER FOREIGN MATTER GET INTO THE SAMPLE. PROTECT SAMPLE FROM LOSS OR GAIN IN MOISTURE.

NECESSARY TOOLS: SHOVEL, TAMPER, BLANKET (MEASURING ABOUT 6 BY 8 FT.), BROOM, AND RAKE. USE RAKE FOR RAKING OVER COAL WHEN CRUSHING IT, SO THAT ALL LUMPS WILL BE CRUSHED. SWEEP FLOOR OR BLANKET CLEAN OF ALL DISCARDED COAL AFTER EACH TIME SAMPLE IS HALVED OR QUARTERED.
6. The progressive reduction in the weight of the sample to
the quantities indicated in Table I shall be done by the following
methods, which are illustrated in Plate III:

(a) The alternate-shovel method of reducing the gross
sample shall be repeated until the sample is reduced to approxi-
mately 250 lb., and care shall be observed before each reduction
in quantity that the sample has been crushed to the fineness
prescribed in Table I.

The crushed coal shall be shoveled into a conical pile (Figs. 2
or 7, Plate III) by depositing each shovelful of coal on top of the
preceding one, and then formed into a long pile in the following
manner: The sampler shall take a shovelful of coal from the
conical pile and spread it out in a straight line (Figs. 3A or 8A)
having a width equal to the width of the shovel and a length of
5 to 10 ft. His next shovelful shall be spread directly over the
top of the first shovelful, but in the opposite direction, and so
on back and forth. The pile being occasionally flattened, until
all the coal has been formed into one long pile (Figs. 3B or 8B).
The sampler shall then discard half of this pile, proceeding as
follows:

Beginning on one side of the pile, at either end, and shoveling
from the bottom of the pile, the sampler shall take one shovelful
(shovelful No. 1, Figs. 4 or 9) and set it aside; advancing
along the side of the pile a distance equal to the width of the
shovel, he shall take a second shovelful (shovelful No. 2) and
discard it; again advancing in the same direction one shovel
width, he shall take a third shovelful (shovelful No. 3) and add
it to the first. The fourth (shovelful No. 4) shall be taken in a
like manner and discarded, the fifth (shovelful No. 5) retained,
and so on, the sampler advancing always in the same direction
around the pile so that its size will be gradually reduced in a
uniform manner. When the pile is removed, about half of the
original quantity of coal should be contained in the new pile
formed by the alternate shovelfuls which have been retained.
(Figs. 5A or 10A show the retained halves, and Figs. 5B or 10B
the rejected halves.)

(b) After the gross sample has been reduced by the above
method to approximately 250 lb., further reduction in quantity
shall be by the quartering method. Before each quartering, the
sample shall be crushed to the fineness prescribed in Table I.
Quantities of 125 to 250 lb. shall be thoroughly mixed by coning and re-coning (Figs. 12 and 13); quantities less than 125 lb. shall be placed on a suitable cloth, measuring about 6 by 8 ft., mixed by raising first one end of the cloth and then the other (Figs. 18, 24 or 30), so as to roll the coal back and forth, and after being thoroughly mixed shall be formed into a conical pile by gathering together the four corners of the cloth (Figs. 19, 25 or 31). The quartering of the conical pile shall be done as follows:

The cone shall be flattened, its apex being pressed vertically down with a shovel, or board, so that after the pile has been quartered, each quarter will contain the material originally in it. The flattened mass, which shall be of uniform thickness and diameter, shall then be marked into quarters (Figs. 14, 20, 26 or 32) by two lines that intersect at right angles directly under a point corresponding to the apex of the original cone. The diagonally opposite quarters (BB in Figs. 16, 22, 28 or 34) shall then be shoveled away and discarded and the space that they occupied brushed clean. The coal remaining shall be successively crushed, mixed, coned, and quartered until the sample is reduced to the desired quantity.

(c) The 30-lb. quantity (Fig. 29) shall be crushed to \( \frac{3}{16} \) in. or 4-mesh size, mixed, coned, flattened and quartered. The laboratory samples shall include all of one of the quarters, or all of two opposite quarters (Fig. 34), as may be required. The laboratory sample shall be immediately placed in a suitable container and sealed in such a manner as to preclude tampering.

7. Only such mechanical means as will give equally representative samples shall be used in substitution for the hand method of preparation herein standardized.

II. FOR THE DETERMINATION OF TOTAL MOISTURE.

8. The special moisture sample shall weigh approximately 100 lb., and shall be accumulated by placing in a waterproof receptacle with a tight-fitting and waterproof lid small equal parts of freshly taken increments of the standard gross sample. The accumulated moisture sample shall be rapidly crushed and
reduced mechanically or by hand to about a 5-lb. quantity, which shall be immediately placed in a container and sealed air-tight and forwarded to the laboratory without delay.

9. Only when equally representative results will be obtained shall the standard gross sample be used instead of the special moisture sample for the determination of total moisture.
STANDARD METHODS

FOR

LABORATORY SAMPLING AND ANALYSIS OF COAL.

Serial Designation: D 22–16.

These methods are issued under the fixed designation D 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

Amdpt, 1916.

PREPARATION OF LABORATORY SAMPLES.

APPARATUS.

Air-Drying Oven.—The oven is to be used for air-drying wet samples and may be of the form shown in Fig. 1. This is not absolutely necessary but is economical where many wet samples are received.¹

Galvanized-Iron Pans 18 by 18 by 1.5 in. Deep.—For air-drying wet samples.

Balance or Solution Scale.—For weighing the galvanized-iron pans with samples. It should have a capacity of 5 kg. and be sensitive to 0.5 g.

Serial Designation: D 22—16.

Jaw Crusher.—For crushing coarse samples to pass a 4-mesh sieve.

Roll Crusher or Coffee-Mill Type of Grinder.—For reducing, the 4-mesh product to 20-mesh. The coffee-mill type of grinder should be entirely enclosed and have an enclosed hopper and a receptacle capable of holding 10 lb. of coal. This is to reduce the moisture losses while crushing.

Fig. 1.—Drier for Coarse Samples. The Outlet for Air at the Top may be connected with a Chimney or any other Device which will furnish a Suitable Draft. (Bulletin No. 9, Geological Survey of Ohio, p. 312.)

Abbé Ball Mill, Planetary Disk Crusher, Chrome-Steel Bucking Board, or any Satisfactory Form of Pulverizer.—For reducing the 20-mesh product to 60-mesh. The porcelain jars for the ball mill should be approximately 9 in. in diameter and 10 in. high. The flint pebbles should be smooth, hard and well rounded.
A Large Riffle Sampler, with $\frac{1}{2}$ or $\frac{3}{4}$-in. Divisions.—For reducing the 4-mesh sample to 10 lb. (Fig. 2).  

A Small Riffle Sampler, with $\frac{1}{4}$ or $\frac{3}{8}$-in. Divisions.—For dividing down the 20 and 60-mesh material to a laboratory sample (Fig. 2).

An 8-in. 60-mesh Sieve with Cover and Receiver.

Containers for Shipment to Laboratory.—Samples in which the moisture content is important should always be shipped in moisture-tight containers. A galvanized-iron or tin can with a screw top which is sealed with a rubber gasket and adhesive tape is best adapted to this purpose. Glass fruit jars sealed with rubber gaskets may be used, but require very careful packing to avoid breakage in transit. Samples in which the moisture content is of no importance need no special protection from loss of moisture.

---

Method of Sampling.

(A) When Coal Appears Dry.

If the sample is coarser than 4-mesh (0.20 in.) and larger in amount than 10 lb., quickly crush it with the jaw crusher to pass a 4-mesh sieve and reduce it on the larger riffle sampler to 10 lb.; then crush at once to 20-mesh by passing through rolls or an enclosed grinder, and take, without sieving, a 60-g. total moisture sample, immediately after the material has passed through the crushing apparatus. This sample should be taken with a spoon from various parts of the 20-mesh product, and should be placed directly in a rubber-stoppered bottle.

Thoroughly mix the main portion of the sample, reduce on the small riffle sampler to about 120 g., and pulverize to 60-mesh by any suitable apparatus without regard to loss of moisture. After all the material has been passed through the 60-mesh sieve, mix and divide it on the small riffle sampler to 60 g. Transfer the final sample to a 4-oz. rubber-stoppered bottle. Determine moisture in both the 60 and the 20-mesh samples by the method given under moisture.

Computation.—Compute the analysis of the 60-mesh coal, which has become partly air-dried during sampling, to the dry-coal basis, by dividing each result by 1 minus its content of moisture. Compute the analysis of the coal “as received” from the dry-coal analysis by multiplying by 1 minus the total moisture found in the 20-mesh sample.

(B) When Coal Appears Wet.

Spread the sample on tared pans, weigh, and air-dry at room temperature, or in the special drying oven, shown in Fig. 1, at 10 to 15° C. above room temperature, and weigh again. The drying should be continued until the loss in weight is not more than 0.1 per cent per hour. Complete the sampling as under dry coal.

Computation.—Correct the moisture found in the 20-mesh, air-dried sample to total moisture “as received,” as follows:

1 If the sample is crushed to pass a 6-mesh screen it may be reduced to 5 lb.
100—percentage of air-drying loss \( \times \) percentage of moisture in 20-mesh coal

\[
\frac{100 - \text{percentage of air-drying loss}}{100} + \text{percentage of air-drying loss} = \text{total moisture "as received."}
\]

Compute the analysis to "dry-coal" and "as-received" bases as under dry coal, using for the "as-received" computation the total moisture as found by the formula in place of the moisture found in the 20-mesh coal.

**Notes.**

Freshly mined or wet coal loses moisture rapidly on exposure to the air of the laboratory, hence the sampling operations between opening the container and taking the 20-mesh total-moisture sample must be conducted with the utmost dispatch and with minimum exposure to air.

The accuracy of the method of preparing laboratory samples should be checked frequently by resampling the rejected portions and preparing a duplicate sample. The ash in the two samples should not differ more than the following limits:

- No carbonates present: \( 0.4 \) per cent
- Considerable carbonate and pyrite present: \( 0.7 \) "
- Coals with more than 12 per cent ash, containing considerable carbonate and pyrite: \( 1.0 \) "

**DETERMINATION OF MOISTURE.**

**Apparatus.**

*Moisture Oven.*—This must be so constructed as to have a uniform temperature in all parts and a minimum of air space. It may be of the form shown in Fig. 3. Provision must be made for renewing the air in the oven at the rate of two to four times a minute, with the air dried by passing it through concentrated sulfuric acid.

*Capsules with Covers.*—A convenient form, which allows the ash determination to be made on the same sample, is the Royal Meissen porcelain capsule No. 2, \( \frac{3}{8} \) in. deep and \( 1\frac{3}{4} \) in. in diameter; or a fused silica capsule of similar shape. This is to be used with a well-fitting flat aluminum cover, illustrated in Fig. 4.
Glass capsules with ground-glass caps may also be used. They should be as shallow as possible, consistent with convenient handling.

**Method.**

(A) *Sixty-Mesh Sample.*

Heat the empty capsules under the conditions at which the coal is to be dried, stopper or cover, cool over concentrated sulfuric acid, sp. gr. 1.84, for 30 minutes, and weigh. Dip out with a spoon or spatula from the sample bottle approximately 1 g. of coal; put this quickly into the capsule, close, and weigh at once.

An alternative procedure (more open to error), after transferring an amount slightly in excess of 1 g., is to bring to exactly 1 g. in weight (±0.5 mg.) by quickly removing the excess weight of coal with a spatula. The utmost dispatch must be used in
order to minimize the exposure of the coal until the weight is found.

After removing the covers, quickly place the capsules in a pre-heated oven (at 104° to 110° C.) through which passes a current of air dried by concentrated sulfuric acid. Close the oven at once and heat for 1 hour. Then open the oven, cover the capsules quickly and place them in a desiccator over concentrated sulfuric acid. When cool, weigh.

![Diagram of porcelain capsule with flat aluminum cover]

\[ \text{Fig. 4.—Porcelain Capsule with Flat Aluminum Cover.} \]

(B) Twenty-mesh sample.

Use 5-g. samples, weighed with an accuracy of 2 mg., and heat for 1½ hours; the procedure is otherwise the same as with the 60-mesh sample. Methods of greater accuracy for the determination of moisture are given in the preliminary report.

The permissible differences in duplicate determinations are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Same Analyst, Different Analysts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture under 5 per cent</td>
<td>0.2</td>
</tr>
<tr>
<td>&quot; over 5 &quot;</td>
<td>0.3</td>
</tr>
</tbody>
</table>
DETERMINATION OF ASH.

APPARATUS.

Gas or Electric Muffle Furnace.—The muffle should have good air circulation and be capable of having its temperature regulated between 700 and 750° C.

Porcelain Capsules.—Royal Meissen Porcelain Capsules No. 2, 3/8 in. deep and 1 3/8 in. in diameter, or similar shallow dishes.

METHOD.

Place the porcelain capsules containing the dried coal from the moisture determination in a cold muffle furnace, or on the hearth at a low temperature, and gradually heat to redness at such a rate as to avoid mechanical loss from too rapid expulsion of volatile matter. Finish the ignition to constant weight (±0.001 g.) at a temperature between 700 and 750° C. Cool in a desiccator, and weigh as soon as cold.

The permissible differences in duplicate determinations are as follows:

<table>
<thead>
<tr>
<th>Same Analyst, Per Cent.</th>
<th>Different Analysts, Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No carbonates present...</td>
<td>0.2</td>
</tr>
<tr>
<td>Carbonates present......</td>
<td>0.3</td>
</tr>
<tr>
<td>Coals with more than 12% of ash, containing carbonates and pyrite...</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Notes.

Before replacing the capsules in the muffle for ignition to constant weight, the ash should be stirred with a platinum or nichrome wire. Stirring once or twice before the first weighing hastens complete ignition.

The result obtained by this method is "uncorrected" ash. For "corrected" ash see the preliminary report. The actual mineral matters in the original coal are usually very different in weight and composition from the weight of the "uncorrected" ash.
Methods for Analysis of Coal.

Determination of Volatile Matter.

Apparatus.

*Platinum Crucible with Tightly Fitting Cover.*—The crucible should be of not less than 10 nor more than 20-cc. capacity; of not less than 25 nor more than 35 mm. in diameter; of not less than 30 nor more than 35 mm. in height.

*Vertical Electric Tube Furnace; or a Gas or Electrically Heated Muffle Furnace.*—The furnace may be of the form as shown in Fig. 5. It is to be regulated to maintain a temperature of 950° C. (±20° C.) in the crucible, as shown by a thermocouple kept in the furnace. A suitable form of electric furnace is shown in Fig. 5. If the determination of volatile matter is not an essential feature of the specifications under which the coal is bought, a Meker burner may be used.

Method.

Weigh 1 g. of the coal in a weighed 10 to 20-cc. platinum crucible, close with a capsule cover, and place on platinum or nichrome-wire supports in the furnace chamber, which must be at a temperature of 950° C. (±20° C.). After the more rapid discharge of volatile matter has subsided, as shown by the disappearance of the luminous flame, tap the cover lightly to more perfectly seal the crucible and thus guard against the admission of air. After heating exactly 7 minutes, remove the crucible from the furnace and, without disturbing the cover, allow it to cool. Weigh as soon as cold. The loss of weight minus moisture equals the volatile matter.

*Modification for Sub-Bituminous Coal, Lignite, and Peat.*—Mechanical losses are incurred on suddenly heating peat, subbituminous coal, and lignite; therefore they must be subjected to a preliminary gradual heating for 5 minutes; this is best done by playing the flame of a burner upon the bottom of the crucible in such a manner as to bring about the discharge of volatile matter at a rate not sufficient to cause sparking. After the preliminary heating, transfer the crucible to the volatile-matter furnace and heat for 6 minutes at 950° C. as in the regular method.
Fig. 5.—Electric Tube Furnace for Determining Volatile Matter. For 110-volt Alternating Current, 60 ft. of Nichrome Wire, No. 17 B. & S. Gage will give the required temperature. The temperature must be controlled by an external resistance. (Technical Paper No. 76, Bureau of Mines, p. 21.)
Methods for Analysis of Coal.

The permissible differences in duplicate determinations are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Same Analyst, per cent.</th>
<th>Different Analysts, per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bituminous coals</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Lignites</td>
<td>1.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Notes.

The cover should fit closely enough so that the carbon deposit from bituminous and lignite coals does not burn away from the under side.

Regulation of temperature to within the prescribed limits is important.

DETERMINATION OF FIXED CARBON.

Compute fixed carbon as follows:

\[
100 - (\text{moisture} + \text{ash} + \text{volatile matter}) = \text{percentage of fixed carbon}
\]

DETERMINATION OF SULFUR BY THE ESCHKA METHOD.

Apparatus.

Gas or Electric Muffle Furnace, or Burners.—For igniting coal with the Eschka mixture and for igniting the barium sulfate.

Porcelain, Silica, or Platinum Crucibles or Capsules.—For igniting coal with the Eschka mixture.

No. 1 Royal Meissen porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.

No. 1 Royal Berlin porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coal, owing to the deeper form, than with the shallow capsules described above.

No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the barium sulfate.
**Solutions and Reagents.**

*Barium Chloride.*—Dissolve 100 g. of barium chloride in 1000 cc. of distilled water.

*Saturated Bromine Water.*—Add an excess of bromine to 1000 cc. of distilled water.

*Eschka Mixture.*—Thoroughly mix 2 parts (by weight) of light calcined magnesium oxide and 1 part of anhydrous sodium carbonate. Both materials should be as free as possible from sulfur.

*Methyl Orange.*—Dissolve 0.02 g. in 100 cc. of hot distilled water and filter.

*Hydrochloric Acid.*—Mix 500 cc. of hydrochloric acid, sp. gr. 1.20, and 500 cc. of distilled water.

*Normal Hydrochloric Acid.*—Dilute 80 cc. of hydrochloric acid, sp. gr. 1.20, to 1 liter with distilled water.

*Sodium Carbonate.*—A saturated solution, approximately 60 g. of crystallized or 22 g. of anhydrous sodium carbonate in 100 cc. of distilled water.

*Sodium-Hydroxide Solution.*—Dissolve 100 g. in 1 liter of distilled water. This solution may be used in place of the sodium-carbonate solution.

**Method.**

*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper 1 g. of coal and 3 g. of Eschka mixture. Transfer to a No. 1 Royal Meissen porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 Royal Berlin crucible or a platinum crucible of similar size, and cover with about 1 g. of Eschka mixture.

*Ignition.*—On account of the amount of sulfur contained in artificial gas, the crucible shall be heated over an alcohol, gasoline or natural gas flame as in procedure (a) below, or in a gas or electrically heated muffle, as in procedure (b) below. The use of artificial gas for heating the coal and Eschka mixture is permissible only when the crucibles are heated in a muffle.

(a) Heat the crucible, placed in a slanting position on a triangle, over a very low flame to avoid rapid expulsion of the volatile matter, which tends to prevent complete absorption of the products of combustion of the sulfur. Heat the crucible
slowly for 30 minutes, gradually increasing the temperature and stirring after all black particles have disappeared, which is an indication of the completeness of the procedure.

(b) Place the crucible in a cold muffle and gradually raise the temperature to 870–925° C. (cherry-red heat) in about 1 hour. Maintain the maximum temperature for about 1½ hours and then allow the crucible to cool in the muffle.

Subsequent Treatment.—Remove and empty the contents into a 200-cc. beaker and digest with 100 cc. of hot water for ½ to ¾ hour, with occasional stirring. Filter and wash the insoluble matter by decantation. After several washings in this manner, transfer the insoluble matter to the filter and wash 5 times, keeping the mixture well agitated. Treat the filtrate, amounting to about 250 cc., with 10 to 20 cc. of saturated bromine water, make slightly acid with hydrochloric acid and boil to expel the liberated bromine. Make just neutral to methyl orange with sodium-hydroxide or sodium-carbonate solution, then add 1 cc. of normal HCl. Boil again and add slowly from a pipette, with constant stirring, 10 cc. of a 10-per-cent solution of barium chloride (BaCl₂·2H₂O). Continue boiling for 15 minutes and allow to stand for at least 2 hours, or preferably over night, at a temperature just below boiling. Filter through an ashless filter paper and wash with hot distilled water until a silver-nitrate solution shows no precipitate with a drop of the filtrate. Place the wet filter containing the precipitate of barium sulfate in a weighed platinum, porcelain, silica or alundum crucible, allowing a free access of air by folding the paper over the precipitate loosely to prevent spattering. Smoke the paper off gradually and at no time allow it to burn with flame. After the paper is practically consumed, raise the temperature to approximately 925° C. and heat to constant weight.

The residue of magnesia, etc., after leaching, should be dissolved in hydrochloric acid and tested with great care for sulfur. When an appreciable amount is found this should be determined quantitatively. The amount of sulfur retained is by no means a negligible quantity.¹

Blanks and Corrections.—In all cases a correction must be applied either (1) by running a blank exactly as described above, using the same amount of all reagents that were employed in the regular determination, or more surely (2) by determining a known amount of sulfate added to a solution of the reagents after these have been put through the prescribed series of operations. If this latter procedure is adopted and carried out, say, once a week or whenever a new supply of a reagent must be used, and for a series of solutions covering the range of sulfur content likely to be met with in coals, it is only necessary to add to or subtract from the weight of barium sulfate obtained from a coal, whatever deficiency or excess may have been found in the appropriate "check" in order to obtain a result that is more certain to be correct than if a "blank" correction as determined by the former procedure is applied. This is due to the fact that the solubility error for barium sulfate, for the amounts of sulfur in question and the conditions of precipitation prescribed, is probably the largest one to be considered. Barium sulfate is soluble in acids and even in pure water, and the solubility limit is reached almost immediately on contact with the solvent. Hence, in the event of using reagents of very superior quality or of exercising more than ordinary precautions, there may be no apparent "blank," because the solubility limit of the solution for barium sulfate has not been reached or at any rate not exceeded.

As shown in the preliminary report, the Atkinson and sodium-peroxide methods give results in close agreement with the Eschka method. Register has shown that if 5 per cent of nitrogen is present in the gases contained in the bomb calorimeter the sulfur of a coal is almost completely oxidized to sulfuric acid and the washings of the calorimeter may be used for the determination of sulfur.

The permissible differences in duplicate determinations are as follows:

<table>
<thead>
<tr>
<th>Sulfur under 2 per cent</th>
<th>Same Analyst, Per Cent</th>
<th>0.05</th>
<th>Different Analysts, Per Cent</th>
<th>0.10</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot; over 2 &quot;</td>
<td>Same Analyst, Per Cent</td>
<td>0.10</td>
<td>Different Analysts, Per Cent</td>
<td>0.20</td>
</tr>
</tbody>
</table>

3 Ibid., Vol. 6, p. 812 (1914).
Determination of Phosphorus in Ash.

Method No. 1. To Cover All Cases.—To the ash from 5 g. of coal in a platinum capsule is added 10 cc. of nitric acid and 3 to 5 cc. of hydrofluoric acid. The liquid is evaporated and the residue fused with 3 g. of sodium carbonate. If unburned carbon is present 0.2 g. of sodium nitrate is mixed with the carbonate. The melt is leached with water and the solution filtered. The residue is ignited, fused with sodium carbonate alone, the melt leached and the solution filtered. The combined filtrates, held in a flask, are just acidified with nitric acid and concentrated to a volume of 100 cc. To the solution, brought to a temperature of 85° C., is added 50 cc. of molybdate solution and the flask is shaken for 10 minutes. If the precipitate does not form promptly and subside rapidly, add enough ammonium nitrate to cause it to do so. The precipitate is washed six times, or until free from acid, with a 2-per-cent solution of potassium nitrate, then returned to the flask and titrated with standard sodium hydroxide solution. The alkali solution may well be made equal to 0.00025 g. phosphorus per cubic centimeter, or 0.005 per cent for a 5-g. sample of coal, and is 0.995 of one-fifth normal.¹ Or the phosphorus in the precipitate is determined by reduction and titration of the molybdenum with permanganate.

Note on Method No. 1.—The advantage of the use of hydrofluoric acid in the initial attack of the ash lies in the resulting removal of silica. Fusion with alkali carbonate is necessary for the elimination of titanium, which if present and not removed will contaminate the phospho-molybdate and is said to sometimes retard its precipitation.

Method No. 2.—When titanium is so low as to offer no objection, the ash is decomposed as under method No. 1, but evaporation is carried only to a volume of about 5 cc. The solution is diluted with water to 30 cc., boiled and filtered. If the washings are turbid they are passed again through the filter. The residue is ignited in a platinum crucible, fused with a little sodium carbonate, the melt dissolved in nitric acid and its solution, if clear, added to the main one. If not clear it is filtered. The subsequent procedure is as under method

¹ Ulmann and Buch, Chemical Engineer, Vol. 10, p. 130 (1909).
No. 1. The fusion of the residue may be dispensed with in routine work on a given coal if it is certain that it is free from phosphorus.

ULTIMATE ANALYSIS.

CARBON AND HYDROGEN.

The determination of carbon and of hydrogen is made with a weighed quantity of sample in a 25-burner combustion furnace of the Glaser type. The products of combustion are thoroughly oxidized by being passed over red-hot copper oxide and lead chromate, and are fixed by absorbing the water in a weighed Marchand tube filled with granular calcium chloride (CaCl₂) and by absorbing the carbon dioxide in a Liebig bulb containing a 30-per-cent solution of potassium hydroxide (KOH).

The apparatus used consists of a purifying train, in duplicate, a combustion tube in the furnace, and an absorption train. The purifying train consists of the following purifying reagents arranged in order of passage of air and oxygen through them: sulfuric acid, potassium-hydroxide solution, soda lime, and granular calcium chloride. One of the trains is for air and one for oxygen. In the sulfuric-acid and potassium-hydroxide scrubbing bottles the air and the oxygen are made to bubble through about 5 mm. of the purifying reagent. Both purifying trains are connected to the combustion tube by a Y-tube, the joint being made tight by a rubber stopper.

The combustion tube is made of hard Jena glass. Its external diameter is about 21 mm., and its total length is 1 meter. The first 30 cm. of the tube are empty; following this empty space is an asbestos plug (acid-washed and ignited) or in its place a roll of oxidized copper gauze may be used; the next 40 cm. are filled with "wire" copper oxide; a second asbestos plug separates the copper oxide from 10 cm. of fused lead chromate, which is held in place by another asbestos plug 20 cm.
from the end of the tube. The end of the tube is drawn out for rubber-tubing connection with the absorption train.

The absorption train consists, first, of a Marchand tube filled with granular calcium chloride (CaCl₂) to absorb moisture. The CaCl₂ should be saturated with CO₂ before using. The Marchand tube is followed by a Liebig bulb containing a 30-per-cent potassium-hydroxide (KOH) solution, in which any possible impurities, as ferrous iron or nitrites, have been oxidized by a little potassium permanganate (KMnO₄). A guard tube, containing granular calcium chloride and soda lime, is attached to the Liebig bulb to absorb any carbon dioxide escaping the potassium-hydroxide solution and any water evaporating from that solution.

The train is connected to an aspirator which draws the products of combustion through the entire train. A guard tube of calcium chloride prevents moisture from running back into the absorption train. The suction is maintained constant by a Mariotte flask. The advantage of aspirating the gases through the train rather than forcing them through by pressure is that the pressure on the rubber connections is from the outside, so that gas-tight connections are more easily maintained than if the pressure is on the inside of the tube. The connections are made as tight as possible. The usual test for tightness is to start aspiration at the rate of about three bubbles of air per second through the potash bulb, and then to close the inlet for air and oxygen at the opposite end of the train; if there is no more than one bubble per minute in the potash bulb, the apparatus is considered tight.

Before starting a determination when the train has been idle some hours, or after any changes in chemicals or connections, a blank is run by aspirating about 1 liter of air through the train, which is heated in the same manner as if a determination on coal were being made. If the Liebig bulb and the tube containing calcium chloride show a change in weight of less than 0.5 mg. each, the apparatus is in proper condition for use.

A porcelain or platinum boat is provided with a glass weighing tube of suitable size, which is fitted with an accurately ground glass stopper. The tube and empty boat are weighed. Approximately 0.2 g. of the air-dry coal (60-mesh and finer, or better,
100-mesh if much free impurity is present) are quickly placed in the boat. The boat is at once placed in the weighing tube, which is quickly stoppered to prevent moisture change in the coal while weighing, and transferring to the furnace. The absorption tubes are connected and the boat and sample are transferred from the weighing tube to the combustion tube, which should be cool for the first 30 cm. The copper oxide should be red hot and the lead chromate at a dull-red heat. The transfer of the boat from weighing tube to combustion tube should be made as rapidly as possible. As soon as the boat is in place near the (asbestos plug at the beginning of the copper oxide) the stopper connecting with the purifying train is inserted and the aspiration started with pure oxygen gas at the rate of three bubbles per second. One burner is turned on about 10 cm. back from the boat, and the aspiration is continued carefully until practically all the moisture is expelled from the sample. The heat is then increased very gradually until all the volatile matter has been driven off. In driving off the volatile matter the heat must be applied gradually in order to prevent a too rapid evolution of gas and tar, which may either escape complete combustion or may be driven back into the purifying train. The heat should be slowly increased by turning on more burners under the open part of the tube until the sample is ignited; then the temperature can be increased rapidly, but care should be taken not to melt the combustion tube. Any moisture collecting in the end of the combustion tube or in the rubber connection joining it to the calcium-chloride tube is driven over into the calcium-chloride tube by carefully warming with a piece of hot tile. The aspiration with oxygen is continued for 2 minutes after the sample ceases to glow, the heat is then turned off and about 1200 cc. of air are aspirated. The absorption bulbs are then disconnected, wiped with a clean cloth, and allowed to cool to the balance-room temperature before weighing.

\[
\text{Percentage of hydrogen} = \frac{11.19 \times \text{increase in weight of CaCl}_2 \text{ tube}}{\text{Weight of sample}}
\]

\[
\text{Percentage of carbon} = \frac{27.27 \times \text{increase in weight of KOH bulb}}{\text{Weight of sample}}
\]
The ash in the boat is weighed and carefully inspected for any unburned carbon, which would destroy the value of the determination.

*Method with Electrically Heated Combustion Furnace.*—An electrically heated combustion furnace of the Heraeus type is used by the Bureau of Mines.¹

It consists of three independent heaters, two of which are provided with sheave wheels, and are mounted on a track so that they are movable along the tube; the third heater which surrounds the lead chromate, is stationary.

The furnace as provided by the manufacturer does not include the small stationary heater. This can be made in the laboratory by winding an alundum tube 12 cm. in length with No. 20 nichrome II wire and enclosing it in a cylinder packed with magnesia-asbestos. The movable heaters have very thin platinum foil, weighing about 9 g. in all, wound on a porcelain tube of 30 mm. internal diameter. The larger one which heats the copper oxide, is 350 mm. in length, and the smaller one, which heats the sample in the boat, is 200 mm. in length. The Jena glass or fused silica combustion tube, of about 21 mm. external diameter and 900 mm. in length, is supported by an asbestos-lined nickel trough. The current through each heater is regulated independently by separate rheostats, mounted on the frame of the furnace. The two platinum-wound heaters require an average current of about 4.5 amperes at a pressure of 220 volts, although for heating rapidly a larger amperage is necessary.

The oxygen or air entering the combustion tube is purified by passing through a Tauber's drying apparatus, which contains the following reagents arranged in order of the passage of air or oxygen through them: sulfuric acid, for removing possible traces of ammonia, 30-per-cent potassium-hydroxide (KOH) solution, granular soda lime, and granular calcium chloride. One side of the train is connected directly to a Linde oxygen tank, which is provided with a reducing valve for regulating the oxygen pressure; the other side of the train is used for purifying the air supply.

The absorption train consists of a 5-in. U-tube, filled with granular calcium chloride (CaCl₂) to absorb moisture. Before using, the calcium chloride should be saturated with carbon dioxide to avoid possible absorption of carbon dioxide during a determination by any traces of calcium oxide that may be present. This saturating is done most conveniently by placing a quantity of calcium chloride in a large drying jar, and filling the jar with carbon dioxide. After standing over night, dry air is drawn through the jar to remove the carbon dioxide. The treated calcium chloride is kept in well-stoppered bottles.

The calcium-chloride tube is connected to a Vanier potash bulb containing a 30-per-cent potassium-hydroxide solution and granular calcium chloride. Six to eight determinations can be made without recharging this bulb. The potash bulb is connected to an aspirator through a guard tube containing granular calcium chloride and soda lime, and a Mariotte flask. The Mariotte flask keeps the pressure constant.

In general, the method of determination is the same as the one used with the gas furnace. By moving the heaters toward the end of the tube where the gases enter, and cutting in the electric current, the air can be warmed enough to thoroughly dry the tube and its contents. The current is then cut off from the small heater, and the large heater is moved over the copper oxide; about 250 mm. of that part of the combustion tube between the two heaters where the boat containing the sample is to be placed is kept exposed. The full current is then turned on the large heater to bring the copper oxide to a red heat. When this temperature is reached it is necessary to reduce the current with the rheostat to avoid melting the tube. In the meantime the absorption train is weighed and connected, and the boat containing the sample is placed in the exposed and cooler part of the tube between the two heaters.

The current is then passed through the shorter heater. By manipulating the rheostat and by gradually pushing this heater toward the boat, the rate of evaporation of moisture and evolution of volatile matter can be readily controlled.

After combustion is complete, the electric current is turned off the smaller heater and this heater moved back to allow the tube to cool for the next determination. The final aspiration
of air and the weighing of the absorption train is conducted as described under the gas-furnace method.

**Note.**

In place of granulated CaCl₂, concentrated sulfuric acid may be used for collecting the water formed by combustion. In such cases the air and oxygen entering the combustion tube and the gas leaving the potash bulb must also be dried by sulfuric acid.

Other suitable forms of absorption vessels than those indicated in the above procedure may be used.

**Nitrogen.**

The Kjeldahl-Gunning method is recommended for the determination of nitrogen. This method has the advantage over either the simple Kjeldahl or the Gunning method, in requiring less time for the complete oxidation of the organic matter, and in giving the most uniform results.

*The Kjeldahl-Gunning Method.*—One gram of the coal sample is boiled with 30 cc. of concentrated sulfuric acid (H₂SO₄), 7 to 10 g. of potassium sulfate (K₂SO₄), and 0.6 to 0.8 g. of metallic mercury in a 500-cc. Kjeldahl flask until all particles of coal are oxidized and the solution nearly colorless. The boiling should be continued at least 2 hours after the solution has reached the straw-colored stage. The total time of digestion will be from 3 to 4 hours. The addition of a few crystals of potassium permanganate (KMnO₄), after the solution has cooled enough to avoid violent reaction, tends to insure complete oxidation.

After cooling, the solution is diluted to about 200 cc. with cold water. If the dilution with water has warmed the solution, it should be again cooled and the following reagents added: 25 cc. potassium-sulfide (K₂S) solution (40 g. K₂S per liter) to precipitate the mercury; 1 to 2 g. of granular zinc to prevent bumping; and finally enough strong sodium-hydroxide (NaOH) solution (usually 80 to 100 cc.) to make the solution distinctly alkaline. The danger of loss of ammonia may be minimized by holding the flask in an inclined position while the sodium-hydroxide solution is being added. The alkaline solution runs down the side of the flask and forms a layer below the lighter acid solution. After adding the alkaline solution, the flask is
at once connected to the condensing apparatus and the solution mixed by gently shaking the flask.

The ammonia (NH₃) is distilled over into a measured amount (10 cc.) of standard sulfuric-acid solution, to which has been added sufficient cochineal indicator for titration. Care should be taken that the glass connecting tube on the end of the condenser dips under the surface of the standard acid. The solution is slowly distilled until 150 to 200 cc. of distillate has passed over. To avoid mechanically entrained alkali passing over into the condenser, the rate of distillation should not exceed 100 cc. per hour. The distillate is titrated with standard ammonia solution (20 cc. NH₄OH solution = 10 cc. H₂SO₄ solution = 0.05 g. nitrogen). Standard NaOH or KOH solution with methyl orange or methyl red as indicator may be used instead of ammonia and cochineal.

A blank determination should be made in exactly the same manner as described above, except that 1 g. of pure sucrose (cane sugar) is substituted in place of the coal sample. The nitrogen found in this blank determination is deducted from the result obtained with the coal sample.

The potassium sulfide and sodium hydroxide may be dissolved in a single stock solution. Sufficient potassium sulfide is dissolved in the water before adding the sodium hydroxide, to make a solution in which the quantity necessary for a nitrogen determination (80 to 100 cc.) contains 1 g. of potassium sulfide. Twelve grams of potassium sulfide and 500 g. of sodium hydroxide in one liter of water, are required for the above proportions.

Coke and anthracite should be ground to an impalpable powder, as they are very difficult to oxidize. Even if this is done the digestion may require 12 to 16 hours.

**Oxygen.**

There being no satisfactory direct method of determining oxygen, it is computed by subtracting the sum of the percentages of hydrogen, carbon, nitrogen, sulfur, water and ash from 100. The result so obtained is affected by all the errors incurred in the other determinations and especially by the change in weight of the ash-forming constituents on ignition; iron pyrite changes to ferric oxide, increasing the ash and causing a negative error in the oxygen equivalent to three-eighths of the pyritic sulfur.
On the other hand, there is always a loss on ignition, of water of composition from the clayey and shaley constituents, carbon dioxide from carbonates, etc., which tends to compensate the absorption of oxygen.

Corrected Oxygen.—When a more correct oxygen value is desired, it may be obtained by making the corrections indicated in the following formula:

Corrected oxygen = 100 - [(C - C') + (H - H') + N + H₂O + S' + corrected ash],

in which

C = total carbon,
C' = carbon of carbonates,
H = total hydrogen less hydrogen of water,
H' = hydrogen from water of composition in clay, shale, etc.,
N = nitrogen,
H₂O = moisture as found at 105° C.,
S' = sulfur not present as pyrite or sulfate. This is usually small. In many types of coal it may be disregarded.

Corrected ash = mineral constituents originally present in the coal. For most purposes this can be determined with sufficient accuracy by adding to the ash, as found, five-eighths of the weight of pyritic sulfur, the CO₂ of carbonates and the water of composition of clay, shale, etc. See also ash determination.

CALORIMETRIC DETERMINATION.

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Apparatus.

Combustion Bombs.—The Atwater, Davis, Emerson, Mahler, Parr, Peters, Williams, or similar bombs may be used. The bomb shall have an inner surface of platinum, gold, porcelain enamel, or other material which is not attacked by nitric and sulfuric acids, or other products of combustion.

Calorimeter Jacket.—The calorimeter must be provided with a water-jacket having a cover to protect the calorimeter
from air currents. The jacket must be kept filled with water within 2 or 3° C. of the temperature of the room (except in calorimeters which are totally submerged, where the jacket temperature is controlled by a thermostat) and should be stirred continuously by some mechanical stirring device.

_Stirring of the Calorimeter Water._—The water in the calorimeter must be stirred sufficiently well to give consistent thermometer readings while the temperature is rising rapidly. The speed of stirring should be kept constant. A motor-driven screw or turbine stirrer is recommended and the speed should not be excessive. This may be determined by adjusting the temperature of the calorimeter to equality with that of the jacket and allowing the stirrer to run continuously for ten minutes. If the temperature of the calorimeter rises more than about 0°.01 C. in this length of time, the rate of stirring is excessive. Accurate results cannot be obtained when too much energy is supplied by the stirring device or when the rate of stirring is irregular. The portion of the stirring device immersed in the calorimeter should be separated from that outside by non-conducting material, such as hard rubber, to prevent conduction of heat from the motor or outside air.

_Thermometers._—Thermometers used shall have been certified by a government testing bureau and shall be used with the corrections given on the certificate. This shall also apply to electrical resistance or thermo-electric thermometers. Correction shall also be made for the temperature of the emergent stem of all mercurial thermometers, and for the “setting” of Beckmann thermometers. For accurate work, either Beckmann or special calorimetric thermometers graduated to 0.01 or 0°.02 C. are required. Such thermometers should be tapped lightly just before each reading to avoid errors caused by the sticking of the mercury meniscus, particularly when the temperature is falling. A convenient method is to mount a small electric buzzer directly on the top of the thermometer and connect it up with a dry cell and a push button. The button should be pressed for a few seconds immediately before each reading.

_Oxygen._—The oxygen used for combustions shall be free from combustible material. The bomb when filled should contain at least 5 per cent of nitrogen to insure complete oxidation
Methods for Analysis of Coal.

of the sulfur.\textsuperscript{1} The total amount of oxygen contained in the bomb for a combustion shall not be less than 5 g. per gram of coal. But the combustion must be complete, as shown by the absence of any sooty deposit on opening the bomb after firing.

\textit{Firing Wire}.—The coal in the bomb may be ignited by means of either iron or platinum wire. If iron wire is used, it should be of about No. 34 B. & S. gage and not more than 10 cm. (preferably 5 cm.) should be used at a time. A correction of 1600 calories per gram weight of iron wire burned is to be subtracted from the observed number of calories.

\textit{Standardization}.—The water equivalent of a calorimeter can best be determined by the use of the standard combustion samples supplied by the Bureau of Standards. The required water equivalent is equal to the weight of the sample multiplied by its heat of combustion per gram and divided by the corrected rise in temperature.

The calorimeter shall be standardized by the combustion of standard samples supplied by the Bureau of Standards, and used according to the directions given in the certificates which accompany them. A standardization shall consist of a series of not less than five combustions of either the same or different standard materials. The conditions as to the amount of water, oxygen, firing wire, method of correcting for radiation, etc., under which these combustions are made shall be the same as for coal combustions. In the case of any disagreement between contracting parties a check standardization may consist of two or more combustions of standardizing samples.

\textbf{MANIPULATION.}

1. \textit{Preparation of Sample}.—The ground sample is to be thoroughly mixed in the bottle and an amount, approximately 1 g., is to be taken out and weighed in the crucible in which it is to be burned. Coals which are likely to be blown out of the crucible should be briquetted. After weighing, the sample should preferably be immediately placed in the bomb and this closed. This procedure is necessary to avoid sublimation in the use of naphthalene for standardization.

\textsuperscript{1} Register, \textit{Journal of Industrial and Engineering Chemistry}, Vol. 16, p. 812 (1914).
2. *Preparation of the Bomb.*—The firing wire, if iron, should be measured and coiled in a small spiral and connected between the platinum terminals, using, if necessary, a piece of platinum wire somewhat heavier than the iron wire, to make the connection. The platinum and the iron must both be clean. About 0.5 cc. of water should be placed in the bottom of the bomb to saturate with moisture the oxygen used for combustion. When the crucible is put in place in the bomb, the firing wire should touch the coal or briquette of standard material. For the combustion of standardizing samples iron wire is preferable to platinum.

3. *Filling the Bomb with Oxygen.*—Oxygen from the supply tank is to be admitted slowly to avoid blowing the coal from the crucible, and the pressure allowed to reach 20 atmospheres for the larger bombs or about 30 atmospheres for the smaller bombs, so that the bomb shall contain an amount of oxygen sufficient for complete combustion, namely, at least 5 g. per gram of coal, or other combustible. This method of filling will insure 4 per cent of nitrogen in the larger bombs, irrespective of the nitrogen contained in the oxygen.

4. *Calorimeter Water.*—The calorimeter is to be filled with the required amount of distilled water, depending upon the type of calorimeter. The amount may be determined either by measurement in a standardized flask or by weighing. The amount must be kept the same as that used in standardization of the apparatus.

5. *Temperature Adjustments.*—The initial temperature in the calorimeter should be so adjusted that the final temperature, after the combustion, will not be more than 1° C., preferably about 0°.5 C., above that of the jacket, under which conditions the total correction for heat gained from or lost to the surroundings will be small when the rise of temperature is 2 or 3° C. and the effect of evaporation will also be small.

6. *Firing Current.*—The electric current used for firing the charge should be obtained from storage or dry cells having an electro-motive force of not more than 12 volts, since a higher voltage is liable to cause an arc between the firing terminals, introducing additional heat, which cannot be measured with certainty. The circuit should be closed by means of a switch.
which should remain closed for not more than 2 seconds. When possible, it is recommended that an ammeter be used in the firing circuit to indicate when the firing wire has burned out.

7. Method of Making an Observation.—The bomb when ready for firing, is to be placed in the calorimeter, the firing wires connected, the cover put in place and the stirrer and thermometer so placed as not to be in contact with the bomb or container. The stirrer is then started and after the thermometer reading has become steady, not less than 2 minutes after the stirrer is started, temperatures are read at 1-minute intervals for 5 minutes and the charge is then fired, the exact time of firing being noted. Observations of temperature are then made at intervals depending upon the method to be used for computing the cooling correction. When the temperature has reached its maximum and is falling uniformly, a series of thermometer readings is taken at 1-minute intervals for 5 minutes to determine the final cooling rate.

8. Titration.—After a combustion the bomb is to be opened, after allowing the gas to escape, and the inside examined for traces of unburned material or sooty deposit. If these are found, the observations shall be discarded. If the combustion appears complete, the bomb is to be rinsed out thoroughly and the washings titrated with a standard alkali solution (1 cc. = 0.02173 g. HNO₃ = 5 calories) using methyl-orange or methyl-red indicator, to determine the amount of acid formed. A correction of 230 calories per gram of nitric acid should be subtracted from the total heat observed. An additional correction of 1300 calories per gram of sulfur in the coal should be made for the excess of difference in heats of formation of SO₂ and aqueous H₂SO₄ over the heat of formation of aqueous HNO₃.

Computation of Results.

The following method of computation is recommended to take the place of the Pfaundler or other similar formulas for computing the cooling correction (radiation correction). Observe (1) the rate of rise (r₁) of the calorimeter temperature in degrees per minute for 5 minutes before firing; (2) the time (a) at which the last temperature reading is made immediately before firing; (3) the time (b) when the rise of
temperature has reached six-tenths of its total amount (this point can generally be determined by adding to the temperature observed before firing, 60 per cent of the expected temperature rise, and noting the time when this point is reached); (4) the time \( c \) of a thermometer reading taken when the temperature change has become uniform some 5 minutes after firing; (5) the final rate of cooling \( r_2 \) in degrees per minute for 5 minutes.

The rate \( r_1 \) is to be multiplied by the time \( b - a \) in minutes and tenths of a minute, and this product added (subtracted if the temperature was falling at the time \( a \)) to the thermometer reading taken at the time \( a \). The rate \( r_2 \) is to be multiplied by the time \( c - b \) and this product added (subtracted if the temperature was rising at the time \( c \) and later) to the thermometer reading taken at the time \( c \). The difference of the two thermometer readings thus corrected, provided the corrections from the certificate have already been applied, gives the total rise of temperature due to the combustion. This multiplied by the water equivalent of the calorimeter gives the total amount of heat liberated. This result, corrected for the heats of formation of \( \text{HNO}_3 \) and \( \text{H}_2\text{SO}_4 \) observed and for the heat of combustion of the firing wire, when that is included, is to be divided by the weight of the charge to find the heat of combustion in calories per gram. Calories per gram multiplied by 1.8 give the British thermal units per pound. (See example.)

The permissible differences in duplicate determinations are as follows:

<table>
<thead>
<tr>
<th>Per Cent.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Same analyst</td>
<td>0.3</td>
</tr>
<tr>
<td>Different analysts</td>
<td>0.5</td>
</tr>
</tbody>
</table>

In practice, the time \( b - a \) will be found so nearly constant for a given calorimeter with the usual amounts of fuel that \( b \) need be determined only occasionally.

1 When the temperature rise is not approximately known beforehand, it is only necessary to take thermometer readings at 40, 50, 60 seconds (and possibly 70 seconds with some calorimeters) after firing, and from these observations to find when the temperature rise had reached 60 per cent of the total. Thus, if the temperature at firing was 2°.135, at 40 seconds 3°.05, at 50 seconds 3°.92, at 60 seconds 4°.16, and the final temperature was 4°.200, the total rise was 2°.07; 60 per cent of it was 1°.24. The temperature to be observed was then 2°.14+1°.24 = 3°.38. Referring to the observations at 40 and 50 seconds, the temperatures were respectively 3.05 and 3.92. The time corresponding to the temperature of 3°.38 was therefore

\[
40 + \frac{3.38 - 3.05}{3.92 - 3.05} \times 10 = 44 \text{ seconds.}
\]
The results should be reduced to calories per gram or British thermal units per pound of *dry coal*, the moisture being determined upon a sample taken from the bottle at about the same time as the combustion sample is taken.

### Example.

#### Observations.

Water equivalent = 2550 g.
Weight of charge = 1.0535 g.
Approximate rise of temperature expected = 3°.2
60 per cent of approximate rise = 1°.9

<table>
<thead>
<tr>
<th>Time</th>
<th>Thermometer Readings</th>
<th>Corrected Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-21</td>
<td>15°.244</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>.250</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>.255</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>.261</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>.266</td>
<td></td>
</tr>
<tr>
<td>(a) 26</td>
<td>.272</td>
<td>15°.276</td>
</tr>
<tr>
<td>(b) 27.2</td>
<td>17°.2^d</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>18°.500</td>
<td>18°.497</td>
</tr>
<tr>
<td>32</td>
<td>.498</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>.497</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>.498</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>.494</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>.493</td>
<td></td>
</tr>
</tbody>
</table>

**Computation.**

\[ r_1 = 0°.028 \div 5 = 0°.0056 \text{ per minute.} \quad b - a = 1.2 \text{ minutes.} \]

The corrected initial temperature is

\[ 15°.276 + 0°.0056 \times 1.2 = 15°.283 \]

\[ r_2 = 0°.007 \div 5 = 0°.0014 \text{ per minute; } c - b = 3.8 \text{ minutes} \]

The corrected final temperature is

\[ 18°.497 + 0.0014 \times 3.8 = 18°.502 \]

Total rise \[ 18°.502 - 15°.283 = 3°.219 \]

Total calories \[ 2550 \times 3.219 = 8209 \]

Titration, etc. \[ -7 \]

Calories from 1.0535 g. coal \[ 8202 \]
Calories per gram \[ 7785 \]
or British thermal units per pound \[ 14013 \]

^d The initial temperature is 15°.27; 60 per cent of the expected rise is 1°.9. The reading to observe is then 17°.2.
The results obtained by the above method of computation and determination is the total heat of combustion at constant volume, with the water in the products of combustion condensed to liquid at the temperature of the calorimeter, that is, about 20 to 35° C.

Net heat of combustion at 20°, shall refer to results corrected for latent heat of vaporization, as follows:

Total heat of combustion in B. t. u. \(-1040 \text{(hydrogen } X 9)\) = net heat of combustion in B. t. u. per pound.

Also

Total heat of combustion in calories \(-580 \text{(hydrogen } X 9)\) = net heat of combustion in calories per gram.

Notes.

For anthracite, coke and coal of high ash content, which do not readily burn completely, the following procedure is recommended:

The inside of the crucible is lined completely with ignited asbestos in a thin layer pressed well down into the angles. The coal is then sprinkled evenly over the surface of the asbestos. Otherwise the procedure is as previously described.

The method of computing the "cooling correction" described in Technical Paper No. 8, Bureau of Mines, pages 28 to 32, may also be used.
STANDARD METHODS
FOR
TESTING OF COTTON RUBBER-LINED HOSE.


These methods are issued under the fixed designation D 15; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

METHODS FOR THE CHEMICAL ANALYSIS OF RUBBER LINING.

I. SAMPLING.

Samples. 1. Samples shall be taken both as to number and location at the discretion of the inspector.

Blanks. 2. Blank tests shall be run on all determinations and deductions made accordingly.

Checks. 3. In the event of any determination not falling within the limits given in these methods of test, a duplicate determination which shall agree within the limits specified shall be made and the average value taken as the true value.

Preparation of Sample. 4. A sample of not less than 15 g., taking pieces from various parts of the rubber for analysis, shall be prepared. The backing shall be buffed off before grinding.

Grinding. 5. The sample shall be cut into small pieces and run through the grinder until all of it will pass a 20-mesh sieve. Care must be taken that the grinder does not become appreciably warm.

(580)
6. A strong magnet shall be passed through the sample to remove any metal from the grinder, and the sample shall be mixed thoroughly and put in tightly stoppered bottles. It shall not be exposed to sunlight or heat.

II. REAGENTS.

7. Acetone shall be distilled not more than 10 days before use over anhydrous potassium carbonate, using the fraction which distills at 56 to 57° C.

8. Alcoholic potash shall be of normal strength, made by dissolving the required amount of potassium hydroxide in absolute alcohol the day before use and allowing to settle. Only the clear solution shall be used.

9. Barium-chloride solution shall be made by dissolving 100 g. of crystallized barium chloride in one liter of distilled water and adding two or three drops of concentrated hydrochloric acid. If there is any insoluble matter or cloudiness the solution shall be heated on the steam bath over night and filtered. All reagents shall be of a purity equal to that called for in Krauch’s “Standard Chemical Reagents; their Purity and Test.”

III. ANALYSES.

10. The extraction apparatus shall conform to that shown in Fig. 1. It shall be heated so that the period of filling an empty syphon cup with acetone and completely emptying it will be between $2\frac{1}{2}$ and $3\frac{1}{2}$ minutes.

Two grams of the rubber shall be extracted continuously with acetone for 8 hours, using a sample that has been prepared within 24 hours. Distill off the acetone and dry the flask and contents for 4 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down from the side of the flask.

11. Add to the flask containing the acetone extract 50 to 60 cc. of distilled water and 2 or 3 cc. of bromine (if the acetone
extract indicates a large amount of free sulfur the amount of bromine should be increased). Heat gently on the steam bath until the solution is practically colorless and filter into a 400-cc. beaker. Dilute with distilled water until the volume is about 400 cc. Cover the beaker with a watch glass, heat to boiling on the steam bath, add 10 cc. of 10-per-cent barium-chloride solution and allow the precipitate to stand over night. The next day filter off the precipitate, ignite the filter paper and weigh.

12. Dry the residue from the acetone extraction at 50 to 60° C., put into a 200-cc. Erlenmeyer flask with 50 cc. of the alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution into a beaker and wash twice, using each time 25 cc. of hot absolute alcohol and then wash thoroughly with hot water. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. 5 normal HCl, using this to rinse the
beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

13. Mix a 0.5-g. sample with 4 g. of Na₂O₂ and 6 g. of K₂CO₃ in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion. Then bring to quiet fusion for 15 to 20 minutes, applying heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate if silica is present; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 400 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent barium-chloride solution. Allow to stand over night, filter, wash, ignite, weigh the BaSO₄ and calculate to sulfur.

14. Weigh out a 1-g. sample in a porcelain crucible, heat in a muffle furnace, the temperature of which is carefully regulated so that no material amount of visible products are given off. After the mass is charred the temperature shall be raised sufficiently to burn the carbon. The whole process shall be conducted at as low a temperature as possible. At the end of this operation the crucible shall be removed from the furnace, cooled in a desiccator and weighed; the ash broken up and inspected for carbon. If any visible carbon is present a new determination shall be conducted.
IV. CALCULATIONS.

15. The percentage of rubber shall be considered to be the difference between 100 and the sum of the total sulfur and ash expressed as percentages and figured on the total compound. If the alcoholic-potash extract is over 2 per cent of the rubber as first calculated, subtract this excess also from the rubber. The organic-acetone extract shall be obtained by taking the difference between the total acetone extract and the free sulfur. The organic-acetone extract, free sulfur, total sulfur and alcoholic-potash extract shall be figured on the amount of gum as found by the above procedure.

V. CHECK ANALYSES.

16. Duplicate determinations when required shall check within the following limits, expressed as percentages of the gum present, as found by analysis, except as stated.

<table>
<thead>
<tr>
<th>Check Within, Per Cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic-acetone extract</td>
</tr>
<tr>
<td>Free sulfur</td>
</tr>
<tr>
<td>Total sulfur</td>
</tr>
<tr>
<td>Alcoholic-potash extract</td>
</tr>
<tr>
<td>Ash calculated on total compound</td>
</tr>
</tbody>
</table>

VI. SAMPLING OF RUBBER LINING.

17. Samples shall be taken both as regards to number (except where limited by the specifications) and location at the discretion of the inspector. All samples shall be cut transversely from the hose.

18. Not less than three pieces from each sample shall be tested and their results taken in calculating the average, unless
some individual result is apparently in error in which case a retest shall be made.

19. Tests of rubber shall be made with the temperature of the air not lower than 65 or higher than 90° F., and the samples shall be kept at temperatures within these limits, for at least one half hour previous to the time of test.

VII. PREPARATION OF TEST SPECIMENS OF RUBBER LINING.

20. (a) Test specimens of rubber shall be stamped out with a die constructed in accordance with Fig. 2.

(b) All specimens for these tests shall have the backing entirely removed by means of a grinder shown in Fig. 3.
Test specimens which have become burnt in buffing shall be discarded.

(c) If it is necessary to use naphtha to separate the rubber from the fabric, the naphtha shall be what is technically known as 76° Baume, free from oil. When naphtha has been used the test specimen shall be allowed to remain at rest for not less than one hour before testing. In all cases after buffing the test specimen shall remain at rest not less than ten minutes before testing.

VIII. PHYSICAL TESTS OF RUBBER LINING.

Friction Test. 21. Test specimens shall be accurately cut transversely 1½ in. wide and the full length of the circumference. They shall be
cut through the walls so that they can be laid out flat the full length of the piece. One-quarter inch of the rubber lining shall be carefully and cleanly trimmed off on each side without injuring the fabric, leaving a strip of rubber lining 1 in. wide undisturbed on a strip of cover 1½ in. wide. A separation between lining and cover of this strip shall be started for about 1½ in. The free end of fabric shall then be clamped in a fixed jaw so that the hose will hang approximately vertical. The free end of rubber lining

shall be clamped to a movable jaw to which is suspended a specified weight, and the rate of separation noted.

22. Tensile strength tests shall be made on an apparatus, the general designs of which conform to the "Schopper" machine. The grips for holding the test specimens shall be such that they will tighten automatically, exerting a uniform pressure across the full width of the piece proportionate to the applied tension. The jaws shall separate at a rate of 20 in. per minute. The thickness of the test specimens shall be accurately determined at three points equidistant between the marks. A spring micrometer gage accurate to within 0.001 in. and having a circular foot 0.4 in. in diameter shall be used.
23. The elongation at the breaking point shall be determined during the tension test as follows:

Previous to placing in the machine for the tension test, mark with two parallel lines 2 in. apart. For this purpose use a stamp having two marking edges placed 2 in. apart. On the test specimen a rule graduated to at least \( \frac{1}{10} \) in. shall be kept opposite the two marks and the distance between the outside edges of these marks noted at the instant of breaking.

24. The determination of set shall be carried out on a specimen which has not been stretched or used for any other test.

Mark two lines on the test sample 2 in. apart and at right angles to the direction of pull. Place in the tension testing machine, stretch to the amount specified by separating the jaws at the rate of 20 in. per minute and hold in that position 10 minutes; immediately release and 10 minutes thereafter measure the distance between the marks. If the sample breaks prior to being released it shall be considered that it has failed in this test.

25. If the break occurs outside the gage marks on the test specimen during the tension test and the tensile strength or stretch are below the requirements, the test shall be repeated.

The broken surfaces of test specimens shall be examined for flaws or defects and if the results of the test confirm the observation of flaws the test shall be repeated.

IX. HYDRAULIC PRESSURE TEST.

26. The determination of bursting or proof pressure shall be made in the following manner:

The hose shall be stretched on a plane surface in a straight line and connected to the water line or pump and filled with water, leaving the air cock open to allow the air to escape. The air cock shall then be closed and a pressure of 10 lb. per sq. in. applied. The test shall then begin by taking original measurements with the pressure at 10 lb. per sq. in. Pressures shall be measured with a standardized gage.

The increase in pressure shall be made at the rate of 300 lb. per minute. The hose while making the elongation and twist measurements shall be held at the specified pressure for not more than two minutes.
In making the bursting test in the curved position the apparatus shown in Fig. 4 shall be used.

The kinked test shall be made on 3-ft. samples with the ends tied together, and the couplings touching with a sharp kink in the middle of the hose; or if made on a 50-ft. sample the hose shall be tied together at a point 18 in. from where the kink occurs.
STANDARD DEFINITIONS
OF
TERMS RELATING TO PAINT SPECIFICATIONS.


These definitions are issued under the fixed designation D 16; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1915.

Standard.—Materials, methods, qualities, properties, etc., set forth by specification as a basis for the measurement of requirements.

Equal To.—The use of this term should be avoided if possible.

The avoidance of this term is recommended wherever possible because the specifications themselves should state the qualities, etc., desired. In specifications having the sanction of the American Society for Testing Materials, it is to be assumed that this feature will be developed to its fullest extent.

Pure.—Free from admixture of any foreign substance.

Commercially Pure.—The use of this term should be avoided if possible.

The avoidance of this term is recommended wherever possible because it involves the acceptance of standards likely to cause dispute, whereas specifications having the sanction of the American Society for Testing Materials should involve the establishment of their own standards.
Adulteration.—The partial substitution of one substance for another without acknowledgment.

The addition of the words “without acknowledgment” makes this definition clear. Substitution with acknowledgment involves no improper motive. If it is done without acknowledgment an improper motive may be assumed.

Adulterant.—A substance substituted partially for another without acknowledgment.

Bulk.—The bulk of a pigment is the total volume thereof plus voids.

In referring to the bulk of a substance, it is often convenient to say: “Its bulk is (say) 10 g. to the cubic inch.” In this case the word bulk is synonomous with “apparent density” and involves a determination by a specific method.

Voids.—The spaces between the particles of a pigment.

Opacity.—The degree of obstruction to the transmission of visible light.

In this sense “opacity” is a relative term, it being considered that given a film sufficiently thin, in paint technology at least, there is no absolutely opaque substance.

Covering Power.—The use of this term should be avoided if possible.

This term has been used so loosely that it might mean hiding power, spreading power, or the simple property of producing a coat.

Hiding Power.—The power of a paint or paint material as used to obscure a surface painted with it.

In this definition the word “obscure” means to render invisible or to cover up a surface so that it cannot be seen.

Spreading Rate.—The rate at which a paint or paint material, as used, is brushed out to a continuous uniform film expressed in terms of the area to which a unit volume, as used, is applied.

This term must not be confused with the much-abused term “spreading power.” The use of the term “spreading rate” is illustrated in the following sentence: “The paint when spread on a planished iron surface at the rate of 600 sq. ft. to the gallon will not sag or run when placed in a vertical position at 70° F.”

Fineness.—A term used to denote the extent of sub-division and expressive of the number of particles of pigment in a unit volume exclusive of voids.

According to this definition if pigment A has a specific gravity of 6 and pigment B a specific gravity of 2, and if these two pigments have equal fineness, in 6 g. of pigment A there would be the same number of particles as in 2 g. of pigment B.
Definitions of Paint Terms.

Crystallin.—Having a definite structure referable to one of the crystallographic systems.

According to definition a material is not crystallin if it has not a crystallin form irrespective of the optical and other properties it may possess.

Amorphous.—Without regular or definite form.

This definition as given here has a broader meaning than it possesses when it is used in mineralogical writings. Protozoa, if of definite form, are not amorphous and may not be crystallin.

Paint.—A mixture of pigment with vehicle, intended to be spread in thin coats for decoration or protection, or both.

According to this definition a mixture of pigment and varnish is a paint, and on the other hand a solution of stains in oil or varnish, no pigment being present, is not a paint.

Pigment.—The fine solid particles used in the preparation of paint, and substantially insoluble in the vehicle.

Asphaltic materials are not pigments except when they contain substances substantially insoluble in the vehicle in which they are used.

Vehicle.—The liquid portion of a paint.

Here anything that is dissolved in the liquid portion of a paint is a part of the vehicle.

Volatile Thinner.—All that liquid portion of a paint, water excepted, which is volatile in a current of steam at atmospheric pressure.

Non-Volatile Vehicle.—The liquid portion of a paint excepting its volatile thinner and water.

Tinting Strength.—The power of coloring a given quantity of paint or pigment selected as a medium standard for estimating such power.

Color.—A generic term referring inclusively to all of the colors of the spectrum, white and black, and all tints, shades and hues which may be produced by their admixture.

Color involves a definite effect produced by the action of light upon the retina of the eye dependent upon the optical composition of the light. This term is also used in reference to material substances such as pigments, stains, dyes, etc., but in specifications it should be recognized that color is primarily a physiological sensation.

Tint.—A color produced by the admixture of a coloring material, not white, with a white pigment or paint, the white predominating.
Shade.—A term descriptive of that difference between colors which results from a difference in luminosity only, the other color constants being essentially equal. A darker shade of a color is one that has a lower luminosity.

Primarily the term “shade” is akin to shadow designating darkness or reduced illumination, and therefore when strictly used should express only such change as depends on reduced luminosity; it has been defined by several authorities as the mixture of black with a color, thus establishing its opposite character to “tint,” but by extension of its relative sense it has been frequently and widely used to include lighter shades by use of the adjective “lighter” or “paler.” Although such expressions apparently involve a contradiction, it is clear that while we may have a shade of color or darker color of the same sort, it is easy to conceive of another shade not quite so dark and therefore lighter.

Hue.—The predominating spectral color in a color mixture.
Tone.—The color which principally modifies a hue or a white or a black.
Drying.—The solidification of a film.
Drier.—A material containing metallic compounds added to paints and painting materials for the purpose of accelerating drying.
Specific Gravity.—The ratio of the weight of a unit volume of a substance to the weight of an equal volume of water at defined temperatures.
Density.—The use of this term should be avoided if possible.

Density is a scientific term meaning the mass of a unit volume. Its numerical expression will vary with the units selected, and there is no occasion for using it when the term “specific gravity” is defined. Confusion may be avoided by not using the word “density” in specifications.

Gallon.—The measured gallon is 231 cu. in. Where a measured gallon is called for, the temperature at which it is to be measured should be specified. Where a gallon of definite weight is called for, the weight should be specified or obtained from the specific gravity of the material at a definite temperature.

This is the standard United States gallon.
Water.—Dissolved water or water not definitely or chemically combined.
Dry.—In paint materials: containing no uncombined water.
In paint films: completely solidified.
STANDARD DEFINITIONS
OF
TERMS RELATING TO MATERIALS FOR ROADS
AND PAVEMENTS.

Serial Designation: D 8-15.

These definitions are issued under the fixed designation D 8; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1912; REVISED, 1915.

BITUMINOUS MATERIALS.

Bitumens.—Mixtures of native or pyrogenous hydrocarbons and their non-metallic derivatives, which may be gases, liquids, viscous liquids, or solids, and which are soluble in carbon disulfide.

Bituminous.—Containing bitumen or constituting the source of bitumen.

Dead Oils.—Oils with a density greater than water which are distilled from tars.

Fixed Carbon.—The organic matter of the residual coke obtained upon burning hydrocarbon products in a covered vessel in the absence of free oxygen.

Free Carbon in Tars.—Organic matter which is insoluble in carbon disulfide.

Asphalts.—Solid or semi-solid native bitumens, solid or semi-solid bitumens obtained by refining petroleum, or solid or
semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt upon the application of heat and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds.

Asphaltenes.—The components of the bitumen in petroleums, petroleum products, malthas, asphalt cements and solid native bitumens, which are soluble in carbon disulphide but insoluble in paraffin naphthas.

Blown Petroleums.—Semi-solid or solid products produced primarily by the action of air upon liquid native bitumens which are heated during the blowing process.

Carbenes.—The components of the bitumen in petroleums, petroleum products, malthas, asphalt cements and solid native bitumens, which are soluble in carbon disulphide but insoluble in carbon tetrachloride.

Cut-Back Products.—Petroleum or tar residuums which have been fluxed with distillates.

Tars.—Bitumens which yield pitches upon fractional distillation and which are produced as distillates by the destructive distillation of bitumens, pyrobitumens or organic materials.

Coal Tar.—The mixture of hydrocarbon distillates, mostly unsaturated ring compounds, produced in the destructive distillation of coal.

Coke-Oven Tar.—Coal tar produced in by-product coke ovens in the manufacture of coke from bituminous coal.

Dehydrated Tars.—Tars from which all water has been removed.

Gas-House Coal Tar.—Coal tar produced in gas-house retorts in the manufacture of illuminating gas from bituminous coal.

Oil-Gas Tars.—Tars produced by cracking oil vapors at high temperatures in the manufacture of oil gas.

Pitches.—Solid residues produced in the evaporation or distillation of bitumens, the term being usually applied to residues obtained from tars.

Refined Tar.—Tar freed from water by evaporation or distillation which is continued until the residue is of desired consistency; or a product produced by fluxing tar residuum with tar distillate.
Definitions of Terms Relating to Roads.

Water-Gas Tars.—Tars produced by cracking oil vapors at high temperatures in the manufacture of carburetted water-gas.

Normal Temperature.—As applied to laboratory observations of the physical characteristics of bituminous materials, is 25° C. (77° F.).

Solid Bituminous Materials.—Those having a penetration at 25° C. (77° F.), under a load of 100 g. applied for 5 seconds, of not more than 10.

Liquid Bituminous Materials.—Those having a penetration at 25° C. (77° F.), under a load of 50 g. applied for 1 second, of more than 350.

Semi-Solid Bituminous Materials.—Those having a penetration at 25° C. (77° F.), under a load of 100 g. applied for 5 seconds, of more than 10, and a penetration at 25° C. (77° F.), under a load of 50 g. applied for 1 second, of not more than 350.

Flux.—Bitumens, generally liquid, used in combination with harder bitumens for the purpose of softening the latter.

Asphalt Cement.—A fluxed or unfluxed asphalt specially prepared as to quality and consistency for direct use in the manufacture of bituminous pavements, and having a penetration at 25° C. (77° F.) of between 5 and 250, under a load of 100 g. applied for 5 seconds.

Straight-run Pitch.—A pitch run to the consistency desired, in the initial process of distillation, without subsequent fluxing.

Native Asphalt.—Asphalt occurring as such in nature.

Consistency.—The degree of solidity or fluidity of bituminous materials.

Artificial Asphalt.—Recommended that the use of term be discontinued.

Road Asphalt.—This is a trade term not subject to definition.

Liquid Asphalt.—This is a trade term not subject to definition.

Non-Bituminous Materials.

Chert.—Compact silicious rock formed of calcedonic or opaline silica, or both.

Crusher-Run.—The total unscreened product of a stone crusher.

Granite.—A granitoid igneous rock consisting of quartz, orthoclase, more or less oligoclase, biotite and muscovite.
Granitoid.—A textural term to describe those igneous rocks which are entirely composed of recognizable minerals.

Matrix.—The binding material or mixture of binding material and fine aggregate in which the large aggregate is embedded or held in place.

Rubble.—Rough stones of irregular shapes and sizes, broken from larger masses either naturally or artificially, as by geological action, in quarrying, or in stone cutting or blasting.

Soil.—A mixture of fine earthy material with more or less organic matter resulting from the growth and decomposition of vegetation or animal matter.

Stone Chips.—Small angular fragments of stone containing no dust.

Tailings.—Stones which after going through the crusher do not pass through the largest openings of the screen.
STANDARD DEFINITIONS
OF
TERMS RELATING TO STRUCTURAL TIMBER.


These definitions are issued under the fixed designation D 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ADOPTED, 1907; REVISED, 1915.

I. DEFINITION OF STRUCTURAL TIMBER.

By the term “Structural Timber” is understood all such products of wood in which the strength of the timber is the controlling element in their selection and use. The following is a list of products which are recommended for consideration as structural timbers:

Trestle Timbers.—Stringers, caps, posts, mud sills, bracing, bridge ties, guard rails.

Car Timbers.—Car framing, including upper framing; car sills.

Framing for Buildings.—Posts, mud sills, girders, framing joists.

Ship Timbers.—Ship timbers, ship decking.

Cross Arms for Poles.

II. STANDARD DEFECTS.

Measurements which refer to the diameter of knots or holes should be considered as referring to the mean or average diameter.
1. **Sound Knot.**—A sound knot is one which is solid across its face and which is as hard as the wood surrounding it; it may be either red or black, and is so fixed by growth or position that it will retain its place in the piece.

2. **Loose Knot.**—A loose knot is one not firmly held in place by growth or position.

3. **Pith Knot.**—A pith knot is a sound knot with a pith hole not more than $\frac{1}{4}$ in. in diameter in the center.

4. **Encased Knot.**—An encased knot is one whose growth rings are not intergrown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a sound knot; if completely intergrown on one face, it is a watertight knot.

5. **Rotten Knot.**—A rotten knot is one not as hard as the wood it is in.

6. **Pin Knot.**—A pin knot is a sound knot not over $\frac{1}{2}$ in. in diameter.

7. **Standard Knot.**—A standard knot is a sound knot not over $1\frac{1}{2}$ in. in diameter.

8. **Large Knot.**—A large knot is a sound knot, more than $1\frac{1}{2}$ in. in diameter.

9. **Round Knot.**—A round knot is one which is oval or circular in form.

10. **Spike Knot.**—A spike knot is one sawn in a lengthwise direction; the mean or average width shall be considered in measuring these knots.

11. **Pitch Pockets.**—Pitch pockets are openings between the grain of the wood containing more or less pitch or bark. These shall be classified as small, standard and large pitch pockets.

   (a) **Small Pitch Pocket.**—A small pitch pocket is one not over $\frac{1}{8}$ in. wide.

   (b) **Standard Pitch Pocket.**—A standard pitch pocket is one not over $\frac{3}{8}$ in. wide, or 3 in. in length.

   (c) **Large Pitch Pocket.**—A large pitch pocket is one over $\frac{3}{8}$ in. wide, or over 3 in. in length.

12. **Pitch Streak.**—A pitch streak is a well-defined accumulation of pitch at one point in the piece. When not sufficient
to develop a well-defined streak, or where the fiber between
grains, that is, the coarse-grained fiber, usually termed "spring
wood," is not saturated with pitch, it shall not be considered
a defect.

13. Wane.—Wane is bark, or the lack of wood from any
cause, on edges of timbers.

14. Shakes.—Shakes are splits or checks in timbers which
usually cause a separation of the wood between annual rings.

15. Rot, Dote and Red Heart.—Any form of decay which
may be evident either as a dark red discoloration not found in
the sound wood, or the presence of white or red rotten spots,
shall be considered as a defect.

16. Ring Shake.—An opening between the annual rings.

17. Through Shake.—A shake which extends between two
faces of a timber.

III. STANDARD NAMES FOR STRUCTURAL TIMBERS.

1. Southern Yellow Pine.—This term includes the species
of yellow pine growing in the southern states from Virginia to
Texas, that is, the pines hitherto known as longleaf pine (Pinus
palustris), shortleaf pine (Pinus echinata), loblolly pine (Pinus
taeda), Cuban pine (Pinus heterophylla) and pond pine (Pinus
serotina).

Under this heading, two classes of timber are designated:
(a) dense southern yellow pine and (b) sound southern yellow
pine. It is understood that these two terms are descriptive
of quality rather than of botanical species.

(a) Dense southern yellow pine shall show on either end
an average of at least six annual rings per inch and at least
one-third summer wood, or else the greater number of the rings
shall show at least one-third summer wood, all as measured
over the third, fourth, and fifth inches on a radial line from
the pith. Wide-ringed material excluded by this rule will be
acceptable, provided that the amount of summer wood as above
measured shall be at least one-half.

The contrast in color between summer wood and spring
wood shall be sharp and the summer wood shall be dark in
color, except in pieces having considerably above the minimum
requirement for summer wood.
Fig. 1.—Loose Knot.

Fig. 2.—Pith Knot.

Fig. 3.—Encased Knot.

Fig. 4.—Rotten Knot.
Standard Definitions of Terms Relating to Structural Timber.

Fig. 6.—Standard Knot.

Fig. 7.—Large Knot.
PLATE VI
1916 A.S.T.M. STANDARDS.

STANDARD DEFINITIONS OF TERMS RELATING TO STRUCTURAL TIMBER.

Fig. 5.—Pin Knot.

Fig. 8.—Spike Knot.

Fig. 9.—Pitch Pocket.

Fig. 10.—Pitch Streak.
(b) Sound southern yellow pine shall include pieces of southern pine without any ring or summer-wood requirement.

2. Douglas Fir.—The term "Douglas Fir" is to cover the timber known likewise as yellow fir, red fir, western fir, Washington fir, Oregon or Puget Sound fir or pine, norwest and west coast fir.

3. Norway Pine, to cover what is known also as "Red Pine."

4. Hemlock, to cover Southern or Eastern hemlock; that is, hemlock from all States east of and including Minnesota.

5. Western Hemlock, to cover hemlock from the Pacific coast.

6. Spruce, to cover Eastern spruce; that is, the spruce timber coming from points east of and including Minnesota.

7. Western Spruce, to cover the spruce timber from the Pacific coast.

8. White Pine, to cover the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin and Minnesota.


10. Western Pine, to cover the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon and Washington. This is the timber sometimes known as "Western Yellow Pine," or "Ponderosa Pine," or "California White Pine," or "Western White Pine."

11. Western Larch, to cover the species of larch or tamarack from the Rocky Mountain and Pacific coast regions.

12. Tamarack, to cover the timber known as "Tamarack," or "Eastern Tamarack," from States east of and including Minnesota.

13. Redwood, to include the California wood usually known by that name.
STANDARD METHODS
FOR
TESTING.

Serial Designation: E 1–16.

These methods are issued under the fixed designation E 1; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

I. ADOPTED, 1910; REVISED, 1916.
II. ADOPTED, 1910; REVISED, 1916.
III. ADOPTED, 1911.
IV. ADOPTED, 1915.
V. ADOPTED, 1910.

I. METHODS FOR TENSION TESTS OF METALS.

1. Definition of Terms.

Elastic Limit is the greatest load per unit of original cross-section which does not produce a permanent set.

This determination is rarely made in the commercial testing of materials.

Proportional Limit is the load per unit of original cross-section at which the deformations cease to be directly proportional to the loads.

This determination is rarely made in the commercial testing of materials.

Yield Point is the load per unit of original cross-section at which a marked increase in the deformation of the specimen occurs without increase of load. It is usually determined by
the drop of the beam of the testing machine, or by the use of dividers.

2. Information obtained from the various laboratories in which tension tests are made shows that in many cases the forms and dimensions of specimens as recommended by the American Society for Testing Materials are in use, and that in other cases these forms and dimensions most nearly reconcile the differences that exist between the various forms employed.

3. It is therefore recommended that the selection of specimens, and their forms and dimensions, shall conform to the specifications for each material, as are now adopted by the American Society for Testing Materials.

In the case of flats \( \frac{1}{2} \) in. or under in thickness, the dimensions shall be as follows: Width equal to 5 times the thickness of the specimen, except that in no case shall the width be less than \( \frac{3}{4} \) in.; gage length equal to 24 times the thickness of the specimen, except that in no case shall the gage length be less than 2 in.

4. It is believed that the distance between the end of gage length and beginning of shoulders, as prescribed in the standard specifications of the American Society for Testing Materials, is ample to avoid interference with proper elongation, and no grounds are found for recommending any change.

5. All information obtained confirms the investigations of Committee O (since dissolved), to the effect that within the limits of speed common in commercial testing, the effect of different speeds on results is not of observable moment; that is, within ranges of speed varying from 1 to 6 in. per minute.

6. Beyond these limits, however, very rapid loading influences the ultimate strength, which increases with the speed. Whether the elongation is increased or decreased depends somewhat upon the nature of the material, though in general, very rapidly applied loads will increase the stretch, owing to the elongation occurring over the whole body of the specimen, rather than chiefly at the point of reduction, which is more marked with slowly applied loads.

7. Within the limits of speed customary in determining the modulus of elasticity, it does not appear that the rate of loading influences the value obtained, but whether this value be deter-
mined by an autographic attachment to the machine, or by an 
extensometer on the specimen, it is desirable that the loading 
be not too rapid, or not over 0.05 in. per minute, to avoid im-
pairing the accuracy of the sensitive devices employed. 

8. In determining the modulus of elasticity, the elastic 
limit, and the proportional limit, the extensometer should be 
attached to at least two sides of the specimen, to compensate 
for unequal elongation, for improper holding, or for any slight 
bending that may exist in the specimen. 

9. All authorities seem to regard it as desirable to measure 
the elongation on two or more sides of the test specimen, and 
most extensometers provide for so doing. 

10. The greatest accuracy is required in determining the 
modulus of elasticity, since small errors in measuring elongation 
are of considerable consequence in the result. 

11. Since the modulus is determined for points well within 
the elastic limit, the total elongation to be measured is much 
smaller than at the elastic limit. 

12. The elastic limit should be determined with great care, 
but any inaccuracy will cause less proportionate error than in 
the case of the modulus. The yield point, being less well defined, 
cannot be so closely determined, and it is believed that in most 
cases the use of dividers instead of an extensometer will give 
sufficiently accurate results. 

13. It is considered undesirable in accurate determinations 
of the modulus of elasticity to use a shorter gage length than 
8 in. It is evident that the greater the total elongation measured, 
the less will be the error due to inaccuracy of the reading, and 
the accuracy thus appears to increase directly as the gage length. 

14. That the difference between short and long gage lengths 
has a greater influence in affecting results than other factors 
(personal error, inaccuracy of the testing machine, etc.), is shown 
by the closely agreeing readings obtained with the greater lengths. 

15. The effect of improper methods of holding specimens 
could not be established from the results of actual tests. The 
result of improper methods of gripping materials of low elonga-
tion, such as cast iron, is well known, and it is probable that in 
material of a more ductile nature, the effect is largely local and does 
not extend to the portion of the specimen within the gage marks.
Conditions to Ensure Correct Testing Machines.

16. It is recommended that in machines on which specimen tests are made, whether the power be applied hydraulically or by means of screws and gears, the load be measured by a separate system of levers and knife edges, or by a method similar to that employed in the Emery testing machines.

17. All knife edges shall be kept sharp, and free from oil and dirt, and the machine shall be sensitive to a variation in load of one two-hundred-and-fiftieth of the load carried. Design and workmanship on testing machines shall be good, and they shall be calibrated at least once every six months by the following method:

Calibration of Testing Machines.

18. Test for accuracy by loading the weighing table with standard weights, and compare the actual weight at each addition with the reading of the beam. If the table is uniformly loaded in this manner with the full amount of weights that it will accommodate, the proportionality of the levers and the weighing beam can be successfully established. This relation, in a properly designed machine, will remain constant for all loads, but as a further test for sensitiveness under greater loads than can be accommodated in this manner, the following procedure is recommended:

19. Place in the machine a tension bar of such cross-section that the maximum capacity will not stress it to the elastic limit. Stress this bar to various extents through the full range of the machine, and at each load balance the beam and place upon the weighing table standard weights of 100 lb. A weight one two-hundred-and-fiftieth of the total load on the machine should produce a readable movement of the beam.

20. Where evidence of the accuracy of the machine over its whole range is desired, a known load may be applied by means of an extensometer and calibrated bar, whose modulus of elasticity has been determined with exactness.

21. It is recommended that a device be adopted conforming to the following requirements, in which the extensometer and bar are permanently attached to each other:
Methods for Testing.

(a) The bar shall be of high-elastic-limit material, and of such cross-section that this limit will be well above the total capacity of the machine on which it is to be used.

(b) This bar shall be annealed or otherwise treated so as to eliminate internal or unequal stress in the material, and to ensure its elastic modulus being uniform for successive tests.

(c) The extensometer shall be permanently attached to the bar, and shall measure the elongation on two opposite sides.

(d) The extensometer shall be preferably of the indicating or direct-reading type, and shall indicate to ten-thousandths of an inch or less.

(e) The method of securing the bar in the drawheads of the machine shall be positive and without slip, and shall ensure its axial location.

(f) The length of the bar measured by the extensometer shall be sufficient that the smallest extensometer division, that is, 0.0001 in., shall correspond to a difference in loading of 0.2 per cent of the capacity of the machine, or less.

(g) The extensometer shall be protected from injury by a permanently attached case with cover removable for reading the scale.

(h) The apparatus shall be plainly marked with the maximum load that can be safely applied without injury.

(i) The apparatus shall itself be calibrated either by the United States Bureau of Standards, or in a manner that will ensure equally trustworthy results.

Methods of Gripping Test Specimens.

22. It is recommended that for specimens of rolled material, serrated grips, flat and V-shaped, be adopted, the former for rectangular and the latter for round specimens. Serrated grips with curved faces appear to have no advantage, and to cause crushing of the material.

23. Wedges with ball and socket do not seem to be necessary, and for commercial testing their use has been generally discontinued.
24. Specimens of turned form, with threaded ends, should be secured in such a manner that side bending stresses are avoided.

25. It is considered important for correct results that the specimen be located in the exact center of the heads, and to better secure this condition, the openings in the heads should be lined up with each other by means of a plumb-bob and be tested for parallelism with a spirit level. Each pair of packing pieces and wedges that are to be used together in the same head should correspond exactly in thickness and other dimensions, and the wedges should be inserted an equal distance when the specimen is in place.

**Selection and Preparation of Specimen.**

26. Specimens representative of steel castings may be cut from the bottom of a sink head or riser, or from a coupon attached to the casting. In either case the part from which the specimen is taken should be relatively large in proportion to the size of the casting and should be annealed with it.

27. Workmanship on specimens shall be of the most careful nature, and surfaces should be free from nicks and tool marks. All wire edges should be removed and corners generously rounded.

28. If specimens of rolled material are sheared in the rough from sections, at least \( \frac{1}{2} \) in. of the material should be removed from the sheared edges in machining.

**General Requirements for the Measuring of Elongation.**

29. In determining the modulus of elasticity and the elastic limit, it is recommended that when practicable the elongation be measured in a length not less than 8 in., and that the following requirements be provided for:

(a) The specimen shall be round in section, finished as smooth as possible, and shall be provided with threaded ends for attachment to the draw-heads of the machine.
Methods for Testing.

(b) The specimen shall be placed in the exact center of the heads, and be secured in some positive manner, so that slip and side bending stresses do not occur.

(c) The extensometer should be of a type to measure the elongation on two or more sides of the specimen.

(d) It should read to 0.0001 in. or less.

(e) It should be of such a design that no change of zero will occur upon release of the load in determining the real elastic limit.

(f) The load shall be applied so slowly that simultaneous readings of elongation and load can be obtained with certainty.

(g) The testing machine shall have previously been calibrated for accuracy and sensitiveness, and heads lined up and made parallel.

II. METHODS FOR COMPRESSION TESTS OF METALS.

1. Definition of Terms.

Elastic Limit is the greatest load per unit of original cross-section which does not produce a permanent set.

This determination is rarely made in the commercial testing of materials.

Proportional Limit is the load per unit of original cross-section at which the deformations cease to be directly proportional to the loads.

This determination is rarely made in the commercial testing of materials.

Yield Point is the load per unit of original cross-section at which a marked increase in the deformation of the specimen occurs without increase of load. It is usually determined by the drop of the beam of the testing machine, or by the use of dividers.

2. The test specimen shall be a cylinder having plane ends truly normal to its axis.

Only two replies from testing laboratories mention cubes. A cylindrical specimen will usually be cheaper to prepare than a cube. The stresses are probably less uniformly distributed over a square than over a circular section, owing to the influence of the corners, this being especially the case with the internal shearing stresses which accompany the compression.
3. The diameter of the specimen shall be not less than 1 in. nor greater than 1.13 in. A specimen 1 in. in diameter is to be preferred.

The range of diameter mentioned in the replies from testing laboratories is from 1 in. to 1.129 in. A diameter of 1.128 in. gives a section area of 1 sq. in.

4. The length of the specimen should be between 2.5 and 4 diameters.

Two testing laboratories use a length of 1 diameter, one a length of from 1.5 to 2 diameters, one a length of 2.6 diameters, and one a length of 10.5 diameters. It is believed that a length less than 2.5 diameters is not sufficient for the internal shear to be properly developed, and that such short lengths give a fictitious strength owing to the friction of the bearing plates of the machine, which causes the specimen to assume a barrel-like form.

5. No bedding should be used for the ends of the specimen.

Only one reply favors bedding. It is known by general experience that bedding modifies the breaking load and that different kinds of bedding have different influences.

6. The bearing blocks which transmit the pressure from the testing machine should be truly normal to the plane ends of the specimen. To secure this, one of the blocks should be provided with a hemispherical bearing which can turn freely.

These requirements seem essential in order that the load may not be eccentrically applied to the specimen, and are generally recommended in the replies from testing laboratories.

7. The speed of compression should be slow, not exceeding 0.1 in. per minute. Near the elastic limit and yield point, the load should be increased very slowly.

A lower speed than that stated might be advisable if permitted by the testing machine. Evidently a higher speed may be allowed with a long specimen than with a short one.

8. For determining modulus of elasticity, the linear compression of the specimen should be observed by a precise compressometer which is attached to the specimen and does not touch the bearing blocks of the machine. Readings of the compressometer should be taken for three loads, the first at about one-fourth, the second at about one-half, and the third at about three-fourths of the elastic limit.
It is believed that these measurements are sufficient for most commercial work. Nothing is said about the release of the specimen from load, since opinions differ as to its advisability.

9. To determine the elastic and also the proportional limit, several readings of the compressometer should be taken as that limit is approached for load increments of 1000 lb. per sq. in.

This requirement seems sufficient to determine the proportional limit for materials in which such a limit exists. It does not seem wise to require the first permanent set to be observed for ordinary commercial work.

10. The yield point is to be noted as corresponding to that load for which the compressometer shows a linear compression without an increase in load. In the absence of a compressometer this point may be noted, for ductile materials, by the drop of the scale beam.

This requirement corresponds to the usual practice of testing laboratories. It is regarded as important that the term "elastic limit" should not be used to designate the yield point.

11. Measurements for the modulus of elasticity, elastic limit, proportional limit, and yield point may be made, if desired, on a specimen ranging in length from 10 to 15 diameters.

This clause is inserted because it may often be difficult to apply a compressometer in a length shorter than 4 in.

12. The record of the test should mention any phenomena observed near the elastic limit, proportional limit, and yield point. The manner of final failure should also be noted when the test is carried to this limit.

This requirement furnishes data for comparing the behavior of brittle and ductile metals near critical points of molecular change.

III. METHODS FOR TRANSVERSE TESTS OF METALS.

1. In the case of cast metals, when transverse tests are to be used to aid in determining the quality of the material, the specimen used shall be cast vertical, shall be $1\frac{1}{4}$ in. in diameter, and long enough to use a span of at least 15 times the diameter.
It is important that a definite and uniform standard be adopted so that the results may be comparable with each other; hence the diameter specified above (sectional area corresponding to practically one square inch). The determination of span is at present the subject of international tests to decide upon a definite distance to replace the present standard of 12 in. It will probably be 16 to 18 in.

The circular section will best secure a uniform thickness of skin, and thus avoid this irregularity when other sections are employed.

In the case of ductile materials (except in impact tests) transverse tests shall never be used to determine the quality of the material, tension tests being those suitable for the purpose.

In small round or square bars of ductile material, both the modulus of rupture and the transverse elastic limit vary considerably with the span.

In the case of tests made for determining constants to be used for designing, the specimen shall conform as nearly as possible with the form and size of the piece to be used. Thus, if I or T-sections are to be used, the specimens shall be of I or T-section. In the case of flat springs or plate glass, they shall be flat; in the case of timber, rectangular; etc.

It is well known that the modulus of rupture varies with the shape of the section, being very much greater in the case of round than in I-sections. Hence the modulus of rupture suitable for use for one would be entirely unsuitable for the other.

In rolled sections, the smaller ones are subjected to a more thorough working in the process of rolling than the larger.

2. In the case of the "Arbitration Bar" adopted for cast iron, the span has been fixed at 12 in., but may be extended as above stated. The bar will serve for cast and brittle materials.

In the case of ductile materials, when the modulus of rupture is desired, the span shall generally be less than 12 or 15 times the depth. Exceptions, however, occur, as in flat springs and in some cases in full-size pieces, when the spans and methods of supporting the ends, etc., shall conform to the conditions of service.

3. In the case of cast and brittle metals, the speed of testing shall not exceed 0.2 in. per minute. For other specimens the speed shall be correspondingly low.

4. The preparation of the specimen shall be such that it truly represents the material itself. The introduction of extra-
Methods for Testing.

Neous influences should be avoided as far as the knowledge of the material will permit. Thus, in cast metals no coupons shall be used; cast materials for tests shall go into dry molds standing vertical.

No specimen shall be machined before testing, except when information is specifically desired regarding the strength of such machined specimens.

5. The transverse yield point for ductile materials shall be noted approximately by the drop of the scale beam.

6. If the transverse elastic limit is to be determined for comparison with that obtained in the tensile test, the successive increments of load in the neighborhood of the transverse elastic limit shall be comparatively small, and after each load has been applied and the corresponding deflection measured by means of the deflectometer, the load shall be removed and the deflection measured again to determine the permanent set.

In those cases where the arbitration bar is used for such cast materials as have an elastic limit, the increment of load used near the transverse elastic limit shall be 250 lb.

It is well known that when the transverse elastic limit is determined, of course by means of a transverse test, the extreme fiber stress at this transverse elastic limit is not the same as that at the tensile elastic limit of the material; and moreover, that it varies with both the section and the span; hence the desirability of comparing the transverse elastic limit with the tensile elastic limit.

7. In the case of ductile materials, the arrangement of the supports shall be such that longitudinal tension in the specimen due to the rigidity of the supports is avoided.

8. In the case of ductile materials, special care shall be used when determining the ultimate load. For this purpose it will be necessary when approaching the ultimate (that is, the maximum) load, to make the speed of testing slow enough to enable the observer to note the maximum load.

In many cases, as in I and T-beams, the maximum load can be easily ascertained, while in others, such as round or flat sections with short spans, it may not be possible to determine it exactly; but it will almost always be possible to determine it with sufficient accuracy for all practical purposes.
IV. METHODS FOR BRINELL HARDNESS TESTS OF METALS.

CHEMICAL COMPOSITION AND HEAT TREATMENT OF BALLS.

1. The chemical composition, as far as carbon and chromium are concerned, should be from 1 to 1.2 per cent of carbon, and from 1 to 1.5 per cent of chromium.

2. The heat treatment should be such as will result in making the balls as hard as possible, consistent with the ability to resist the pressure without cracking or crushing.

While a long series of careful experiments would be needed to justify the specifications of more exact conditions in these regards, and while some users of these tests think that the chemical composition (within limits) plays a very small part, if any, in the problem, it is believed that the above requirements will be found satisfactory for commercial work, until such time as suitable experiments shall have furnished the data necessary for making the conditions more precise.

DIAMETER AND FORM OF BALLS.

3. The standard diameter of balls should be 10 mm. with a permissible variation of 0.0025 mm. (0.0001 in.) plus or minus; no ball either new or old showing a greater variation is to be employed. The standard diameter should always be employed, except in very rare cases when some other is absolutely necessary. If, at any time in testing, a hardness of No. 600 be exceeded, the balls should be remicrometered.

Thus far there is not sufficient evidence to show that the hardness numbers will be the same when different diameters of balls are used, and some of the evidence indicates that the reverse is the case; hence the importance of adhering to one size of ball.

PRESSURE.

4. The standard pressures used should be 3000 kg. for steel, and 500 kg. for softer metals. Departure from these pressures should never be tolerated, except in rare cases where it is unavoidable. The time of pressure should be at least 30 seconds.

The fact that, with our present light on the subject, we can only regard the results as comparative, renders it important to employ as few different pressures as possible.
Methods for Testing.

Measurement of Diameter or Depth of Indentation.

5. Whether the diameter or the depth of the indentation is measured, apparatus should be used that will give results as accurately as a microscope mounted on, and moved by, a micrometer screw.

As to the choice between the two, there exists a very decided difference of opinion, some thinking one and some the other more conducive to accuracy. The source of error in either case (assuming the measuring apparatus to be accurate) is the depression or the elevation of the metal immediately surrounding the indentation.

V. METHODS FOR METALLOGRAPHIC TESTS OF METALS.

Microscopic Examination.

For unhardened iron and steel, the following process has given satisfaction:

1. After polishing, examine under a magnification of 50 to 150 diameters. Look for slag or cinder in wrought iron, manganese sulphide, etc., in steel, and size and shape of graphite in cast iron.

2. Etch with a saturated solution of picric acid in alcohol for 15 seconds. This reveals the pearlite by turning it darker than the accompanying ferrite or cementite. In wrought iron, any pearlite present shows up, and the general appearance will sometimes show whether the material was puddled, etc., or made from reheated scrap. Those who wish to bring out the ferrite grains can do so easily and quickly by etching with nitric acid. To this end, nitric acid of 1.42 specific gravity should be diluted with either:

(a) 90 parts by volume of water to 10 of acid,
(b) 75 " " " " 25 " " or preferably
(c) 96 " " " " amyl alcohol to 4 of acid.

3. Near the eutectoid point, that is, 0.6 to 1.0 per cent of carbon, it is often difficult to distinguish between thin envelopes of ferrite and cementite. This difficulty can be overcome by etching with a solution of sodium picrate, which turns cementite dark brown or black but does not color the other constituents. The solution is made by adding 2 parts of picric acid to 98 parts of a solution containing 25 per cent of caustic soda, and is used at 100° C.  

4. In order to interpret the results of such an etching, they should be compared with standard etched specimens.  

5. In the case of hardened and tempered steel the indications are less decisive than in the case of unhardened steel, probably because the former class has been studied less than the latter. Coarse grain, segregation of constituents, presence of oxide, etc., are all signs of bad material. For etching use a solution of 4 parts of nitric acid, specific gravity 1.42, in 96 of amyl alcohol. The time needed has to be found by trial in each case. Hence etch for 5 seconds, examine, re-etch if necessary, etc.  

MACROSCOPIC EXAMINATION.  

6. Macroscopic examination shows up defects due to segregation, blowholes, piping, and the like, and when used in connection with microscopic examination yields valuable information. A section is cut with a saw, filed smooth, and polished with No. 0 and No. 00 emery paper; it is then ready for etching. Quite a number of etching reagents have been used to develop the structure. Whichever solution is chosen, the specimen is first carefully washed with a strong caustic potash solution, well rinsed under the tap, and then immersed in the etching solution. The following may be mentioned:  

(a) Freshly prepared solution of 20 g. of I and 30 g. of KI, in 1000 g. of water.

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Methods for Testing.

(b) Dilute HCl or H$_2$SO$_4$ up to 30 per cent acid, using the 1.2 and 1.84 specific gravity respectively.

(c) Nitric acid, from 10 to 30 per cent of the 1.42 specific gravity\textsuperscript{1} acid in 90 to 70 per cent of water.

(d) Concentrated HCl, specific gravity 1.2.

(e) A solution of 10 or 12 parts of double copper-ammonium chloride in 90 or 88 parts of water.

To bring out the structure of wrought iron rapidly, \((d)\) is used, while \((c)\) or \((b)\) will bring it out more slowly.

For steel, first etch with \((a)\), which shows up the segregation of carbon very well. Take care not to over-etch; 5 seconds is enough for some materials. To show up the impurities and the segregation of MnS, slag, etc., \((d)\) acts quickly, but \((b)\) gives better results though taking longer.

Some prefer light etching, say after 1 or 2 minutes, but an older method is to etch with \((b)\) very deeply, indeed to a depth so great that several hours may be needed to reach it. In this way the segregation of the carbon and the impurities like slag and MnS are shown simultaneously. A picture of the object thus etched can be had by treating it like an engraving, that is, inking it with printer's ink, and printing on white paper directly from it. A common letter-copying press is convenient for this printing.

\textsuperscript{1} Stead, Proc. Cleveland Inst. of Engrs., Sept., 1906, p. 3.
DATA RELATIVE TO COMMITTEES AND PUBLICATIONS
OFFICERS
OF THE
AMERICAN SOCIETY FOR TESTING MATERIALS.

President,
A. A. STEVENSON

Vice-Presidents,
W. H. BIXBY
S. S. VOORHEES
*(Term Expiring in 1917)*
*(Term Expiring in 1918)*

Secretary-Treasurer,
EDGAR MARBURG

MEMBERS OF EXECUTIVE COMMITTEE.
*(Term Expiring in 1917)*

J. H. GIBBONEY
W. K. HATT

J. A. MATHEWS
EDWARD ORTON, Jr.

*(Term Expiring in 1918)*

JOHN BRUNNER
W. H. BASSETT

G. W. THOMPSON
F. E. TURNEAURE

*(Ex-Officio)*

ARTHUR N. TALBOT
A. W. GIBBS
MANSFIELD MERRIMAN
*(Term Expiring in 1917)*
*(Term Expiring in 1918)*
*(Term Expiring in 1919)*

FINANCE COMMITTEE.

W. H. BIXBY
J. H. GIBBONEY
A. W. GIBBS *(Chairman)*

(618)
REGULATIONS GOVERNING THE EXECUTIVE COMMITTEE.

Regular meetings shall be held on the second Tuesday in January, April, July and October. Five members shall constitute a quorum.

At each meeting the Secretary-Treasurer shall report the names of all new members and of members who have resigned during the previous quarter, and shall present a financial statement.

At the January meeting the Secretary-Treasurer shall report the names of all members whose dues are unpaid.

The accounts of the Secretary-Treasurer shall be duly audited at the middle and close of each fiscal year, and the report of the auditors shall be presented in writing at the July and January meetings.

Special meetings may be held at any time at the call of the President, or upon the written request of four members of the Executive Committee. The notice for such meetings shall be mailed by the Secretary-Treasurer at least one week in advance of the meeting, and the business shall be stated in the notice.

The Secretary-Treasurer shall transmit the net balance to the credit of the International Association on January 1, April 1, and July 1 to that Association within five days from the dates mentioned.

REGULATIONS GOVERNING THE FINANCE COMMITTEE.

1. The books and accounts of the Society shall be audited semi-annually by certified public accountants. The accountants shall be appointed by, or shall be approved by, the Finance Committee.

2. A copy of the semi-annual report of the auditors shall be transmitted to the Chairman of the Finance Committee as soon as it is received by the Secretary-Treasurer, in order that the Finance Committee may be prepared to make such suggestions, criticisms or inquiries as it may see fit at the next meeting of
the Executive Committee. The Chairman of the Finance Committee shall furnish the Secretary-Treasurer with a statement embodying such suggestions, criticisms or inquiries in advance of the meeting of the Executive Committee at which these matters are to be presented.

3. During the second week of each month all vouchers for accumulated bills, and salary vouchers for the current month (the latter payable at the end of the month), shall be sent to the Chairman of the Finance Committee, or to a member of that committee designated by the chairman, for counter-signature. The Secretary-Treasurer shall pay no bills—except in case of emergencies for which he shall be accountable to the Chairman of the Finance Committee—unless the corresponding vouchers have been thus countersigned. The provisions in this paragraph shall not be applicable to expenditures from Committee Funds. These, as prescribed in the Regulations Governing Standing Committees, shall be "subject to disbursement only on vouchers signed by the chairman of the committee concerned."

4. The Chairman of the Finance Committee shall be authorized to approve, jointly with the Secretary-Treasurer, proposed expenditures for account of a standing committee up to $250 during a given quarter, without previous specific authorization by the Executive Committee, and such expenditures are to be reported by the Secretary-Treasurer at the following quarterly meeting of the Executive Committee.

5. The Secretary-Treasurer shall be authorized to maintain a petty cash fund of $100 on which he shall be authorized to draw without previous approval of the proposed expenditures on the part of the Finance Committee. Of this fund not more than $25 may be carried in cash to meet expenditures for express-age, telegrams, etc. Vouchers covering expenditures out of this fund shall be submitted monthly for approval by the Finance Committee.

6. Any recommendation affecting salaries, and proposed extraordinary expenditures out of the general funds of the Society, as distinguished from the petty cash fund, shall be submitted to the Finance Committee for approval before presentation to the Executive Committee for final action.
7. The Secretary-Treasurer shall obtain competitive bids for printing and binding the publications of the Society at intervals of not over five years. The results shall be submitted to the Finance Committee in time for presentation at the January quarterly meeting of the Executive Committee, beginning with this meeting in 1916, and thereafter at intervals of not over five years.

8. The Finance Committee shall be authorized to inspect the books and accounts, etc., of the Society at any time, and such inspection shall be made at least once in two years.
# TABULAR LIST OF STANDING COMMITTEES.

## A. Ferrous Metals.

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## C. Cement, Lime, Gypsum, and Clay Products.

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PERSONNEL OF STANDING COMMITTEES

OF THE

AMERICAN SOCIETY FOR TESTING MATERIALS.

A. FERROUS METALS.

COMMITTEE A-1 ON STEEL.

C. D. YOUNG, Chairman.
G. AERTSEN, Vice-Chairman.
J. A. CAPP, Vice-Chairman.
C. L. WARWICK, Secretary.

Non-Producers (69).

Abbott, R. R.
American Car and Foundry Co.,
  A. E. Ostrander.
American Locomotive Co.,
  F. J. Cole.
  S. V. Hunnings.
Baldwin Locomotive Works,
  H. V. Wille.
Beall, F. F.
Bureau of Construction and Repair,
  U. S. N.
Bureau of Steam Engineering, U. S. N.,
  Inspection Division.
  Machinery Division.
Cain, John R.
Campbell, W.
Churchill, Charles S.
Clark, F. H.
Clements, F. O.
Colby, Albert Ladd.
Committee C-2 on Reinforced Concrete,
  Richard L. Humphrey.
  H. H. Quimby.
Cramp and Sons Ship and Engine Building Co., William,
  W. A. Dobson.
Crawford, J. C.
Cromwell, O. C.
Deans, John Sterling.
Edwards, L. N.
Force, H. J.
Fore River Shipbuilding Corporation,
  H. H. Schulze.

General Electric Co.,
  J. A. Capp (Vice-Chairman).
  J. M. Darke.
General Motors Co.,
  K. W. Zimmerschied.
Gibboney, J. H.
Hartford Steam Boiler Inspection and Insurance Co.,
  S. F. Jeter.
Hunt and Co., Robert W.
Job, Robert.
Johnson, R. P.
Lanza, Gaetano.
Laverie, R. H.
Lloyd's Register of Shipping,
  J. French.
  N. E. McClelland.
Lothrop, M. T.
MacFarland, H. B.
MacPherran, R. S.
Marburg, Edgar.
McDonnell, M. E.
McMahon, H. R.
Newkirk, W. M.
Newport News Shipbuilding and Dry Dock Co.,
  John W. Gray.
New York Central Railroad Co.,
  A. W. Carpenter.
  W. B. Geiser.
Northern Pacific Railway Co.,
  H. G. Burnham.
Onderdonk, J. R.

(624)
Standing Committees. 625

Committee A-1 (Continued).

Non-Producers (Continued).

Perfection Spring Co., Z. B. Leonard.
Pierce-Arrow Motor Car Co., D. Ferguson.
Pittsburgh Testing Laboratory, A. R. Ellis.
Pressed Steel Car Co., H. J.Gearhart.
Quimby, H. H.
Ramage, J. C.
Rigg, E. H.
Robinson, A. F.
Scofield, H. H.
Seattle Construction and Dry Dock Co., J. V. Paterson.
Smith, H. E.
Smith, H. T.
Snow, F. A.

Producers (41).

American Steel and Wire Co., S. M. Rodgers.
American Steel Foundries, J. C. Davis.
Bacon, C. G., Jr.
Bethlehem Steel Co., Bethlehem Plant, E. O'C. Acker.
Birdsboro Steel Foundry and Machine Co., L. E. Thomas.
Bunnell, F. O.
Camden Forge Co., W. D. Kerlin.
Carbon Steel Co., C. E. Middleton.
Carpenter Steel Co., J. H. Parker.
Central Iron and Steel Co., R. H. Irons.

Snow, J. P.
Studebaker Corporation, F. M. Zeeder.
Van Gundy, C. P.
Wallis, J. T.
Waring, F. M.
Warwick, C. L. (Secretary).
Webster, William R.
Wickhorst, M. H.
Winchester Repeating Arms Co., W. H. Buell.
Young, C. D. (Chairman).
Young, J. B.
Zeleny, Frank.

Columbia Steel and Shafting Co., E. L. Parker.
Davis, J. A.
Heppenstall Forge and Knife Co., R. C. Drinker.
Illinois Steel Co., P. E. Carhart.
Johnson, A. L.
Jones and Laughlin Steel Co., Jesse J. Shuman.
F. S. Slocum.
Lackawanna Steel Co., F. E. Abbott.
Locomotive Superheater Co., H. B. Oatley.
Lukens Iron and Steel Co., Charles L. Huston.
H. Taggart.
Mathews, John A.
Midvale Steel Co., G. Aerts (Vice-Chairman).
R. Furness.
National Tube Co., F. N. Speller.
Norris, George L.
Penn Seaboard Steel Corporation, W. S. Bickley.
Standing Committees.

Committee A-1 (Continued)

Producers (Continued).

Pollak, J. A.
Rail Steel Bar Manufacturers Association,
  A. S. Hook.
  E. E. Hughes.
  W. H. Woodcock.
Railway Steel Spring Co.,
  A. S. Henry.
  A. N. Lukens.
Sargent, George W.
Schmid, M. H.
Standard Steel Works Co.,
  L. H. Fry.
  A. A. Stevenson.
Steel Co. of Canada,
  J. G. Morrow.
Titanium Alloy Manufacturing Co.,
  H. H. Cook.
Union Drawn Steel Co.,
  F. N. Beegle.
Woodruffe, G. H.
Wood Iron and Steel Co., Alan,
  W. A. Cooper.
Worth Brothers Co.,
  E. T. Ickes.

Sub-Committees of Committee A-1.

Advisory Committee.

Young, C. D. (Chairman).
American Locomotive Co.,
  F. J. Cole.
Baldwin Locomotive Works,
  H. V. Wille.
Bethlehem Steel Co., Steelton Plant,
  F. A. Robbins, Jr.
Bureau of Construction and Repair,
  U. S. N.
Cambria Steel Co.,
  E. F. Kenney.
Carnegie Steel Co.,
  C. F. W. Rys.
  H. P. Tiemann.
Colby, A. L.
General Electric Co.,
  J. A. Capp.
  J. M. Darke.
Gibbony, J. H.
Jones and Laughlin Steel Co.,
  J. J. Shuman.
Lackawanna Steel Co.,
  F. E. Abbott.
Lanza, Gaetano.
MacFarland, H. B.
Marburg, Edgar (ex officio).
Midvale Steel Co.,
  G. Aertsen.
Standard Steel Works Co.,
  A. A. Stevenson.
Warwick, C. L.

Sub-Committee I on Steel Rails and Accessories.

Cambria Steel Co.,
  E. F. Kenney (Chairman).
Bethlehem Steel Co., Steelton Plant,
  F. A. Robbins, Jr.
Carnegie Steel Co.,
  C. F. W. Rys.
Churchill, C. S.
Colby, A. L.
Crawford, J. C.
Illinois Steel Co.,
  P. E. Carhart.
Lackawanna Steel Co.,
  F. E. Abbott.
MacFarland, H. B.
National Tube Co.,
  F. N. Speller.
Snow, J. P.
Steel Co. of Canada,
  J. G. Morrow.
Wickhorst, M. H.
Young, J. B.
COMMITTEE A-1 (Continued).

SUB-COMMITTEE II on Structural Steel for Bridges, Buildings and Rolling Stock.

Lackawanna Steel Co.,
F. E. Abbott (Chairman).
American Car and Foundry Co.,
A. E. Ostrander.
Bacon, C. G., Jr.
Bureau of Construction and Repair,
U. S. N.
Cambria Steel Co.,
E. P. Kenney.
Carnegie Steel Co.,
J. O. Leech.
Deans, J. S.

Edwards, L. N.
Jones and Laughlin Steel Co.,
J. J. Shuman.
New York Central Railroad Co.,
A. W. Carpenter.
Pressed Steel Car Co.,
H. J. Gearhart.
Quimby, H. H.
Robinson, A. F.
Snow, J. P.
Waring, F. M.

SUB-COMMITTEE III on Structural Steel for Ships.

Bureau of Construction and Repair,
U. S. N. (Chairman).
Bethlehem Steel Co., Steelton Plant,
F. A. Robbins, Jr.
Cambria Steel Co.,
E. P. Kenney.
Carnegie Steel Co.,
J. O. Leech.
Central Iron and Steel Co.,
R. H. Irons.
Cramp and Sons Ship and Engine Building Co., William,
W. A. Dobson.
Davis, J. A.

Fore River Shipbuilding Corporation,
H. H. Schulze.
Laverie, R. H.
Lloyds' Register of Shipping,
J. French.
Newport News Shipbuilding and Dry Dock Co.,
John W. Gray.
Rigg, E. H.
Seattle Construction and Dry Dock Co.,
J. V. Paterson.
Worth Brothers Co.,
E. T. Ickes.

SUB-COMMITTEE IV on Spring Steel and Steel Springs.

MacFarland, H. B. (Chairman).
American Locomotive Co.,
S. V. Hunnings.
Bethlehem Steel Co., Steelton Plant,
F. A. Robbins, Jr.
Bureau of Construction and Repair,
U. S. N.
Cambria Steel Co.,
E. P. Kenney.
Carnegie Steel Co.,
H. P. Tiemann.
Carpenter Steel Co.,
J. H. Parker.
General Motors Co.,
K. W. Zimmerschied.
Lanza, Gaetano.
Mathews, J. A.
McMahon, H. R.
Midvale Steel Co.,
G. Aertslen.

Newkirk, W. M.
New York Central Railroad Co.,
W. B. Geiser.
Norris, G. L.
Northern Pacific Railway Co.,
H. G. Burnham.
Perfection Spring Co.,
Z. B. Leonard.
Railway Steel Spring Co.,
A. N. Lukens.
Sargent, G. W.
Smith, H. E.
Standard Steel Works Co.,
L. H. Fry.
A. A. Stevenson.
Waring, F. M.
Zeleny, Frank.
COMMITTEE A-1 (Continued).

SUB-COMMITTEE V ON STEEL REINFORCEMENT BARS.

Carnegie Steel Co.,
C. F. W. Rys (Chairman).
Carnegie Steel Co.,
G. E. Thackray.
Colby, A. L.
Committee C-2 on Reinforced Concrete,
Richard L. Humphrey.
H. H. Quimby.
Hunt and Co., R. W.,
H. H. Morgan.
Johnson, A. L.

Jones and Laughlin Steel Co.,
J. J. Shuman.
Lanza, Gaetano.
Pittsburgh Testing Laboratory,
A. R. Ellis.
Rail Steel Bar Manufacturers’ Association,
A. S. Hook.
E. E. Hughes.
W. H. Woodcock.
Scifield, H. H.
Steel Co. of Canada,
J. G. Morrow.

SUB-COMMITTEE VI ON STEEL FORGINGS AND BILLETS.

Carnegie Steel Co.,
H. P. Tiemann (Chairman).
American Locomotive Co.,
P. J. Cole.
Baldwin Locomotive Works,
H. V. Wille.
Bethlehem Steel Co., Bethlehem Plant,
E. O’C. Acker.
Bethlehem Steel Co., Steelton Plant,
P. A. Robbins, Jr.
Bureau of Construction and Repair,
U. S. N.
Bureau of Steam Engineering, U. S. N., Inspection Division.
Cambria Steel Co.,
E. F. Kenney.
Camden Forge Co.,
W. D. Kerlin.
Campbell, W.
Carpenter Steel Co.,
J. H. Parker.
Colby, A. L.
Force, H. J.
General Electric Co.,
J. A. Capp.
J. M. Darke.

Gibboney, J. H.
Heppenstall Forge and Knife Co.,
R. C. Drinker.
Jones and Laughlin Steel Co.,
J. J. Shuman.
Lloyd’s Register of Shipping,
N. E. McClelland.
MacFarland, H. B.
MacPherran, R. S.
Midvale Steel Co.,
G. Aertsen.
Norris, George L.
Onderdonk, J. R.
Pollak, J. A.
Schmid, M. H.
Standard Steel Works Co.,
A. A. Stevenson.
Smith, H. E.
Titanium Alloy Manufacturing Co.,
H. H. Cook.
Waring, F. M.
Westinghouse Electric and Manufacturing Co.,
T. D. Lynch.
Young, J. B.
Zeleny, Frank.

SUB-COMMITTEE VII ON ROLLED STEEL WHEELS AND STEEL TIRES.

Standard Steel Works Co.,
A. A. Stevenson (Chairman).
Bacon, C. G., Jr.
Bunnell, F. O.
Carnegie Steel Co.,
L. W. Conroy.
Cromwell, O. C.
Gibboney, J. H.

MacFarland, H. B.
Midvale Steel Co.,
G. Aertsen.
Railway Steel Spring Co.,
A. S. Henry.
Waring, F. M.
Zeleny, Frank.
STANDING COMMITTEES.

COMMITTEE A-1 (Continued).

SUB-COMMITTEE VIII on Steel Castings.

Bethlehem Steel Co., Steelton Plant, 
F. A. Robbins, Jr., (Chairman).
American Locomotive Co., 
S. V. Hunnings.
American Steel Foundries, 
J. C. Davis.
Birdsboro Steel Foundry and Ma-
chine Co., 
L. E. Thomas.
Bureau of Construction and Repair, 
U. S. N.
Bureau of Steam Engineering, U. S. N., 
Inspection Division.
Colby, A. L.
Eagan-Rogers Steel and Iron Co., 
J. I. Rogers.

General Electric Co., 
J. A. Capp.
J. M. Darke.
National Malleable Castings Co., 
W. G. Kranz.
Penn Seaboard Steel Corporation, 
W. S. Bickley.
Standard Steel Works Co., 
L. H. Fry.
A. A. Stevenson.
Waring, F. M.
Westinghouse Electric and Manu-
facturing Co., 
T. D. Lynch.
Young, J. B.

SUB-COMMITTEE IX on Steel Tubing and Pipe.

Baldwin Locomotive Works, 
H. V. Wille (Chairman).
American Locomotive Co., 
F. J. Cole.
Bethlehem Steel Co., Steelton Plant, 
F. A. Robbins, Jr.
Bureau of Steam Engineering, U. S. N., 
Inspection Division.

Locomotive Superheater Co., 
H. B. Oatley.
National Tube Co., 
P. N. Speller.
Smith, H. E.
Wallis, J. T.
Woodruff, G. H.
Zeleny, Frank.

SUB-COMMITTEE X on Automobile Steels.

Colby, A. L. (Chairman).
Abbott, R. R.
American Locomotive Co., 
S. V. Hunnings.
American Steel and Wire Co., 
S. M. Rodgers.
Beall, F. F.
Bethlehem Steel Co., Bethlehem 
Plant.
E. O'C. Acker.
Bethlehem Steel Co., Steelton Plant, 
F. A. Robbins, Jr.
Cambria Steel Co., 
E. F. Kenney.
Carnegie Steel Co., 
J. O. Leech.
Carpenter Steel Co., 
J. H. Parker.

General Motors Co., 
K. W. Zimmernerschied.
Heppenstall Forge and Knife Co., 
R. C. Drinker.
Lothrop, M. T.
Mathews, J. A.
Midvale Steel Co., 
G. Aertszen.
Norris, G. L.
Perfection Spring Co., 
Z. B. Leonard.
Pierce-Arrow Motor Car Co., 
D. Ferguson.
Sargent, G. W.
Schmid, M. H.
Snow, F. A.
Studebaker Corporation, 
F. M. Zeeder.
COMMITTEE A-1 (Continued).

SUB-COMMITTEE XI ON BOILER STEEL.

American Locomotive Co.,
F. J. Cole (Chairman).
Baldwin Locomotive Works,
H. V. Wille.
Bethlehem Steel Co., Bethlehem
Plant,
E. O'C. Acker.
Bethlehem Steel Co., Steelton Plant,
F. A. Robbins, Jr.
Bureau of Steam Engineering, U.S.N.,
Inspection Division.
Cambria Steel Co.,
E. F. Kenney.
Carbon Steel Co.,
C. E. Middleton.
Carnegie Steel Co.,
J. O. Leech.
Clark, F. H.
Hartford Steam Boiler Inspection and
Insurance Co.,
S. F. Jeter.
Illinois Steel Co.,
P. E. Carhart.
Lukens Iron and Steel Co.,
C. L. Huston.
H. Taggart.
Ramage, J. C.
Waring, F. M.
Wood Iron and Steel Co., Alan,
W. A. Cooper.
Worth Brothers Co.,
E. T. Ickes.
Young, J. B.
Zeleny, Frank.

SUB-COMMITTEE XII ON METHODS OF CHEMICAL ANALYSIS.

Gibboney, J. H. (Chairman).
American Locomotive Co.,
S. V. Hunnings.
Cain, John R.
Cambria Steel Co.,
E. F. Kenney.
Carnegie Steel Co.,
G. A. Hopkins.
Hunt and Co., R. W.,
J. H. Campbell.
Illinois Steel Co.,
W. Brady.
Job, Robert.
McDonnell, M. E.
Van Gundy, C. P.

SUB-COMMITTEE XIII ON METHODS OF PHYSICAL TESTS.

Lanza, Gaetano (Chairman).
American Locomotive Co.,
F. J. Cole.
Baldwin Locomotive Works,
H. V. Wille.
Bethlehem Steel Co., Steelton Plant,
F. A. Robbins, Jr.
Bureau of Construction and Repair,
U. S. N.
Cambria Steel Co.,
E. F. Kenney.
Carnegie Steel Co.,
C. F. W. Rys.
H. P. Tiemann.
Colby, A. L.
General Electric Co.,
J. M. Darke.
Gibboney, J. H.
Jones and Laughlin Steel Co.,
J. J. Shuman.
Lackawanna Steel Co.,
F. E. Abbott.
MacFarland, H. B.
Standard Steel Works Co.,
A. A. Stevenson.
Warwick, C. L.

SUB-COMMITTEE XIV ON TOOL STEEL.

General Electric Co.,
J. M. Darke (Chairman).
American Locomotive Co.,
S. V. Hunnings.
Baldwin Locomotive Works,
H. V. Wille.
Beall, F. F.
Bethlehem Steel Co., Bethlehem
Plant,
E. O'C. Acker.
Bureau of Construction and Repair,
U. S. N.
Bureau of Steam Engineering, U.S.N.,
Machinery Division.
Standing Committees.

Committee A-1 (Continued).

Sub-Committee XIV (Continued).

Carpenter Steel Co.,  
J. H. Parker.  
Colby, A. L.  
Johnson, R. P.  
Mathews, J. A.  

McDonnell, M. E.  
Midvale Steel Co.,  
R. Furness.  
Sargent, G. W.  
Smith, H. T.

Sub-Committee XV on Cold-Drawn Steel.

Jones and Laughlin Steel Co.,  
J. J. Shuman (Chairman).  
American Steel and Wire Co.,  
S. M. Rodgers.  
Bureau of Steam Engineering, U. S. N.,  
Inspection Division.  
Cambria Steel Co.,  
E. F. Kenney.  
Carnegie Steel Co.,  
J. O. Leech.  
Columbia Steel and Shafting Co.,  
E. L. Parker.

Clements, F. O.  
General Electric Co.,  
J. A. Capp.  
Standard Screw Co.,  
E. H. Ehrman.  
Union Drawn Steel Co.,  
P. N. Beegle.  
Westinghouse Electric and Manufacturing Co.,  
T. D. Lynch.  
Winchester Repeating Arms Co.,  
W. H. Buell.

Sub-Committee XVI on Literary Form.

C. L. Warwick, (Chairman).  
Carnegie Steel Co.,  
J. O. Leech.

Committee A-2 on Wrought Iron.

S. V. Hunnings, Chairman.  
J. B. Young, Secretary.

Non-Producers (20).

American Electric Railway Engineering Association.  
American Locomotive Co.,  
S. V. Hunnings (Chairman).  
Baldwin Locomotive Works,  
H. V. Wille.  
Bureau of Construction and Repair,  
U. S. N.  
Bureau of Steam Engineering, U.S.N.,  
Inspecting Division.  
Clark, F. H.  
Colby, J. A.  
Cramp and Sons Ship and Engine Building Co., William,  
W. A. Dobson.

Gannon, Thomas J.  
Geiser, W. B.  
Hartford Steam Boiler Inspection and Insurance Co.,  
S. F. Jeter.  
Lloyds' Register of Shipping,  
James French.  
Onderdonk, J. R.  
Ramage, J. C.  
Smith, H. E.  
Snow, J. P.  
Tilt, E. B.  
Waring, F. M.  
Young, C. D.  
Young, J. B. (Secretary).
Standing Committees.

Committee A-2 (Continued).

Producers (18).

American Iron and Steel Manufacturing Co.,
J. P. Brock.
Beale, H. A., Jr.
Bradlee and Co.,
T. E. Newbold.
Brown and Co., Incorporated,
James Neale.
Burden Iron Co.,
J. A. Burden.
Crockett, A. E.
Gillespie, J. M.
Glasgow Iron Co.,
J. P. Roe.
Hayden Corbett Chain Co.,
J. F. Corbett.

McKay Co., James,
T. J. McKay.
Molleson, G. E.
Pittsburgh Forge and Iron Co.,
F. E. Richardson.
Reading Iron Co.,
George Schuhmann.
Rome Merchant Iron Mill,
Weston Jenkins, Jr.
Ryerson Co., J. T.
H. A. Gray.
Stafford, B. E. D.
Worth Brothers Co.,
E. T. Ickes.
Woodroffe, G. H.

Sub-Committees of Committee A-2.

Sub-Committee I on Tubes and Pipe.

G. H. Woodroffe (Chairman).
Baldwin Locomotive Works,
H. V. Wille.
Beale, H. A., Jr.
Bureau of Construction and Repair,
U. S. N.
Clark, F. H.
Gannon, Thomas J.
Geiser, W. B.

Hartford Steam Boiler Inspection and Insurance Co.,
S. P. Jeter.
Molleson, G. E.
Reading Iron Co.,
George Schuhmann.
Worth Brothers Co.,
E. T. Ickes.

Sub-Committee II on Merchant Bar Iron.

Young, J. B. (Chairman).
American Electric Railway Engineering Association.
American Iron and Steel Manufacturing Co.,
J. P. Brock.
Baldwin Locomotive Works,
H. V. Wille.
Bureau of Steam Engineering, U.S.N.

Gillespie, J. M.
Pittsburgh Forge and Iron Co.,
F. E. Richardson.
Ramage, J. C.
Reading Iron Co.,
George Schuhmann.
Snow, J. P.

Sub-Committee III on Staybolt and Engine-Bolt Iron.

American Locomotive Co.,
S. V. Hunnings (Chairman).
American Electric Railway Engineering Association.
Brown and Co., Incorporated,
James Neale.
Burden Iron Co.,
James A. Burden.

Bureau of Steam Engineering, U.S.N.
Gillespie, J. M.
Hartford Steam Boiler Inspection and Insurance Co.,
S. F. Jeter.
Rome Merchant Iron Mill,
Weston Jenkins, Jr.
STANDING COMMITTEES.

COMMITTEE A-2 (Continued).

SUB-COMMITTEE III (Continued).

Ryerson Co., J. T.,
H. A. Gray.
Stafford, B. E. D.

Smith, H. E.
Tilt, E. B.
Young, C. D.

SUB-COMMITTEE IV on PLATES AND SHAPES.

Glasgow Iron Co.,
J. P. Row (Chairman).
Bureau of Construction and Repair,
U. S. N.
Colby, J. A.

Gannon, Thomas J.
Gillespie, J. M.
Reading Iron Co.,
George Schulmann.
Snow, J. P.

SUB-COMMITTEE V on CHAIN IRON AND IRON CHAIN.

Waring, F. M. (Chairman).
Bradlee and Co.,
T. E. Newbold.
Burden Iron Co.,
James A. Burden.
Bureau of Construction and Repair,
U. S. N.
Cramp and Sons Ship and Engine
Building Co., William,
W. A. Dobson.
Crockett, A. E.

Hayden Corbett Chain Co.,
J. T. Corbett.
Lloyds' Register of Shipping,
James French.
McKay Co., James,
T. J. McKay.
Onderdonk, J. R.
Ryerson Co., J. T.,
H. A. Gray.
Tilt, E. B.

SUB-COMMITTEE VI on WROUGHT IRON BLOOMS AND
FORGINGS.

H. E. Smith (Chairman).
American Locomotive Co.,
S. V. Humphings.
Baldwin Locomotive Works,
H. V. Wille.
Brown and Co.,
James Neale.
Cramp and Sons Ship and Engine
Building Co., William,
W. A. Dobson.

Glasgow Iron Co.,
James P. Roe.
Lloyds' Register of Shipping,
James French.
Pittsburgh Forge and Iron Co.,
P. E. Richardson.
Ramage, J. C.
Young, C. D.

COMMITTEE A-3 ON CAST IRON AND FINISHED CASTINGS.

RICHARD MOLDENKE, Chairman.
WALTER WOOD, Vice-Chairman.
GEORGE C. DAVIES, Secretary.

NON-PRODUCERS (27).

Beckett, James A.
Campbell, William.
Davidson, George M.
Davies, George C. (Secretary).

Detroit Testing Laboratory'
W. P. Putnam.
Diller, H. E.
DuComb, W. C., Jr.
Standing Committees.

Committee A-3 (Continued).

Non-Producers (Continued).

Gibbs, A. W.
Hildreth, P. S.
Howe, Henry M.
Hunt and Co., Robert W.,
  J. C. Ogden.
International Harvester Co.,
  John G. Wood.
Job, Robert.
Koch, George B.
Kreuzpointner, Paul.
Lanza, Gaetano.

MacPherran, R. S.
McKenna, Charles F.
Merica, P. D.
Merriman, Mansfield.
Moldenke, Richard (Chairman).
Outerbridge, Alexander E., Jr.
Ramage, J. C.
Saunders, Walter M.
Sauveur, Albert.
Touceda, Enrique.
Wille, H. V.

Producers (17).

American Car and Foundry Co.,
  D. M. Knox.
*American Locomotive Co.,
  S. V. Hunnings.
Ballentine, W. I.
Central Foundry Co.,
  W. Catchings.
Colorado Fuel and Iron Co.,
  J. B. McKennan.
Evans, G. S.
Fackenthal, B. F., Jr.
*Flagg, Stanley G.

*Johnson, R. K.
*Jones and Laughlin Steel Co.,
  John L. Haines.
Lemoine, L. R.
*Olsen, Tinius.
Peckitt, Leonard.
Wood, F. W.
*Wood, Walter (Vice-Chairman).
York Manufacturing Co.,
  C. H. Ehrenfeld.
Zehnder, C. H.

Sub-Committees of Committee A-3.

Sub-Committee I on Pig Iron.

Davies, George C. (Chairman).
American Locomotive Co.,
  S. V. Hunnings.
International Harvester Co.,
  John G. Wood.

Moldenke, Richard.
Peckitt, Leonard.

Sub-Committee II on Pipe.

Wood, Walter (Chairman).
Hunt and Co., R. W.,
  J. C. Ogden.

Lemoine, L. R.

Sub-Committee III on Cylinders.

Wille, H. V. (Chairman).
American Locomotive Co.,
  S. V. Hunnings.

Koch, George B.

*These members of Committee A-3, classed as Producers, stand in the relation of Producer to certain products, and in that of Non-Producer to other products within the province of the Committee.
Standing Committees.

Committee A-3 (Continued).

Sub-Committee IV on Car Wheels.

Koch, George B. (Chairman).
American Car and Foundry Co.,
D. M. Knox.
Davidson, George M.
Evans, G. S.

Gibbs, A. W.
Job, Robert.
Merica, P. D.
Outerbridge, A. E., Jr.
Ramage, J. E.

Sub-Committee V on Malleable Castings.

Flagg, Stanley G., Jr. (Chairman).
Ballentine, W. I.
Detroit Testing Laboratory,
W. P. Putnam.

Diller, H. E.
Moldenke, Richard.
Touceda, E.

Sub-Committee VI on General Castings.

Diller, H. E. (Chairman).
Beckett, James A.
Hildreth, P. S.
MacPherran, R. S.

Saunders, W. M.
York Manufacturing Co.,
C. H. Ehrenfeld.

Committee A-4 on Heat Treatment of Iron and Steel.

Albert Sauveur, Chairman.
John H. Hall, Secretary.

Non-Producers (7).

Barlow, W. E.
Bureau of Steam Engineering, U. S. N.,
Naval Engineering Experiment
Station, Annapolis, Md.
Inspector of Ordnance, Philadelphia.

Campbell, William.
Howe, Henry M.
Sauveur, Albert (Chairman).
Stansfield, Alfred.
Stoughton, Bradley.

Producers (5).

Bethlehem Steel Co., Bethlehem Plant,
E. O'C. Acker.
Hall, J. H. (Secretary).
Kenney, E. F.

Midvale Steel Co.,
G. Aertsen.
Radclyffe Furness.
Unger, J. S.

Committee A-5 on Corrosion of Iron and Steel.

S. S. Voorhees, Chairman.
J. H. Gibboney, Vice-Chairman.
J. O. Handy, Vice-Chairman.
William H. Walker, Secretary.

Non-Producers (22).

Aston, James.
Bureau of Construction and Repair,
U. S. N.
Bureau of Steam Engineering, U. S. N.,
Naval Engineering Experiment
Station, Annapolis, Md.
Burgess, C. F.
Burgess, G. K.
Campbell, William.

Capp, J. A.
Colby, A. L.
Gibboney, J. H. (Vice-Chairman).
Howe, Henry M.
Job, Robert.
Lynch, T. D.
McDonnell, M. E.
Standing Committees.

Committee A-5 (Continued).

Non-Producers (Continued).

New York Central Railroad Co.,
   Engineering Department,
   A. W. Carpenter.
Pittsburgh Testing Laboratory,
   J. O. Handy (Vice-Chairman).
Potts, S. C.
Sagendorph, G. A.

American Metal Co., Limited,
   H. M. Burkey.
American Steel and Wire Co.,
   S. M. Rodgers.
American Zinc, Lead and Smelting Co.,
   H. A. Wentworth.
Aupperle, J. A.
Buck, D. M.
Carnahan, R. B., Jr.
Carnegie Steel Co.,
   J. S. Unger.
Cooper, W. A.
Cushman, Allerton S.
Fleming, W. R.
Hay, J. T.

Producers (19).

Hess, Henry.
National Tube Co.,
   P. N. Speller.
Stone, G. C.
United States Electric Galvanizing Co.,
   Mason Doyle.
United States Sherardizing Co.,
   C. J. Kirk.
Walker, William H. (Secretary).
Whitaker Glessner Co.,
   G. W. Moore.
Youngstown Sheet and Tube Co.,
   G. A. Reinhardt.

Sub-Committees of Committee A-5.

Advisory Committee.

Voorhees, S. S. (Chairman).
Buck, D. M.
Carnahan, R. B., Jr.
Cooper, W. A.
Cushman, Allerton S.
Fleming, W. R.

Sub-Committee I on Construction.

Buck, D. M. (Chairman).
Cooper, W. A.
Cushman, Allerton S.

Sub-Committee II on Preservative Metallic Coatings for Metals.

Burgess, G. K. (Chairman).
American Metal Co., Limited,
   H. M. Burkey.
American Steel and Wire Co.,
   S. M. Rodgers.
American Zinc, Lead and Smelting Co.,
   H. A. Wentworth.
Aston, James.
Buck, D. M.
Bureau of Construction and Repair,
   U. S. N.
Capp, J. A.
Carnahan, R. B., Jr.
Cushman, Allerton S.
Gibboney, J. H.

Hess, H. S.
McDonnell, M. E.
National Tube Co.,
   P. N. Speller.
New York Central Railroad Co.,
   Engineering Department,
   A. W. Carpenter.
Potts, S. C.
Stone, G. C.
United States Electric Galvanizing Co.,
   Mason Doyle.
United States Sherardizing Co.,
   C. J. Kirk.
Standing Committees.

Committee A-6 on Magnetic Properties of Iron and Steel.

Charles W. Burrows, Chairman.

Beck, W. J.
Brown, Vere.
Burrows, Charles W. (Chairman).
Capp, J. A.
Crocker-Wheeler Co.,
R. B. Treat.
Follansbee Brothers Co.,
J. G. Homan.
Linder, O.
Mathews, J. A.
Pinkerton, Andrew.
Sargent, G. W.
Skinner, C. E.
Splittorf Electrical Co.,
J. K. Leibing.

B. Non-Ferrous Metals.

Committee B-1 on Copper Wire.

J. A. Capp, Chairman.

Non-Producers (5).

General Electric Co.,
J. A. Capp (Chairman).
MacPherran, R. S.
Western Electric Co.,
A. H. Vorum.
Westinghouse Electric and Manufacturing Co.,
T. D. Lynch.
White Engineering Corporation,
The J. G. Co.
D. Gray.

Producers (5).

American Brass Co.,
W. H. Bassett.
American Steel and Wire Co.,
E. H. Peirce.
Roebling's Sons Co., J. A.,
H. J. Horn.
Standard Underground Cable Co.,
C. C. Baldwin.
Waclark Wire Co.,
F. W. Wallace.

Committee B-2 on Non-Ferrous Metals and Alloys.

William Campbell, Chairman.

Vice-Chairmen.

W. H. Bassett.
G. H. Clamer.

W. M. Corse.
W. R. Webster.

Non-Producers (21).

American Locomotive Co.,
F. J. Cole.
American Steel and Wire Co.,
S. M. Rodgers.
Bregowsky, I. M.
Burcan of Steam Engineering, U. S. N.,
Inspecting Division.
Burgess, G. K.
Campbell, William (Chairman).
Capp, J. A.
Coho, H. B.
Harriman, N. F.
Hillebrand, W. F.
Hunnings, S. V.
Standing Committees.

Committee B-2 (Continued).

Non-Producers (Continued).

Inland Steel Co.,
   G. H. Jones.
Lindsay, C. F.
MacPherran, R. S.
Olson, L. W.
Reinhardt, G. A.

Shepard, W. R.
Smith, H. E.
Walker, A. L.
Webbert, L. P.
Wille, H. V.

Producers* (21).

Addicks, L.
Ajax Metal Co.,
   G. H. Clamer (Vice-Chairman).
American Brass Co.,
   W. H. Bassett (Vice-Chairman).
American Manganese Bronze Co.,
   C. R. Spare.
American Smelting and Refining Co.,
   A. H. Gill.
Cairns, F. J.
Calumet and Hecla Mining Co.,
   R. L. Agassiz.
Corse, W. M. (Vice-Chairman).
Cowan, W. A.
Damascus Bronze Co.,
   W. K. Frank.
Furst, E. W.

Gulick, H. S.
Hendricks Brothers, Incorporated,
   E. J. Keane.
Herreshoff, J. B., Jr.
Price, W. B.
Raritan Copper Works,
   F. L. Antisell.
A. C. Clark.
Stone, G. C.
Thompson, J. F.
Webster, W. R. (Vice-Chairman).
Westinghouse Electric and Manufacturing Co.,
   T. D. Lynch.
Winchester Repeating Arms Co.,
   W. H. Buell.

Sub-Committees of Committee B-2.

Sub-Committee I on Pure Metals in Ingot Form.

American Brass Co.,
   W. H. Bassett (Chairman).
Addicks, L.
Ajax Metal Co.,
   G. H. Clamer.
American Steel and Wire Co.,
   S. M. Rodgers.
Antisell, F. L.
Capp, J. A.
Corse, W. M.
Cowan, W. A.
Furst, E. W.

Herreshoff, J. B., Jr.
Olson, L. W.
Price, W. B.
Reinhardt, G. A.
Shepard, W. K.
Stone, G. C.
Walker, A. L.
Webbert, L. P.
Webster, W. R.
Westinghouse Electric and Manufacturing Co.,
   T. D. Lynch.

Sub-Committee II on Wrought Metals and Alloys.

Webster, W. R. (Chairman).
American Brass Co.,
   W. H. Bassett.
Capp, J. A.
Harriman, N. F.
MacPherran, R. S.
Price, W. B.

Smith, H. E.
Thompson, J. F.
Westinghouse Electric and Manufacturing Co.,
   T. D. Lynch.
Winchester Repeating Arms Co.,
   W. H. Buell.

* The members of Committee B-2, classed as Producers, stand in the relation of Producer to certain products, and in that of Non-Producer to other products within the province of the Committee.
Standing Committees.

Committee B-2 (Continued).

Sub-Committee III on Sand-Cast Metals and Alloys.

Corse, W. M. (Chairman).
Ajax Metal Co.,
G. H. Clamer.
American Manganese Bronze Co.,
C. R. Spare.
Bregowsky, I. M.

Olson, L. W.
Thompson, J. F.
Webbent, L. P.
Westinghouse Electric and Manufacturing Co.,
J. L. Jones.

Sub-Committee IV on White Metals—Tin, Lead, and Zinc Base.

Ajax Metal Co.,
G. H. Clamer (Chairman).
Corse, W. M.
Cowan, W. A.
MacPherran, R. S.

Smith, H. E.
Westinghouse Electric and Manufacturing Co.,
J. L. Jones.

Sub-Committee V on Plates, Tubes and Staybolts for Locomotives.

Webster, W. R. (Chairman).
American Locomotive Co.,
F. J. Cole.
American Brass Co.,
W. H. Bassett.
American Smelting and Refining Co.,
A. H. Gill.
Burgess, G. K.
Cohoe, H. B.
Cairns, F. J.

Calumet and Hecla Mining Co.,
R. L. Agassiz.
Hendricks Brothers, Incorporated,
E. J. Keane.
Lindsay, C. F.
Raritan Copper Works,
A. C. Clark.
Wille, H. V.
Winchester Repeating Arms Co.,
W. H. Buell.

Sub-Committee VI on Non-Ferrous Alloys for Railroad Equipment.

Ajax Metal Co.,
G. H. Clamer (Chairman).
Corse, W. M.
Damascus Bronze Co.,
W. K. Frank.

Gulick, H. S.
Hunnings, S. V.
Ramage, J. C.
Smith, H. E.
Wille, H. V.

C. Cement, Lime, Gypsum, and Clay Products.

Committee C-1 on Cement.

R. S. Greenman, Chairman.
H. B. MacFarland, Vice-Chairman.
John B. Lober, Vice-Chairman.
P. H. Bates, Secretary.

Non-Producers (37).
American Institute of Architects,
Thomas Nolan.
American Railway Engineering Association,
H. A. Cassil.
F. P. Sisson.
J. J. Yates.
Standing Committees.

Committee C-1 (Continued).

Non-Producers (Continued).

Bates, P. H. (Secretary).
Blakeley, A. G.
Bureau of Yards and Docks, C. D. Thurber.
Edwards, L. N.
Goldbeck, A. T.
Greenman, R. S. (Chairman).
Hatt, W. K.
Hoff, Olaf.
Holst, J. L.
Humphrey, Richard L.
Johnson, N. C.
Loweth, C. F.
Lucas, George L.
MacFarland, H. B. (Vice-Chairman).
Munsell, A. W.
Murray, John F.
Onderdonk, J. R.
Phillips, A. E.
Pittsburgh Testing Laboratory, J. L. Miner.

Producers (23).

Abrams, D. A.
Ackerman, E. R.
Ashton, Ernest.
Boynton, C. W.
Brobston, Joseph.
Conn, Charles F.
Diedkamp, G. P.
Drew, Harry.
Fraser, D. R.
Harding, W. H.
Hart, O. C.
Hartsell, H. S.
Hicks, T. A.
Porter, J. Madison.
Ray, G. J.
Richardson, Clifford.
Robinson, A. F.
Schall, F. E.
Smith, Emery and Co., E. E. Smith.
Swain, George F.
Testing Laboratory, City of St. Louis, E. P. Withrow.
U. S. Reclamation Service, Arthur P. Davis.
Voorhees, S. S.
Walter, L. W.
Webster, George S.
Westinghouse Church Kerr and Co., Cloyd M. Chapman.
Wig, R. J.
Wilson, Percy H.
Young, C. D.

Sub-Committees of Committee C-1.

Advisory Committee.

Greenman, R. S. (Chairman).
Ashton, Ernest.
Bates, P. H. (Secretary).
Hatt, W. K.
Humphrey, Richard L.
Kelley, F. W.
Kelley, F. W.
Kinney, W. M.
Lobert, J. B.
MacFarland, H. B.
Voorhees, S. S.
Wig, R. J.
Young, C. D.

Sub-Committee I on Definition and Chemical Limitations.

Voorhees, S. S. (Chairman).
American Railway Engineering Association, H. A. Cassil.
Lucas, G. L.
Newberry, S. B.
Richardson, Clifford.
STANDING COMMITTEES.

COMMITTEE C-1 (Continued).

SUB-COMMITTEE II ON SPECIFIC GRAVITY.

Young, C. D. (Chairman).
Diekmann, G. P.
Hoff, Olaf.
Munsell, A. W.

Schall, F. E.
Tagge, A. C.
Wilson, P. H.

SUB-COMMITTEE III ON FINENESS.

Wig, R. J. (Chairman).
Abrams, D. A.
Ashton, Ernest.
Blakeley, A. G.
Brobston, Joseph.
Drew, Harry.

MacFarland, H. B.
Newberry, Spencer, B.
Spackman Engineering Co., H. S.,
H. S. Spackman.
U. S. Reclamation Service,
A. P. Davis.

SUB-COMMITTEE IV ON SOUNDNESS AND CONSTANCY OF VOLUME.

Humphrey, Richard L. (Chairman).
American Railway Engineering Association.
F. E. Schall.
Harding, W. H.

Hicks, T. A.
Ray, G. J.
Voorhees, S. S.
Webster, G. S.

SUB-COMMITTEE V ON NORMAL CONSISTENCY.

Hatt, W. K. (Chairman).
American Railway Engineering Association.
Boynton, C. W.

Goldbeck, A. T.
Hartsell, H. S.
Voorhees, S. S.

SUB-COMMITTEE VI ON TIME OF SETTING.

Kelley, F. W. (Chairman).
American Railway Engineering Association.
J. J. Yates.
Bates, P. H.

Loweth, C. F.
Smith, Emery and Co.
Spackman, Engineering Co., H. S.
Testing Laboratory, City of St. Louis,
E. P. Withrow.

SUB-COMMITTEE VII ON STRENGTH.

Greenman, R. S. (Chairman).
Abrams, D. A.
American Railway Engineering Association.
F. P. Sisson.

Ashton, Ernest.
Bates, P. H.
Kinney, W. M.
Newberry, S. B.
Walter, L. W.

SUB-COMMITTEE VIII ON SAMPLING, STORAGE, PACKAGES AND INSPECTION.

Kinney, W. M. (Chairman).
Fraser, D. R.
Goldbeck, A. T.
Holst, J. L.

Onderdonk, J. R.
Phillips, A. E.
Potter, N. S., Jr.
Walter, L. W.
Standing Committees.

Committee C-1 (Continued).

Sub-Committee IX on General Clauses.

Ashton, Ernest (Chairman).
American Institute of Architects,
Thomas Nolan.
Lesley, R. W.

Committee C-2 on Reinforced Concrete.

F. E. Turneau, Chairman.
Robert W. Lesley, Vice-Chairman.
Richard L. Humphrey, Secretary.

Non-Producers (9).

Fuller, W. B.
Humphrey, Richard L. (Secretary).
Lanza, Gaetano.
Moissieff, Leon S.
Quimby, H. H.

Producers (3).

Lesley, Robert W. (Vice-Chairman).

Committee C-3 on Brick.

Edward Orton, Jr., Chairman.
A. V. Bleininger, Secretary.

Non-Producers (8).

Bleininger, A. V. (Secretary).
Emley, W. E.
Lawson, T. R.
Lazell, E. W.
Orton, Edward, Jr. (Chairman).

Producers (6).

Blair, Will P.
Crume, W. H.
Randall, T. A.

Committee C-4 on Clay and Cement Sewer Pipe.

Rudolph Hering, Chairman.
A. J. Provost, Jr., Vice-Chairman.
E. J. Fort, Secretary.

Non-Producers (12).

Barbour, F. A.
Bleininger, A. V.
Eddy, Harrison P.
Fort, E. J. (Secretary).

Hering, Rudolph (Chairman).
Howe, Malverd A.
Humphrey, Richard L.
Marston, A.
STANDING COMMITTEES.

COMMITTEE C-4 (Continued).

Non-Producers (Continued).
Provoast, A. J., Jr. (Vice-Chairman). Testing Laboratory, City of St. Louis, E. P. Withrow.
Shelley, H. T. Webster, George S.

Producers (8).
Dickey, W. S. Starr, John J.
McCombe, A. S. Zeidler, J. L.
Meriwether, Coleman.
Oberkirch, Frank.

COMMITTEE C-5 ON FIREPROOFING.

IRA H. WOOLSON, Chairman.
R. P. MILLER, Secretary.

Non-Producers (8).
Ewing, W. W.
Freeman, John R.
Hodge, H. W.
Macgregor, J. S.

Producers (3).
Miller, R. P. (Secretary).
Norton, C. L.
Waid, D. E.
Woolson, Ira H. (Chairman).

Bevier, P. H.
Haigh, D. L.

COMMITTEE C-6 ON DRAIN TILE.

A. MARSTON, Chairman.
ARTHUR N. TALBOT, Vice-Chairman.
J. T. STEWART, Secretary.

Non-Producers (8).
Bureau of Irrigation, United States, Orton, Edward, Jr.
Samuel Fortier.
Chatburn, George R. Stewart, J. T. (Secretary).
Hering, Rudolph. Talbot, Arthur N. (Vice-Chairman).
Marston, A. (Chairman). Turneaure, F. E.

Producers (8).
Brooks, Benjamin.
Child, J. Leo.
Dickmann, G. P.
Hammen, J. J.
Rawson, Charles A.
Tefit, G. H.
STANDING COMMITTEES.

COMMITTEE C-7 ON LIME.

J. S. Macgregor, Chairman.
H. S. Spackman, Vice-Chairman.
E. L. Conwell, Secretary.

Non-Producers (11).

Berry, H. C.
Emley, W. E.
Force, H. J.
Hunt and Co., Robert W.,
J. F. Davis.
Lazell, E. W.
Macgregor, J. S. (Chairman).

Producers (5).

Aluminate Patents Co.,
E. L. Conwell (Secretary).
Hough, N. G.
Kelley Island Lime and Transport Co.,
Henry Angel.

COMMITTEE C-8 ON REFRACTORIES.

A. V. Bleininger, Chairman.
W. H. Fulweiler, Secretary.

Non-Producers (14).

Bleininger, A. V. (Chairman).
Fulweiler, W. H. (Secretary).
International Harvester Co.,
J. C. Warnes.
Kanolt, C. W.
Kenney, L. H.
Kerr, C. H.
National Carbon Co.,
A. D. Camp.

Producers (13).

Allen, E. M.
Balz, G. A.
Claiborne, C. H.
Davis, D. D.
Davis, R. P. M.
Kier, R. S.
Laclede-Christy Clay Products Co.,
R. D. Hatton.

SUB-COMMITTEES OF COMMITTEE C-8.

Sub-Committee I on Fusion Tests.

Kanolt, C. W. (Chairman).
Davis, R. P. M.
Kenney, L. H.

Orton, Edward, Jr.
Parmelee, C. W.
Seaver, Kenneth.
STANDING COMMITTEES.

COMMITTEE C-8 (Continued).

SUB-COMMITTEE II ON ANALYSIS.

Kerr, C. H. (Chairman).
Bleininger, A. V.
International Harvester Co.,
J. C. Warnes.

Norton Co.,
R. C. Purdy.
Parmelee, C. W.
Unger, J. S.

SUB-COMMITTEE III ON INDUSTRIAL SURVEY

Bleininger, A. V. (Chairman).
Allen, E. M.
Balz, G. A.
Claiborne, C. H.
Davis, D. D.
Laclede-Christy Clay Products Co.,
R. D. Hatton.

Savage, H. D.
Seaver, Kenneth.
Taylor, A. P.
Unger, J. S.

SUB-COMMITTEE IV ON THERMAL CONDUCTIVITY AND THERMAL EXPANSION.

Norton, C. L. (Chairman).
Allen, E. M.
Balz, G. A.
Fulweiler, W. H.

Kanolt, C. W.
Norton Co.,
R. C. Purdy.

SUB-COMMITTEE V ON POROSITY AND PERMANENT VOLUME CHANGE.

Norton Co.,
R. C. Purdy (Chairman).
Balz, G. A.
Kerr, C. H.

Parmelee, C. W.
Ramsay, J. D.
Savage, H. D.
Unger, J. S.

SUB-COMMITTEE VI ON LOAD TESTS AT HIGH TEMPERATURES.

Fulweiler, W. H. (Chairman).
Bleininger, A. V.
Kenney, L. H.
Laclede-Christy Clay Products Co.,
R. D. Hatton.

Reel, C. S.
Taylor, A. P.
Unger, J. S.

SUB-COMMITTEE VII.—(Discontinued).

SUB-COMMITTEE VIII ON SLAGGING ACTION.

Unger, J. S. (Chairman).
Claiborne, C. H.
International Harvester Co.,
J. C. Warnes.

Kerr, C. H.
Orton, Edward, Jr.
Seaman, H. J.
Standing Committees.

Committee C-9 on Concrete and Concrete Aggregates.

Sanford E. Thompson, Chairman.
Cloyd M. Chapman, Vice-Chairman.
Lewis R. Ferguson, Secretary.

Non-Producers (14).

Abrams, D. A.
Fuller, W. B.
Goldbeck, A. T.
Graf, S. H.
Greenman, R. S.
Johnson, N. C.
Lucas, G. L.
Pittsburgh Testing Laboratory.
    J. L. Miner.

Talbot, Arthur N.
Thompson, Sanford E. (Chairman).
Walter, L. W.
Westinghouse Church Kerr and Co.,
    Cloyd M. Chapman (Vice-Chairman).
Wig, R. J.
Withey, M. O.

Producers (7).

Ashton, Ernest.
Boyer, E. D.
Ferguson, L. R. (Secretary).
Kelley, F. W.

Kinney, W. M.
Moore, H. A.
Renwick, F. W.

Sub-Committees of Committee C-9.

Sub-Committee I on Definitions.
Ferguson, Lewis R. (Chairman).
    Pittsburgh Testing Laboratory,
        J. L. Miner.

Sub-Committee II on Laboratory Tests for Concrete
    and Laws of Mechanical Mixtures.

Abrams, D. A. (Chairman).
Fuller, W. B.
Graf, S. H.
Renwick, F. W.
Talbot, Arthur N.
Withey, M. O.

Sub-Committee III on Sampling and Testing Field
Concrete.

Kinney, W. M. (Chairman).
Greenman, R. S.
Walter, L. W.
Wig, R. J.

Sub-Committee IV on Relative Values of Various
    Strength Tests.

Goldbeck, A. T. (Chairman).
Greenman, R. S.
Withey, M. O.

Sub-Committee V on Impurities Affecting Fine
Aggregates.

Kelley, F. W. (Chairman).
Abrams, D. A.
Boyer, E. D.
Ferguson, Lewis R.
Johnson, N. C.
Standing Committees.

COMMITTEE C-9 (Continued).

SUB-COMMITTEE VI ON METHODS OF TESTS FOR VOIDS, WEIGHTS, DENSITY, SPECIFIC GRAVITY AND CONSISTENCY.

Westinghouse Church Kerr and Co., Lucas, G. L.
Cloyd M. Chapman (Chairman). Pittsburgh Testing Laboratory,
Goldbeck, A. T. J. L. Miner.

SUB-COMMITTEE VII ON METHODS OF TESTS OF COARSE AGGREGATES.

Ashton, Ernest (Chairman). Westinghouse Church Kerr and Co.
Moore, H. A. Cloyd M. Chapman.
Renwick, F. W.

SUB-COMMITTEE VIII ON AVAILABLE AGGREGATES FOR CONCRETE.

Ferguson, Lewis R. Wig, R. J.
Kinney, W. M.

COMMITTEE C-10 ON HOLLOW BUILDING TILE.

L. H. PROVINE, Chairman.
P. H. BEVIER, Vice-Chairman.
E. V. JOHNSON, Secretary.

Non-Producers (8).

Griffith, J. H. Provine, L. H. (Chairman).
Johnson, E. V. (Secretary). Shankland, E. C.
Miller, R. P. United States Gypsum Co.,
Orton, Edward, Jr.

Producers (9).

Bevier, P. H. (Vice-Chairman). Mason City Brick and Tile Co.,
Clay Products Co., The, B. C. Keeler.
H. H. Titsworth. Maahs, J. A.
Demorest, W. G. National Fireproofing Co.,
Hollow Building Tile Manufacturer’s Whitacre Fireproofing Co.,
Association, R. E. Whitacre.
H. C. Downer.

SUB-COMMITTEES OF COMMITTEE C-10.

SUB-COMMITTEE I ON STRENGTH AND LOAD TESTS.

Griffith, J. H. (Chairman). United States Gypsum Co.,
National Fireproofing Co., Whitacre Fireproofing Co.,
Shankland, E. C.

1 The numeric preponderance of the producer element of this committee is inconsistent with the regulations of the Society. This matter is now in course of adjustment.
Standing Committees.

Committee C-10 (Continued).

Sub-Committee II on Fire Tests.

Johnson, E. V. (Chairman).
Clay Products Co., The,
H. H. Titsworth.
Dennison, W. C.
Miller, R. P.
Shankland, E. C.

Sub-Committee III on Absorption and Frost Resistance.

Orton, Edward, Jr. (Chairman).
Bevier, P. H.
Mason City Brick and Tile Co.,
B. C. Keeler.

Sub-Committee IV on Insulation and Acoustics.

United States Gypsum Co.,
V. G. Marani (Chairman).
Demorest, W. G.
Johnson, E. V.
Maahs, J. A.
Orton, Edward, Jr.

Committee C-11 on Gypsum and Gypsum Products.

R. J. Wig, Chairman.
F. A. Wilder, Vice-Chairman.
R. P. Miller, Vice-Chairman.
L. I. Neale, Secretary.

Non-Producers (20).

Abrams, D. A.
American Institute of Architects,
J. R. Rockart.
Ashton, E.
Emley, W. E.
Forster, H. W.
Froehling and Robertson,
Henry Froehling.
Hicks, T. A.
Jones, Bevan.
Latta, H. W.
Macgregor, J. S.
Menefee, F. N.
Miller, R. P. (Vice-Chairman).
Mills, A. P.
Norton, C. L.
Slater, W. A.
Tagge, A. C.
Underwriters Laboratories, Incorporated,
G. W. Riddle.
Waid, D. E.
Wig, R. J. (Chairman).
Woolson, I. H.

Producers (10).

American Cement Plaster Co.,
E. Tupper.
Brown, H. J.
Grand Rapids Plaster Co.,
A. H. Apted.
Gypsum Industries Association, Incorporated,
S. G. Webb.
Haigh, De Lagnel.
Neale, L. I. (Secretary).

Pacific Portland Cement Co., Consolidated,
T. S. Montgomery.
Southern Gypsum Co.,
F. A. Wilder (Vice-Chairman).
Tomkins, C.
United States Gypsum Co.,
C. Henning.
V. G. Marani.
G. L. Southard.
Standing Committees.

COMMITTEE C-11 (Continued).

SUB-COMMITTEES OF COMMITTEE C-11.

SUB-COMMITTEE I ON GYPSUM FOR VARIOUS USES.

Brown, H. J. (Chairman).
American Cement Plaster Co.,
Edward Tupper.
Ashton, E.
Emley, W. E.
Gypsum Industries Association, Incorporated,
S. G. Webb.
Hicks, T. A.
Latta, H. W.
Maegregor, J. S.
Southern Gypsum Co.,
F. A. Wilder.
Tagge, A. C.
United States Gypsum Co.,
G. L. Southard.
Wig, R. J. (ex-officio).

SUB-COMMITTEE II ON GYPSUM PLASTERS.

Haigh, De Lagnel (Chairman).
Abrams, D. A.
American Cement Plaster Co.,
Edward Tupper.
Brown, H. J.
Emley, W. E.
Grand Rapids, Plaster Co.,
A. H. Apted.
Gypsum Industries Association, Incorporated,
S. G. Webb.
United States Gypsum Co.,
G. L. Southard.
Wig, R. J. (ex-officio).

SUB-COMMITTEE III ON STRUCTURAL GYPSUM PRODUCTS.

Slater, W. A. (Chairman).
Porster, H. W.
Gypsum Industries Association, Incorporated,
S. G. Webb.
Miller, R. P.
Neale, L. I.
United States Gypsum Co.,
Charles Henning.
V. G. Marani.
Wig, R. J. (ex-officio).

SUB-COMMITTEE IV ON TESTING METHODS.

Emley, W. E. (Chairman).
Haigh, De Lagnel.
Gypsum Industries Association, Incorporated,
S. G. Webb.
Mills, A. P.
Norton, C. L.
Tomkins, C.
Underwriters' Laboratories, Incorporated,
G. W. Riddle.
United States Gypsum Co.,
V. G. Marani.
Woolson, Ira H.
Wig, R. J. (ex-officio).

SUB-COMMITTEE V ON NOMENCLATURE.

Gypsum Industries Association, Incorporated,
S. G. Webb (Chairman).
American Institute of Architects,
J. R. Rockart.
Grand Rapids Plaster Co.,
A. H. Apted.
Jones, B.
Maegregor, J. S.
United States Gypsum Co.,
V. G. Marani.
Wig, R. J. (ex-officio).
D. MISCELLANEOUS MATERIALS.

COMMITTEE D-1 ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

P. H. WALKER, Chairman.
G. B. HECKEL, Vice-Chairman.
G. W. THOMPSON, Secretary.

NON-PRODUCERS (43).

Aiken, W. A.
Akin, Thomas B.
Bacon, C. V.
Boughton, E. W.
Bragg, C. T.
Dannerth, F.
Dewar, John.
Finch, A. M.
Fitch, R. O.
Force, H. J.
Gibbonney, James H.
Gill, A. H.
Job, Robert.
Johnsen, A. M.
Kellogg, J. W.
Macnichol, Charles.
McDonnell, M. E.
Mellhiney, P. C.
Millwood, J. P.
Muckenfuss, A. M.
New York Central Railroad Co., Engineering Department, A. W. Carpenter.

PRODUCERS (43).

Ashby, G. E.
*Atlantic Refining Co., The, F. C. Robinson.
Cheesman, F. P.
Coleman, R. E.
Davis, S. D.
Dixon Crucible Co., Joseph, M. McNaughton.
Edgerly, D. W.
Evans, S. M.
*Forrest, C. N.
*Gardner, Henry A.
*Gray, G. W.
Gregory, E. D.
*Heckel, G. B. (Vice-Chairman).

* These members of Committee D-1, classed as PRODUCERS, stand in the relation of PRODUCER to certain products, and in that of NON-PRODUCER to other products within the province of the Committee.
Standing Committees.

Committee D-1 (Continued).

Producers (Continued).

Neal, C. S.
*New Jersey Zinc Co.,
  H. Hendricks.
G. C. Stone.
*Paisley, J. W.
Patton Paint Co.,
  Ben Solomon.
*Pickard, Glenn H.
Rinald, C. D.
Rogers, R. E.
Sabin, A. H.
Senderson, J. McE.
  Schaeffer, J. A.
  Seaton, M. Y.
  Sherwin-Williams Co., The,
    E. C. Holton.
  Thompson, G. W. (Secretary).
  Toch, Maximilian.
  United States Gutta Percha Paint Co.,
    W. W. Rice.
*Weiss, J. M.
White, G. D.
Wilhelm Co., The A.,
  Walter S. Davis.

Sub-Committees of Committee D-1.

Sub-Committee I, Advisory Committee.

Walker, P. H. (Chairman).
Aiken, W. A.
Dixon Crucible Co.,
  M. McNaughton.
Gardner, Henry A.
  Gibboney, James H.
  Heckel, G. B.
  Pickard, Glenn H.
  Thompson, G. W.
  Voorhees, S. S.

Sub-Committee II.—(Discontinued).

Sub-Committee III on Testing of Paint Vehicles.

Gardner, Henry A. (Chairman).
Bacon, C. V.
Boughton, E. W.
Bragg, C. T.
Kohr, D. A.
Lindsay, R. W.
Lucas and Co., John,
  L. P. Nemzek.
  Pickard, Glenn H.
  Rogers, Allen.
  Sabin, A. H.
  Schaeffer, J. A.
  White, G. D.

Sub-Committee IV.—(Discontinued).

Sub-Committee V on Linseed Oil.

Pickard, Glenn H. (Chairman).
Boughton, E. W.
Kohr, D. A.
  Seaton, M. Y.
  Thompson, G. W.

Sub-Committee VI on Definitions of Terms Used in Paint Specifications.

Thompson, G. W. (Chairman).
Gibboney, James H.
Heckel, G. B.
Kohr, D. A.
  Mellhiney, P. C.
  Walker, P. H.
  White, G. D.

*These members of Committee D-1, classed as Producers, stand in the relation of Producer to certain products, and in that of Non-Producer to other products within the province of the Committee.
Standing Committees.

Committee D-1 (Continued).

Sub-Committee VII on Accelerated Tests and the Influence of Pigments on Corrosion.

Gardner, H. A. (Chairman). Walker, W. H.
Smith, H. E.

Sub-Committee VIII on Methods of Analysis of Paint Materials.

Smither, F. W. (Chairman). McIlhiney, P. C.
Gibboney, James H. Thompson, G. W.
Ingalls, F. P. Voorhees, S. S.

Sub-Committee IX on Varnish.

Voorhees, S. S. (Chairman). Other members to be appointed.

Sub-Committee X. — (Discontinued).

Sub-Committee XI on Paint Thinners Other Than Turpentine.

Westinghouse Church Kerr and Co., Lunn, C. A.
Cloyd M. Chapman (Chairman). Mackenzie, K. G.
Atlantic Refining Co., The, Maitland, Harold T.
F. C. Robinson. Patton Paint Co.,
Bacon, C. V. Ben Solomon.
Bragg, C. T. Underwriters' Laboratories,
Edgerly, D. W. A. H. Nuckolls.
Forrest, C. N. Veitch, F. P.
Gray, G. W. Voorhees, S. S.
Johnsen, A. M. Weiss, J. M.
Lindsay, R. W.
Lucas and Co., John,
L. P. Nemzek.

Sub-Committee XII on Turpentine.

Veitch, F. P. (Chairman). Voorhees S. S.
Boughton, E. W. Westinghouse Church Kerr and Co.,
Gibboney, J. H.

Sub-Committee XIII on Shellac.

Langmuir, A. C. (Chairman). Paisley, J. W.
Ashby, G. E. Stillwell, A. G.
Bragg, C. T. Victor Talking Machine Co.,
McIlhiney, P. C. E. F. Hicks.
STANDING COMMITTEES.

COMMITTEE D-1 (Continued).

SUB-COMMITTEE XIV ON THE PREPARATION OF IRON AND STEEL SURFACES FOR PAINTING.

New York Central Railroad Co.,
Engineering Department,
A. W. Carpenter (Chairman).
Aiken, W. A.
Cheesman, F. P.
Job, Robert.
McDonnell, M. E.
Sabin, A. H.

SUB-COMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THE FORM.

New Jersey Zinc Co.,
G. C. Stone (Chairman).
Gardner, H. A.
Ingalls, F. P.
Thompson, G. W.
White, G. D.

SUB-COMMITTEE XVI ON TERMS USED IN REPORTING THE CONDITION OF PAINTED SURFACES.

Lucas and Co., John,
L. P. Nemzek (Chairman).
Heckel, G. B.
McDonnell, M. E.
Ramage, J. C.
Sabin, A. H.
Van Gundy, C. P.

SUB-COMMITTEE XVII ON TESTING OF PIGMENTS FOR FINENESS BY THE USE OF SCREENS.

Thompson, G. W. (Chairman).
Other members to be appointed.

COMMITTEE D-2 ON LUBRICANTS.

C. P. VAN GUNDY, Chairman.
P. H. CONRADSON, Vice-Chairman.
K. G. MACKENZIE, Secretary.

Non-Producers (12).

Bureau of Steam Engineering, U. S. N.,
Naval Engineering Experiment Station, Annapolis, Md.
Bacon, C. V.
Blakeley, A. G.
Day, D. T.
Dow, A. W.
Dunbar, W. O.
Flowers, A. E.
French, D. K.
Jeffers, J. M.
Van Gundy, C. P. (Chairman).
Waters, C. E.
Westinghouse Air Brake Co.,
H. C. Loudenbeck.

Producers (7).

Atlantic Refining Co.,
F. C. Robinson.
Baum, George.
Baxter, F. R.
Conradson, P. H. (Vice-Chairman).
Gray, J. L.
Mackenzie, K. G. (Secretary).
Maitland, Harold.
Standing Committees.

Committee D-3 on Methods of Sampling and Analysis of Coal.

S. W. Parr, Chairman.

(Forming part of a joint committee on this subject with a committee of the American Chemical Society.)

Parr, S. W. (Chairman).
Dickinson, H. C.

Haas, Frank R.
Voorhees, S. S.

Committee D-4 on Road Materials.

Logan Waller Page, Chairman.
Prévost Hubbard, Secretary.

Non-Producers (23).

Agg, T. R.
Blanchard, A. H.
Broadhurst, W. H.
Crosby, W. W.
Dow, A. W.
Drowne, H. B.
Fitch, R. O.
Geological Survey of New Jersey,
  R. B. Gage.
Goldbeck, A. T.
Greenman, R. S.
Hubbard, Prévost (Secretary).
Jackson, F. H.

Johnson, Arthur N.
Mattimore, H. S.
Mickey, C. E.
Myers, J. E.
Page, Logan Waller (Chairman).
Pennsylvania State Highway Department,
  Joseph W. Hunter.
Reeve, C. S.
Sargent, Paul D.
Scofield, H. H.
Smith, F. P.
Thompson, S. E.

Producers (13).

Church, S. R.
Cobb, E. B.
Forrest, C. N.
Fulweiler, W. H.
Hemstreet, G. P.
Interocean Oil Co.,
  L. M. Law.
Kershaw, W. H.

McIntyre, W. A.
Miller, J. S., Jr.
Pullar, H. B.
Sharplyes, P. P.
Spencer, Herbert.
Warner-Quinlan Asphalt Co.,
  W. C. Monsell.

Sub-committees of Committee D-4.

Sub-committee I on Bituminous Road and Paving Materials.

Dow, A. W. (Chairman).
Blanchard, A. H.
Broadhurst, W. H.
Church, S. R.
Cobb, E. B.
Crosby, W. W.
Forrest, C. N.
Fulweiler, W. H.
Geological Survey of New Jersey,
  R. B. Gage.

Hemstreet, G. P.
Hubbard, Prévost.
Interocean Oil Co.,
  L. M. Law.
Kershaw, W. H.
Miller, J. S., Jr.
Myers, J. E.
Reeve, C. S.
Sharplyes, P. P.
Smith, F. P.
SUB-COMMITTEE II ON NON-BITUMINOUS ROAD AND PAVING MATERIALS.

Blanchard, A. H. (Chairman).
Agg, T. R.
Crosby, W. W.
Drowne, H. B.
Goldbeck, A. T.
Greenman, R. S.
Johnson, A. N.
Sargent, P. D.
Smith, F. P.
Thompson, S. E.

SUB-COMMITTEE III ON NOMENCLATURE OF BITUMINOUS MATERIALS.

Hubbard, Prévost (Chairman).
Blanchard, A. H.
Cobb, E. B.
Forrest, C. N.
Fulweiler, W. H.
Pulak, H. B.
Sharples, P. P.
Smith, F. P.

COMMITTEE D-5 ON COAL.

G. S. Pope, Chairman.

Non-Producers (20).
Brady, William.
Hume, A. P.
Hunnings, S. V.
Moldenke, Richard.
Parr, S. W.
Pope, G. S. (Chairman).
Randall, D. T.
United Gas Improvement Co., Walton Clark.
Voorhees, S. S.
White, Alfred H.
Woodwell, J. E.

Producers (9).
Adams, H. C.
Belden, A. W.
Blakeley, A. G.
Castner, Curran and Bullitt, Incorporated,
J. S. Burrows.
Fisher, Thomas.
Fleming, Henry S.
Haas, Frank R.
McCreath and Son, Andrew S.,
Andrew S. McCreath.
Wadleigh, F. R.

COMMITTEE D-6 ON COKE.

Richard Moldenke, Chairman.

A. C. Fieldner, Secretary.

Non-Producers (11).
Anaconda Copper Mining Co.,
E. P. Mathewson.
Blakeley, A. G.
Bole, William A.
Fackenthal, B. F., Jr.
Fieldner, A. C. (Secretary).

Haldeman, Horace L.
Hunnings, S. V.
Johnson, R. K.
Lynch, T. D.
Moldenke, Richard (Chairman).
Wood, Walter.
Standing Committees.

Committee D-6 (Continued).

Producers (5).
Belden, A. W.
Haas, Frank R.
Ireland, W. G.
McIlvain, E. M.
Wentz, Daniel B.

Committee D-7 on Timber.

Hermann von Schrenk, Chairman.
J. A. Newlin, Secretary.

Non-Producers (21).
Bateman, E.
Bebb, C. H.
Betts, H. S.
Bohland, J. A.
Bureau of Construction and Repair,
U. S. N.
Cincinnati Chapter, American Institute of Architects,
A. O. Elzner.
Davidson, G. M.
Hatt, W. K.
Hoxie, F. J.
Lohmann, H. W.
Newlin, J. A. (Secretary).
Rex, G. E.
Robinson, A. F.
Russell, E. J.
Schreiber, Martin.
Sterling, E. A.
Taylor, C. M.
Tillson, G. W.
Vanderpoel, W. K.
Von Schrenk, Hermann (Chairman).
Westinghouse Church Kerr and Co.,
Cloyd M. Chapman.

Producers (15).
Calder, R. J.
Church, S. R.
Fant, A. E.
Fulweiler, W. H.
Goss, O. P. M.
Holt, W. A.
Jayne, Howard.
Kaul, J. L.
Kellogg, R. S.
Kuehn, A. L.
Roper Lumber Co., John L.,
C. I. Millard.
Shipley, G. B.
Smith, P. R.
Southern Pine Association,
W. H. Sullivan.
Swan, O. T.

Sub-Committees of Committee D-7.

Sub-Committee I on Classification and Designation of Southern Yellow Pines.

Rex, G. E. (Chairman).
Hatt, W. K.
Holt, W. A.
Hoxie, F. J.
Kaul, J. L.
Lohmann, H. W.
Newlin, J. A.
Roper Lumber Co., John L.,
C. I. Millard.
Southern Pine Association,
W. H. Sullivan.

Sub-Committee II on Uses of Untreated Yellow Pines.

Sterling, E. A. (Chairman).
Betts, H. S.
Cincinnati Chapter, American Institute of Architects,
A. O. Elzner.
Jensen, J. N.
Roper Lumber Co., John L.,
C. I. Millard.
Russell, E. J.
Schreiber, Martin.
Standing Committees. 657

Committee D-7 (Continued).

Sub-Committee III on Pacific Coast Timbers.
Bebb, C. H.
Betts, H. S.
Bohland, J. A.
Goss, O. P. M.
Jayne, Howard.
Newlin, J. A.

Sub-Committee IV on Wooden Paving Blocks.
Tillson, G. W. (Chairman).
Shipley, G. B.
Smith, P. R.
Southern Pine Association,
W. H. Sullivan.
Swan, O. T.

Sub-Committee V on Methods of Preservative Treatment of Timber.
Robinson, A. F. (Chairman).
Kaul, J. L.
Kuehn, A. L.
Shipley, G. B.
Sterling, E. A.
Smith, P. R.
Vanderpool, W. K.

Sub-Committee VI on Timber Preservatives.
Church, S. R. (Chairman).
Bateman, E.
Davidson, G. M.
Fulweiler, W. H.
Hatt, W. K.
Kuehn, A. L.
Rex, G. E.
Taylor, C. M.
Westinghouse Church Kerr and Co.,
Cloyd M. Chapman.

Sub-Committee VII on Inspection of Treated Timber.
Taylor, C. M. (Chairman).
Calder, R. J.
Fant, A. E.
Robinson, A. F.

Sub-Committee VIII on Fireproofing of Timber.
Bateman, E. (Chairman).
Church, S. R.
Fulweiler, W. H.
Hoxie, F. J.
Swan, O. T.

Committee D-8 on Waterproofing.
W. A. Aiken, Chairman.
L. W. Walter, Vice-Chairman.
L. M. Law, Secretary.

Non-Producers (15).
Aiken, W. A. (Chairman).
Barbour, F. A.
Fitch, Roy O.
Force, H. J.
Gaines, R. H.
Gill, A. H.
Hubbard, P.
Little, Incorporated, A. D.,
H. S. Mork.
Munsell, A. W.
Reeve, C. S.
Schreiber, Martin.
Sherrerd, M. R.
Walter, L. W. (Vice-Chairman).
Welty, H. T.
Wig, R. J.
Standing Committees.

Committee D-8 (Continued).

Producers (11).

Abraham, H.
Barrett Co., The, W. S. Babcock.
S. R. Church.
DeKnight, E. W.
Ferguson, L. R.
Forrest, C. N.

Interocean Oil Co., L. M. Law (Secretary).
Kershaw, W. H.
Mackenzie, K. G.
Mastic Bond Co., S. G. Webb.
Spencer, Herbert.
Toch, Maximilian.

Sub-Committees of Committee D-8.

Sub-Committee I—Technical Committee.

Fitch, Roy O. (Chairman).
Abraham, Herbert.
Barrett Co., The, S. R. Church.
Forrest, C. N.
Gill, A. H.
Hubbard, P.

Interocean Oil Co., Leroy M. Law.
Little, Incorporated, A. D., H. S. Mork.
Mackenzie, K. G.
Reeve, C. S.

Committee D-9 on Electrical Insulation.¹

C. E. Skinner, Chairman.

Non-Producers (5).

Bureau of Standards,
P. G. Agnew.
Bureau of Steam Engineering, U. S. N., D. J. McAdam.
Commonwealth Edison Co.,
E. O. Schweitzer.

Electrical Testing Laboratories,
F. M. Farmer.
Western Electric Co.,
A. H. Vorum.

Producers (12).

American Vulcanized Fiber Co.,
William Eves, III.
Boonton Rubber Co.,
R. W. Seabury.
*General Electric Co.,
J. A. Capp,
L. E. Barringer.
Goodrich Co., B. F.,
A. A. Brewster.
Locke Insulator Manufacturing Co.,
The,
B. A. Plimpton.
Ohio Insulator Co., The,
A. O. Austin.

Rossi, Louis.
Schenectady Varnish Co.,
W. H. Wright.
Sherwin-Williams Co., The,
A. F. Roche.
Sterling Varnish Co., The,
J. H. Shugg.
Vacuum Oil Co.,
F. R. Baxter.
*Westinghouse Electric and Manufacturing Co.,
C. E. Skinner (Chairman).

¹The numeric preponderance of the producer element of this committee is inconsistent with the regulations of the Society. This matter is now in course of adjustment.

*These members of Committee D-9, classed as Producers, stand in the relation of Producer to certain products, and in that of Non-Producer to other products within the province of the Committee.
Standing Committees.

Committee D-9 (Continued).

Sub-committees of Committee D-9.

Sub-committee I on Insulating Varnishes.

- Electrical Testing Laboratories, F. M. Farmer (Chairman).
- Schenectady Varnish Co., W. H. Wright.

Sub-committee II on Molded Insulated Materials.

- Boonton Rubber Co., R. W. Seabury (Chairman).
- General Electric Co., L. E. Barringer.
- Goodrich Co., B. F., A. A. Brewster.
- Rossi, L. M.
- Western Electric Co., A. H. Vorum.

Sub-committee III on Sheet Insulation.

- Westinghouse Electric and Manufacturing Co., C. E. Skinner (Chairman).
- American Vulcanized Fiber Co., William Eves, III.
- Commonwealth Edison Co., E. O. Schweitzer.
- Western Electric Co., A. H. Vorum.

Sub-committee IV on Liquid Insulation.

- Bureau of Standards, P. G. Agnew (Chairman).
- Vacuum Oil Co., F. R. Baxter.

Sub-committee V on Porcelain Insulation.

- General Electric Co., L. E. Barringer (Chairman).
- Commonwealth Edison Co., E. O. Schweitzer.
- Ohio Insulator Co., A. O. Austin.
Standing Committees.

Committee D-10 on Shipping Containers.

B. W. Dunn, Chairman.
W. S. Topping, Secretary.

Non-Producers (19).

Carleton, G. E.
Chamberlin, C. D.
Dunn, B. W. (Chairman).
Fairburn, W. A.
Hayner Distilling Co.,
W. S. Kidder.
Heckel, G. B.
Hodges, George.
Independent Petroleum Marketers' Association of the U. S.,
W. C. Platt.
Lucas and Co., John,
F. L. Campbell.
MacFarland, H. B.
Manufacturing Chemists' Association of the U. S.,
Henry Howard.
Nellis, J. C.
Newlin, J. A.
Powe, W. R.
Stone, G. C.
Sturcke, H. E.
Swan, O. T.
Topping, W. S. (Secretary).
Uniform Classification Committee,
J. E. Williams.

Producers (10).

Babcock, G. C.
Hinde and Dauch Paper Co., The,
J. J. Dauch.
Institute of Makers of Explosives,
T. W. Bacchus.
Masters, B. F.
National Tube Co.,
F. N. Speller.
Ohio Boxboard Co., The,
T. W. Ross.
Pressed Steel Tank Co.,
R. H. Hackney.
Sexton, W. D.
Wellford, W. L.
Yegge, C. F.

Committee D-11 on Rubber Products.

E. A. Barrier, Chairman.
F. M. Waring, Secretary.

Non-Producers (19).

Bureau of Construction and Repair,
U. S. N.
Bureau of Steam Engineering, U. S. N.,
Electrical Division.
Dannerth, Frederic.
Electrical Testing Laboratories,
F. M. Farmer.
Force, H. J.
Inspection Department, Associated Factory Mutual Fire Insurance Co.,
E. A. Barrier (Chairman).
Lesser, W. H.
MacFarland, H. B.
Newcomb, R. E.
New York Central Railroad Co.,
C. B. Martin.
Onderdonk, J. R.
Potts, S. C.
Skinner, C. E.
Testing Laboratory, City of St. Louis,
Norman Chivvis.
Turner Co., J. S.,
C. S. Cook.
Waring, F. M. (Secretary).
Wormeley, P. L.
Young, C. D.
Young, J. B.
STANDING COMMITTEES.

COMMITTEE D-11 (Continued).

Producers (11).

Bierer, J. M.
Boggs, C. R.
Dunlop Tire and Rubber Goods Co., Limited,
D. E. Beynon.
Ellinwood, G. H.
Gage, R. M.
General Electric Co.,
W. S. Clark.
Goodrich Co., B. F.,
N. S. Noble.

Gutta Percha and Rubber Manufacturing Co.,
W. E. Campbell.
Hodgman Rubber Co.,
G. B. Hodgman.
Manhattan Rubber Manufacturing Co.,
H. S. Doty.
Whipple, Dorris.

SUB-COMMITTEES OF COMMITTEE D-11.

ADVISORY COMMITTEE.

Inspection Department, Associated Factory Mutual Fire Insurance Co.,
E. A. Barrier, Chairman.
Bierer, J. M.
Dannerth, Frederic.
Gutta Percha and Rubber Manufacturing Co.,
W. E. Campbell.

New York Central Railroad Co.,
C. B. Martin.
Newcomb, R. E.
Waring, F. M.
Young, C. D.
Young, J. B.

SUB-COMMITTEE I ON AIR HOSE.

New York Central Railroad Co.,
C. B. Martin (Chairman).
Gutta Percha and Rubber Manufacturing Co.,
W. E. Campbell.

Goodrich Co., B. F.,
N. S. Noble.
Onderdonk, J. R.
Young, C. D.

SUB-COMMITTEE II ON BELTING.

Gutta Percha and Rubber Manufacturing Co.,
W. E. Campbell (Chairman).
Bierer, J. M.
Dannerth, F.

Goodrich Co., B. F.,
N. S. Noble.
New York Central Railroad Co.,
C. B. Martin.
Onderdonk, J. R.
Potts, S. C.

SUB-COMMITTEE III ON COLD-WATER HOSE.

Inspection Department, Associated Factory Mutual Fire Insurance Co.,
E. A. Barrier (Chairman).

Bierer, J. M.
Bureau of Construction and Repair,
U. S. N.
Campbell, W. E.
COMMITTEE D-11 (Continued).

SUB-COMMITTEE IV.—(Discontinued).

SUB-COMMITTEE V ON INSULATED WIRE.

Young, C. D. (Chairman).
Boggs, C. R.
Bureau of Steam Engineering, U. S. N.,
Electrical Division.
Electrical Testing Laboratories,
F. M. Farmer.

General Electric Co.,
W. S. Clark.
Skinner, C. E.
Whipple, Dorris.

SUB-COMMITTEE VI ON PACKINGS, GASKETS AND PUMP VALVES.

Newcomb, R. E. (Chairman).
Bureau of Construction and Repair,
U. S. N.
Inspection Department, Associated
Factory Mutual Fire Insurance Co.,
E. A. Barrier.

Manhattan Rubber Manufacturing Co.,
H. S. Doty.
Potts, S. C.
Testing Laboratory, City of St. Louis,
Norman Chivvis.

SUB-COMMITTEE VII ON STEAM HOSE.

Young, J. B. (Chairman).
Goodrich Co., B. F.,
N. S. Noble.

Onderdonk, J. R.
Young, C. D.

SUB-COMMITTEE VIII ON DEFINITIONS AND NOMENCLATURE.

Dannerth, Frederic (Chairman).
Bierer, J. M.
Gage, R. M.

Hodgman Rubber Co.,
G. B. Hodgman.
Turner Co., J. S.,
C. S. Cook.

SUB-COMMITTEE IX ON RUBBER INSULATING TAPE.

Bierer, J. M. (Chairman).
Boggs, C. R.
Electrical Testing Laboratories,
F. M. Farmer.

Waring, F. M.
Whipple, D.

COMMITTEE D-12 ON

COMMITTEE D-13 ON TEXTILE MATERIALS.

W. D. HARTSHORNE, Chairman.
D. E. DOUTY, Secretary.

NON-PRODUCERS (21).

Abrams, D. A.
Atlas Portland Cement Co.,
T. A. Hicks.
Barker, E. H.

Bureau of Standards,
W. S. Lewis.
Daniels, F. W.
Douty, D. E. (Secretary).
Standing Committees.

Committee D-13 (Continued).

Non-Producers (Continued).

Firestone Tire and Rubber Co.,
J. W. Cooper.
Gage, R. M.
Goodyear Tire and Rubber Co.,
P. W. Litchfield.
T. Wood.
Hartshorne, W. D. (Chairman).
Lee Tire and Rubber Co.,
E. E. Dearth.
Little, Incorporated, A. D.,
C. E. Swett.
Marble, E. H.
Miller Rubber Co.,
A. E. Warner,
R. T. Griffith.

Racine Rubber Co.,
L. T. Vance.
Republic Rubber Co.,
N. W. Sayles.
Scott and Co., H. L.,
Henry L. Scott.
Tidewater Portland Cement Co.,
W. B. Welch.
United and Globe Rubber Manufacturing Co.,
G. W. Skrim.
United States Rubber Co.,
A. A. Sommerville.
Willard, F. W.

Producers (12).

Beaver Mills,
C. M. Sears.
Bemis Brothers Bag Co.,
A. H. Clarke.
Brighton Mills,
H. V. R. Scheel.
Dallis, Roy.
Eagles, R. P. M.
Jaquith, Horace.

Jenckes Spinning Co.,
H. P. Babcock.
Lane and Co., J. H.,
C. B. Finckel.
Manhasset Manufacturing Co.,
R. A. Ballon.
Rutledge, J. T.
Turner, Spencer.
Turner Co., J. S.,
C. S. Cook.

E. MISCELLANEOUS SUBJECTS.

Committee E-1 on Methods of Testing.

Gaetano Lanza, Chairman.

Abbott, R. R.
Baldwin Locomotive Works,
H. V. Wille.
Boylston, H. M.
Bureau of Steam Engineering, U. S. N.,
Naval Engineering Experiment Station, Annapolis,
Md., Inspection Division.
Cambria Steel Co.,
G. E. Thackray.
Campbell, William.
Carnegie Steel Co.,
H. P. Tiemann.
Deans, John S.
Devries, R. P.
Diller, H. E.
Douty, D. E.
Hatt, W. K.
Howard, J. E.

Howe, Henry M.
Hume, A. P.
Humphrey, Richard L.
Hunnings, S. V.
Job, Robert.
Lanza, Gaetano (Chairman).
Linder, O.
Lothrop, M. T.
Lynch, T. D.
Maegregor, J. S.
Merriman, Mansfield.
Moldenke, Richard.
Moore, H. F.
Nelson, E. D.
Standard Steel Works Co.,
A. A. Stevenson.
Stoughton, Bradley.
Zimmerschied, K. W.
STANDING COMMITTEES.

COMMITTEE E-1 (Continued).

SUB-COMMITTEES OF COMMITTEE E-1.

SUB-COMMITTEE I ON HARDNESS TESTS.

Devries, R. P. (Chairman).
Abbott, R. R.
Boylston, H. M.
Douty, D. E.

Lothrop, M. T.
Macgregor, J. S.
Stoughton, Bradley.

COMMITTEE E-2 ON ELECTRICAL STANDARDS.

C. E. Skinner, Chairman.

Burrows, C. W.
Capp, J. A.

Skinner, C. E. (Chairman).

COMMITTEE E-3 ON REVISION OF PIPE THREADS.

Forming part of a Joint Committee on this subject with committees of the following societies:

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

J. C. Bannister.

S. G. Flagg, Jr.

MANUFACTURERS’ ASSOCIATION ON STANDARDIZATION OF FITTINGS.

A. M. Houser.

C. A. Olsen.

MASTER CAR BUILDERS’ ASSOCIATION.

J. J. Burch.

F. Zeleny.

RAILWAY SIGNAL ASSOCIATION.

C. C. Anthony.

J. C. Mock.

F. P. Patenall.

H. V. Wille, Chairman.
E. W. Smith, Secretary.

NON-PRODUCERS (7).

Bureau of Standards.
Cromwell, O. C.
Kendig, R. B.,
E. Smith.
Tilt, E. B.

Wallis, J. T.,
E. W. Smith (Secretary).
Wille, H. V. (Chairman).
Zeleny, F.

PRODUCERS (3).

Beale, H. A.
National Tube Co.,
F. N. Speller.

Reading Iron Co.,
George Schuhmann.

SUB-COMMITTEES OF COMMITTEE E-3.

SUB-COMMITTEE I ON LABORATORY AND SERVICE TESTS.

Wallis, J. T.,
E. W. Smith (Chairman).

National Tube Co.,
F. N. Speller.

Patenall, F. P.
Committee E-5 on Standing Committees.

This Committee consists of the Chairmen of all Standing Committees, or Representatives designated by the respective Chairmen. The Duties of this Committee are the Formulation of (a) Regulations Governing Standing Committees; (b) Regulations Governing the Form but not the Substance of Standards, and (c) The Classification on Standards.

Edgar Marburg, Chairman (ex-officio).

C. E. Skinner, Vice-Chairman.

Representing Committee.

A-1 C. D. Young.
A-2 S. V. Hunnings.
A-3 Richard Moldenke.
A-4 Albert Sauveur.
A-5 S. S. Voorhees.
A-6 C. W. Burrows.
B-1 J. A. Capp.
B-2 T. D. Lynch.
C-1 R. S. Greenman.
C-2
C-3 T. R. Lawson.
C-4 Rudolph Hering.
C-5 I. H. Woolson.
C-6 A. Marston.
C-7 J. S. Maegregor.
C-8 A. V. Bleininger.
C-9 S. E. Thompson.
C-10 L. H. Provine.

Representing Committee.

C-11 R. J. Wig.
D-1 P. H. Walker.
D-2 C. P. Van Gundy.
D-3 S. W. Parr.
D-4 L. W. Page.
D-5 G. S. Pope.
D-6 R. Moldenke.
D-7 H. von Schrenk.
D-8 W. A. Aiken.
D-9 C. E. Skinner (Vice-Chairman).
D-10 B. W. Dunn.
D-11 E. A. Barrier.
D-13 W. D. Hartshorne.
E-1 G. Lanza.
E-2 C. E. Skinner.
E-3 H. V. Wille.
E-6 Edgar Marburg (Chairman).

Advisory Committee.

Marburg, Edgar (Chairman).
Burrows, C. W.
Capp, J. A.
Greenman, R. S.

Hunnings, S. V.
Skinner, C. E.
Young, C. D.

Committee E-6 on Papers and Publications.

Edgar Marburg, Chairman (ex-officio).

Berry, H. C.
Clamer, G. H.
Humphrey, Richard L.
Marburg, Edgar (Chairman).
Moldenke, Richard.

Page, L. W.
Stevenson, A. A.
Talbot, A. N.
Voorhees, S. S.

Advisory Committee.

Marburg, Edgar (Chairman).
Berry, H. C.
Clamer, G. H.

Humphrey, Richard L.
Stevenson, A. A.
REGULATIONS GOVERNING STANDING COMMITTEES.

Note.—By action of the Executive Committee on January 6, 1912, the responsibility for the general Regulations Governing Standing Committees is vested in the Executive Committee and Committee E-5 on Standing Committees, with the understanding (1) that a proposed change in these Regulations originating with Committee E-5 shall be subject to approval by the Executive Committee of the Society; (2) that the Executive Committee of the Society shall make no changes in these Regulations without first referring the same to Committee E-5; and (3) that proposed changes in these Regulations thus adopted shall be announced in the next circular to members and become effective from the date of issue of that circular.

Creation.—The creation of a standing committee shall be subject to the authorization of the Executive Committee, acting either on a recommendation adopted by majority vote at an annual meeting of the Society, or on its own initiative.

Appointments.—Appointments on standing committees shall be made by the Executive Committee subject to the following provisions:

1. On committees dealing with subjects having a commercial bearing, either an equal numeric balance shall be maintained between the representatives of producing and non-producing interests; or the latter may be allowed to predominate with the acquiescence of the former.

2. The classification of the members of a committee into producers and non-producers shall be left to each committee, subject to the following provisions, and with the understanding that a member dissatisfied with this classification has the right of appeal to the Executive Committee:

   (a) A member who stands in the relation of producer to any product within the province of the committee shall be classed as a producer, although at the request of the officers of the committee concerned, attention shall be called to the status of such members in a footnote worded as follows:

   (666)
These members of Committee, classed as Producers, stand in the relation of Producers to certain products, and in that of Non-Producers to other products within the province of the committee.

(b) A nominally unattached expert, who is permanently retained by producing interests in the field of activities of the committee with which he is connected, shall be classed as a producer. The qualification "permanently retained" is to be understood to mean that the expert receives a regular monthly or yearly retainer from one or more producing interests under an indefinitely continuing arrangement.

3. As a general policy, only one representative from a given firm, company, corporation, laboratory, or other institution shall be eligible to independent membership on a given committee, although exceptions to this rule may be permitted at the discretion of the committee concerned. If the membership on the committee is held in the name of a firm, company, corporation, laboratory, or other institution, more than one representative may, at the discretion of the committee concerned, participate in its activities, with the understanding that such representatives shall jointly command only a single vote.

4. Additional appointments on existing committees shall be made only on the recommendation of, or with the approval of, such committees.

5. Only members of the Society shall be eligible, in general, to appointment on committees, although exceptions may be authorized by the Executive Committee in favor of representatives of government branches or other societies.

Preliminary Organization.—The President of the Society will appoint the chairman pro tem. of a new committee from the representatives of the non-producing interests. The chairman pro tem., after communicating with the other members of the committee, will fix the place and time of the first meeting. He may, at his discretion, appoint one or more members of the committee to prepare matter in advance for consideration at that meeting or he may prepare such matter himself. This procedure is recommended as calculated to economize time at the meeting and to afford a definite basis for discussion.
Permanent Organization.—At the first meeting of a committee a permanent organization shall be effected by the election of a permanent chairman from among the representatives of non-producing interests, and such other officers and sub-committees as the committee may desire. The duties and powers assigned to these officers and sub-committees, and the details of management and administration in general, shall be at the discretion of each committee, subject to the limitations of these regulations.

The meetings of committees and sub-committees shall be open only to their own members and to such visitors whose proposed invitation has been approved by the chairman.

Election of Officers.—Every standing committee shall hold an election of officers at or before the annual meeting of the Society occurring in the even years. The term of office of every officer shall be two years and officers shall be eligible for re-election.

Resignations.—Proposed resignations from office or from membership on a standing committee shall be reported directly to the chairman or the secretary of the committee concerned, and the result of any action taken in such matters shall be reported to the Secretary-Treasurer of the Society.

Proxies.—A member of a standing committee shall be authorized to delegate any desired individual as his proxy with voting power, or without voting power, if so specified; but no individual shall have more than one vote at a meeting of a committee.

Sub-Committees.—Sub-committees shall have no standing in the Society except through their parent committees. Sub-committees on proposed complete standard specifications for materials shall consist of not fewer than six members, and at least one-half of the membership shall be composed of non-producers. Departures from this requirement for exceptional reasons may be authorized by the Executive Committee.

Reports.—The reports of standing committees shall be presented at the annual meetings. The report of every sub-committee shall be made to the parent committee and not to the Society direct. If such a report is embodied wholly or in part in the report of the parent committee to the Society, the latter shall make definite references to such features in its own report and recommendations, if any, based thereon.

The report of a standing committee, before its presentation at the annual meeting, must first have been submitted to letter
ballot of the committee and must have received the approval of the majority of those voting.

A statement of the following form shall appear at the close of every committee report:

This report has been submitted to letter ballot of the committee which consists of ....... members, of whom ....... have voted affirmatively, ....... negatively, and ....... have refrained from voting.

Dissenting members shall have the right to present minority reports individually or jointly.

Standards.—The term “Standards” shall be applied collectively to (a) standard specifications, (b) standard tests, (c) standard methods, and (d) standard definitions.

The term “Standard Specifications” shall be applied to specifications designed to govern the purchase of materials. Such specifications may or may not include reference to tests, but they shall include limits for physical, chemical or other properties.

The term “Standard Tests” shall be applied to prescribed directions for tests of specific materials, but shall not include limits for physical, chemical or other properties.

The term “Standard Methods” shall be applied to prescribed methods of procedure in the conduct of physical, chemical or other tests.

The term “Standard Definitions” is self-explanatory.

In the preparation of proposed standards the consideration of matters of engineering design or construction shall not in general be regarded as falling within the province of the Society. If, however, it should appear to a given committee that the consideration of such matters is, for special reasons, indispensable in specifications designed to cover the customary relations between the producers and consumers of a given product, then reference to such matter in proposed specifications for that product shall be permitted within the scope necessary for the particular purpose above stated. Proposed standards embodying features of the character in question shall be submitted by the committee concerned to the Executive Committee for consideration and comment not later than the quarterly meeting immediately preceding the annual meeting at which the proposed standards are to be presented.

Proposed new standards or the proposed amendment of existing standards must originate in the particular committee within whose province such standards properly belong. No action affecting standards shall be taken by any standing com-
mittee except at meetings called for that purpose. Action at such meetings shall be subject to majority vote of those voting, and subsequently to majority vote of those voting on letter ballot of the entire committee. The results of each letter ballot as to the number of affirmative votes, the number of negative votes, and the number of members not voting, shall be announced in the report of the committee to the Society. Dissenting members shall have the right to present minority reports, individually or jointly, at the annual meeting of the Society at which the majority report is presented.

Any recommendations affecting standards must be transmitted to the Secretary-Treasurer of the Society at least eight weeks in advance of the date of the annual meeting, and copies of these recommendations, in printed form, must be mailed by the Secretary-Treasurer to every member of the Society not less than four weeks before the annual meeting, so that members may come to the meeting prepared to discuss such recommendations, and that members not intending to be present at the meeting may contribute discussions by letter.

Any recommendations affecting standards presented by the appropriate committees at the annual meeting of the Society will be subject to the following provisions in Article VI of the by-laws:

ARTICLE VI.

PROCEDURE GOVERNING THE ADOPTION OF STANDARDS.

The term "Standards" shall be applied collectively to standard specifications, standard tests, standard methods, and standard definitions.

Proposed new standards or proposed amendments of existing standards shall be presented at the Annual Meeting. At this meeting amendments may be made by a two-thirds vote of those voting. The proposed new standards or the proposed amendments of existing standards, as presented or as amended, shall be printed, on two-thirds vote of those voting, in the Proceedings under a section designated "Tentative Standards," on which written discussions addressed to the appropriate committee shall be invited. If introduced in an even year such tentative standards shall be published for two years, and if introduced in an odd year they shall be published for one year. At the Annual Meeting in the next even year following their introduction, such tentative standards shall be subject to amendment by a two-thirds vote of those voting, and to reference by a like vote to letter ballot of the
Society. A two-thirds vote of those voting shall be required for adoption.

The above requirement by which final action on proposed new standards or proposed amendments of existing standards shall be deferred for one or two years may, for exceptional reasons, be waived by a nine-tenths vote of those voting at the Annual Meeting at which they are first presented. In that case the above prescribed vote as to amendments, as to reference to letter ballot, and as to adoption shall remain unaffected.

The term "Recommended Practice" shall be applied to processes and methods not ordinarily subject to contract between purchaser and manufacturer. The above requirements governing action on new standards or proposed amendments of existing standards shall be applicable also to proposed Recommended Practice.

SEC. 2.—Reports, resolutions and recommendations pertaining to or involving the use, or proposed use, in a standard or tentative standard, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Society only with the approval of the Executive Committee.

Cooperation with Other Committees.—A committee may, at its discretion, invite the cooperation of committees of other societies on like or cognate subjects, provided such relations shall entail no obligations at variance with these regulations, and shall impose no restrictions upon the free and independent action of the committee.

A committee desiring to bring about the appointment of similar committees by other societies for purposes of cooperation shall address a recommendation to that effect to the Executive Committee and, on the approval of the latter, negotiations to the desired end shall be conducted on behalf of the Executive Committee by the Secretary-Treasurer of the Society.

Publication.—Committees shall have no right to issue matter for publication through other than the regular Society channels, unless so authorized, for exceptional reasons, by the Executive Committee.

Current Expenses.—Expenses for postage incurred in connection with the business of committees will be refunded by the Secretary-Treasurer of the Society on vouchers approved by the chairman of these committees.
Stationery.—Correspondence relating to the business of committees or sub-committees shall be conducted on official stationery which will be furnished by the Secretary-Treasurer of the Society.

Extraordinary Expenses.—Expenses for items other than postage will not be assumed by the Society, unless such expenditures were incurred in pursuance of previous authorization of the Executive Committee, on recommendation of the chairman of the committee concerned, and within amounts specifically fixed by the Executive Committee.

Special Funds.—Committees engaged on subjects having a commercial bearing shall be authorized to solicit contributions from manufacturers towards research funds. Contributions from consumers to funds for this and other purposes shall be solicited only by the Executive Committee. All funds thus collected shall be transmitted to the Secretary-Treasurer of the Society and deposited by him in bank and placed to the credit of the committees on the books of the Society, subject to disbursement only on vouchers signed by the chairman of the committee concerned.

Salaries and Fees.—Committees shall not be authorized to pay salaries or professional fees in any form to any of their officers or members. Assistants in connection with research work may be engaged at salaries or special compensation fixed by the committees concerned, provided that funds for such salaries or compensations shall previously have been deposited with the Secretary-Treasurer of the Society. Payments for such purposes shall be made by the Secretary-Treasurer of the Society only on vouchers approved by the chairman of the committee concerned.

Discharge of Committees.—Standing committees may be discharged by the Executive Committee, either at their own request or with their consent, on the completion of the work for which they were appointed or in consequence of protracted inactivity. A standing committee which fails to present a report at three successive annual meetings of the Society will be required to show cause, in a written communication to the Executive Committee, why it should not be discharged.

Standing committees may be discharged for cause by the Executive Committee at its own initiative.

American Representation on Committees of the International Association for Testing Materials.

Nominations.—In making nominations for appointment of American members on International committees on a subject,
falling within the province of an American standing committee, the sense of the latter committee as to the selection of the nominee shall be obtained before final action on the part of the Executive Committee.

Relation between American Representatives on International Committees and American Committees on the same Subjects.—The American representative or representatives on an International committee dealing with subjects falling within the province of an American standing committee shall keep that committee fully advised as to the important developments in the work of the International committee. Formal recommendations to the International committee on the part of such representative or representatives, and their vote on letter ballot of that committee, shall be subject to advance approval on the part of the American committee.

Recommendations to Standing Committees.

The following recommendations to standing committees have been approved by the Executive Committee and Committee E-5:

It is recommended that the various standing committees should formulate proposed standard definitions of terms in matters falling in their respective fields, and that in the case of terms which come within the province of two or more committees, such definitions be formulated by joint action, through sub-committees, on the part of the committees concerned. Such proposed standard definitions of terms will be subject to adoption by the Society under the provisions of the by-laws and the Regulations Governing Standing Committees.

An alphabetic glossary of standard definitions of terms will be published in the A. S. T. M. Book of Standards as soon as their number appears to warrant such action.


The basis on which various government branches may cooperate with the committees of this Society are indicated in the A. S. T. M. Book of Standards for 1916. Any committee desiring to establish such cooperative relations shall address a recommendation to that effect to the Executive Committee, and on approval of the latter, negotiations to the desired end shall be conducted by the Secretary-Treasurer of the Society.
REGULATIONS GOVERNING COMMITTEE A-1 ON STEEL.

SUPPLEMENTARY TO REGULATIONS GOVERNING STANDING COMMITTEES.

ARTICLE I.

SECTION 1. These Regulations are supplementary to the "Regulations Governing Standing Committees."

ARTICLE II.

ADVISORY MEMBERS.

SECTION 1. Advisory Members are experts whose advice and cooperation are desired, but who can not or do not wish to become Members of the Committee. They shall be appointed by the Chairman of the Committee upon the request of the chairman of any sub-committee.

SEC. 2. Advisory Members need not be members of the Society. Their names shall not appear in the list of members of Standing Committees printed in the Membership pamphlet or the volume of A.S.T.M. Standards of the Society, but shall be kept on the rolls of the Secretary of the Committee and the chairmen of the sub-committees on which they hold membership. They shall be entitled to a vote on such sub-committees, but shall not be entitled to a vote on the Committee.

SEC. 3. Acknowledgment of the assistance rendered by Advisory Members shall be made in the annual report of the Committee.

ARTICLE III.

OFFICERS AND THEIR ELECTION.

SECTION 1. The executive direction of Committee A-1 shall be vested in an Advisory Committee, which shall consist
Regulations Governing Committee A-1.

of the Secretary-Treasurer of the Society, *ex officio*, the officers of the Committee, the chairmen of the sub-committees, and any member of the Committee not otherwise eligible serving on at least five sub-committees.

Sec. 2. The officers of Committee A-1 shall be a Chairman, two Vice-Chairmen, and a Secretary.

Sec. 3. (a) Any member of the Committee shall be eligible for office; except that the Chairman shall be elected from the representatives of non-producing interests, as provided in the "Regulations Governing Standing Committees."

(b) One Vice-Chairman shall be elected from the representatives of non-producing interests, and the other Vice-Chairman from the representatives of producing interests.

Sec. 4. The term of office shall be two years; and officers shall be eligible for re-election.

Sec. 5. The officers shall be elected at a meeting of the Committee held at the time of the Annual Meeting of the Society in the even-numbered years.

Sec. 6. (a) A Committee on Nomination of Officers, composed of the chairmen of all existing sub-committees and under the chairmanship of one of its members to be designated by the Chairman of Committee A-1, shall organize immediately following the April meeting of Committee A-1 in the even-numbered years, and shall nominate to Committee A-1, at the time of the meeting for election, one member for Chairman, two members for Vice-Chairmen, and one member for Secretary. Any member of the Committee on Nominations shall be eligible for office.

(b) Other nominations may be made on the floor of the meeting.

Article IV.

Meetings.

Section 1. Committee Meetings.—Regular meetings of Committee A-1 shall be held in Philadelphia, on the first Friday of October, the second Friday of January, the first Friday of April, and at the Annual Meeting of the Society prior to the presentation of the annual report of the Committee.

Sec. 2. Sub-Committee Meetings.—(a) Regular meetings of sub-committees shall be held immediately preceding the dates
of the regular meetings of the Committee. Special meetings of sub-committees may be held in the first week of any month on two weeks' notice from the chairman of the sub-committee.

(b) When the chairman of a sub-committee desires to call a meeting of his sub-committee, he shall so notify the Secretary, stating the probable time required for the meeting and his preference as to date and hour. The Secretary shall prepare a schedule of sub-committee meetings with a view of avoiding conflicts, and this schedule shall be printed in the circular letter announcing the meeting of the Committee.

ARTICLE V.
ATTENDANCE AT MEETINGS.

SECTION 1. Committee Meetings.—The Secretary of the Committee shall keep a roll of the members of the Committee and shall record at each meeting of the Committee the members in attendance. If a member, or his authorized representative, is absent from two consecutive meetings, without notice to the Secretary assigning reasons for the same, the Secretary shall notify the member that unless he advises that he wishes to continue as a member of the Committee, with assurance that he will in the future be in position to attend the meetings of the Committee or otherwise to take an active part in its work, his name will be dropped from the roll of membership. Such notices shall be sent out by the Secretary only on the approval of the Chairman of the Committee.

SEC. 2. Sub-Committee Meetings.—The chairman of each sub-committee shall keep a roll of the members of the sub-committee, and shall record at each meeting of the sub-committee the members in attendance. If a member, or his authorized representative, is absent from two consecutive meetings of the sub-committee without notice to the chairman of the sub-committee assigning reasons for the same, the chairman shall notify the Secretary of the Committee. The Secretary shall then notify the member that unless he advises that he wishes to continue as a member of the sub-committee, with assurance that he will in future be in position to attend the meetings of the sub-committee or otherwise to take an active part in its work, his name will be dropped from the roll of
membership of the sub-committee. Such notices shall be sent out by the Secretary only on the approval of the Chairman of the Committee.

**Article VI.**

**Sub-committees.**

**Section 1.** The chairman of a sub-committee shall have authority to appoint, at his discretion, a vice-chairman, a secretary and sub-committees of the sub-committee, and to plan and direct the work of the sub-committee.

**Sec. 2.** (a) All specifications for any given product shall be drafted by the sub-committee in charge of specifications for that product.

(b) Any sub-committee considering the drafting of specifications for a general class of material (e. g., steel for bridges, ships, etc.) involving a special class of material (e. g., castings), specifications for which are in the charge of another sub-committee, shall consult with that sub-committee with the object of having the specifications for that special class of material expanded if they are not sufficiently general to cover the proposed new requirements.

(c) Sub-committees in charge of specifications for given products shall cooperate, whenever necessary, with other sub-committees, with the object of having the specifications for given products such that they may be included in any other specification involving such products, either by full quotation, or merely by reference to the specifications covering such products individually.

**Sec. 3.** The Sub-Committee on Literary Form shall submit all proposed changes in the form of specifications, or such other changes as it may desire to recommend, to the proper sub-committee for their consideration before presentation to the Committee.

**Sec. 4.** The chairman of each sub-committee shall submit to the Committee at each regular meeting a report of the progress of the work assigned to that sub-committee. Such report shall be made by the chairman in person, and a copy filed with the Secretary; except when the chairman is absent
from a meeting, in which case the report of the sub-committee shall be made by some member of the sub-committee designated by the chairman of the sub-committee in writing to the Secretary, which member shall be in position to explain all items contained in the said report. Record of failure to submit such reports shall be entered in the minutes of each meeting.

Sec. 5. If a sub-committee fails to present a report through its chairman, or as otherwise provided in Section 4, at two consecutive meetings of the Committee, the Secretary shall notify the chairman and the members of the sub-committee that they shall show cause to the Advisory Committee why the sub-committee should not be reorganized or discharged. Such notices shall be sent out by the Secretary only on the approval of the Chairman of the Committee.

Sec. 6. The chairman of any sub-committee, or some officer of the same, after the completion of a subject referred to the sub-committee, shall transmit all correspondence filed on that subject to the Secretary of the Committee.

Article VII.

Letter Ballots.

Section I. As required by the Regulations Governing Standing Committees, the Secretary shall submit to letter ballot of the Committee (1) any recommendations affecting standards which have been approved by majority vote of those voting at a meeting of the Committee, and (2) the report of the Committee to the Society. Each ballot shall be provided with three columns entitled respectively "Affirmative," "Negative" and "Not Voting."

Sec. 2. The failure of any member of the Committee to mark such ballot and return it to the Secretary shall be construed as showing a lack of interest on the part of the member in the work of the Committee; in which case the Secretary, on the approval of the Chairman of the Committee, shall notify the member of his failure to comply with this regulation and shall ascertain whether he desires to continue as a member of the Committee.
REGULATIONS GOVERNING COMMITTEE C-1
ON
CEMENT.

SUPPLEMENTARY TO
REGULATIONS GOVERNING STANDING COMMITTEES.

ARTICLE I.
OFFICERS AND THEIR ELECTION.

SECTION 1. The officers of Committee C-1 shall be the Chairman, two Vice-Chairmen and a Secretary, all of whom, except one Vice-Chairman, shall represent non-producing interests.

Sec. 2. The terms of office shall be for two years; and officers shall be eligible for re-election.

ARTICLE II.
DUTIES OF OFFICERS.

SECTION 1. The Executive Direction of the Committee shall be vested in an Advisory Committee which shall consist of the officers of the Committee and the chairmen of its various sub-committees.

Sec. 2. Sub-committees proposed by the Committee shall be appointed by the Advisory Committee, subject to final ratification by the Committee, unless otherwise specified.

Sec. 3. The Chairman shall preside at all meetings of the Committee and be an ex-officio member of all sub-committees.

Sec. 4. In the absence of the Chairman, the Vice-Chairmen, in the order of their seniority, shall perform all the duties of the Chairman.

Sec. 5. The Secretary shall attend all meetings of the Committee and keep the minutes thereof. He shall conduct the correspondence and receive all communications addressed
to the Committee. He shall issue notices of all meetings and promptly inform sub-committees of their appointment and duties. He shall keep a complete list of members with their addresses, and a memorandum of the expenses of the Committee, and shall perform such other duties as may be imposed upon him.

**Article III.**

**Meetings.**

**Section 1.** Regular meetings of the Committee shall be held in the months of October, January, April and during the Annual Meeting of the Society, prior to the presentation of the annual report of the Committee, the time and place to be fixed by the Chairman.

**Sec. 2.** Special meetings may be called at the option of the Chairman or at the request of at least five members.

**Sec. 3.** Five members shall constitute a quorum.

**Sec. 4.** The Secretary shall keep a roll of the members of the Committee and shall record at each meeting the members in attendance. If a member or his authorized representative is absent from two consecutive meetings, without notice to the Secretary assigning reasons for the same, the Secretary shall notify the member that unless he advises that he wishes to continue as a member of the Committee with assurance that he will in the future be in a position to take an active interest in the work of the Committee and attend its meetings, his name will be dropped from the roll of membership. Such notices shall be sent out by the Secretary only on approval of the Chairman of the Committee.

**Article IV.**

**Amendments.**

**Section 1.** All amendments shall be adopted by letter ballot.
REGULATIONS GOVERNING COMMITTEE C-11
ON
GYPSUM AND GYPSUM PRODUCTS.

SUPPLEMENTARY TO
REGULATIONS GOVERNING STANDING COMMITTEES.

ARTICLE I.
REGULATIONS.

SECTION 1. These regulations are supplementary to the "Regulations Governing Standing Committees."

ARTICLE II.
MEMBERSHIP.

SECTION 1. The membership of Committee C-11 shall consist of those originally appointed and subsequently approved by the Executive Committee of the Society.

SEC. 2. Additional appointments to membership in this Committee shall be approved by two-thirds of the members of the Committee and subsequently approved by the Executive Committee of the Society.

SEC. 3. If a member or his authorized representative is absent from two consecutive meetings of the Committee without notice to the Secretary assigning reasons for the same, the Secretary shall, with the approval of the Advisory Board of this Committee, remove his name from the roll of membership. Prior to the regular meeting of this Committee next preceding the annual meeting of the Society in the even-numbered years, all members are to be subject to re-election by written ballot of the Committee. Any member failing to receive a majority of the votes of the Committee shall be dropped from the rolls.

ARTICLE III.
OFFICERS AND THEIR ELECTION.

SECTION 1. The officers of this Committee shall be a Chairman, two Vice-Chairmen, and a Secretary.

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SEC. 2. The Chairman and the second Vice-Chairman shall represent non-producing interests.

SEC. 3. The terms of office shall be for two years and officers shall be eligible for re-election.

SEC. 4. The election of officers shall be held at the regular meeting of this Committee next preceding the annual meeting of the Society in the even-numbered years. Any vacancies shall be filled for an unexpired term by election at any regular meeting.

ARTICLE IV.

DUTIES OF OFFICERS.

SECTION 1. The executive direction of the Committee shall be vested in an Advisory Board which shall consist of the officers of the Committee and the chairmen of its sub-committees.

SEC. 2. Subject to final ratification by the Committee, the Advisory Board shall appoint and discharge sub-committees; shall appoint and discharge their chairman, and shall outline the duties of all sub-committees.

SEC. 3. The Chairman shall preside at all meetings of the Committee and be an ex-officio member of all sub-committees.

SEC. 4. In the absence of the Chairman the first Vice-Chairman and in his absence the second Vice-Chairman shall perform the duties of the Chairman.

SEC. 5. The Secretary shall attend all meetings of the Committee and keep the minutes thereof. He shall send to each member of the Committee immediately after each meeting a copy of the minutes of that meeting. He shall keep a roll of the members of the Committee and its sub-committees. He shall record the members in attendance at each meeting of the Committee. He shall conduct the correspondence and receive and file all communications addressed to the Committee. He shall issue notices of all meetings at the request of the Chairman. He shall promptly inform members of sub-committees of their appointment. He shall have custody of the rules, books, records, reports, and all other documents belonging to the Committee and copies of all the minutes of its
sub-committees. He shall keep a memorandum of the expenses of the Committee and shall perform such other duties as may be assigned to him by the Advisory Board.

**Article V.**

**Meetings.**

**Section 1.** Regular meetings of the Committee shall be held at least twice a year, preferably in December or January and during the Annual Meeting of the Society prior to the presentation of the Annual Report of the Committee; the time and place of meetings to be fixed by the Chairman.

**Sec. 2.** Special meetings may be called at the option of the Chairman or at the written request of at least five members, stating the reasons therefor.

**Sec. 3.** Notice of meetings shall be sent to each member of the Committee at least two weeks in advance of the meeting, stating the time and place at which the meeting will be held and, in case of special meetings, an outline of the business to be transacted. This shall be followed by a second notice mailed to reach the members about three days before the meeting.

**Sec. 4.** One-third of the members of the Committee, but not less than five members, including in this number at least one member of the Advisory Board, shall constitute a quorum.

**Article VI.**

**Sub-committees.**

**Section 1.** Sub-committees shall perform the duties assigned to them and shall present a written report at each regular meeting of the Committee.

**Sec. 2.** The chairman of each sub-committee shall have authority to appoint a vice-chairman, a secretary, and special committees of the sub-committees, and to direct the work of the sub-committee. The chairman of each sub-committee shall keep proper files of all correspondence and papers relating to the work of his sub-committee which shall ultimately be transmitted to the Secretary of the Committee.
Regulations Governing Committee C-11.

Sec. 3. If a sub-committee fails to present a report at two consecutive meetings of the Committee, the Secretary shall notify the Chairman and the members of the sub-committee that they shall show cause to the Advisory Board why the sub-committee shall not be reorganized or discharged.

Sec. 4. No expense shall be incurred by any sub-committee, except for postage, unless previously authorized by the Advisory Board.

Article VII.

Amendments.

Section 1. Amendments to these Regulations shall be adopted on two-thirds vote of the Committee by letter ballot.
REGULATIONS GOVERNING COMMITTEE D-1
ON
PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.
SUPPLEMENTARY TO
REGULATIONS GOVERNING STANDING COMMITTEES.

STATEMENT OF PLAN AND POLICY OF COMMITTEE D-1.

Committee D-1, on Preservative Coatings for Iron and Steel, was organized in 1902 to investigate the problem indicated by the title. The work of the committee has broadened however during the past few years so as to cover the preservation of materials of construction in general by paint and similar coatings. To meet these conditions the Executive Committee of the Society extended the scope to be covered by the work of the committee, so that it is now a "Committee on Preservative Coatings for Structural Materials." The growth and importance of the committee's work, furthermore, have been such that the committee has been re-organized with an Advisory Committee having executive powers, and a number of sub-committees with powers to investigate, etc., along specific lines.

It has become evident to the members of the committee that its membership should be enlarged by adding thereto technical men of ability and experience who are interested in preservative coatings, so that the committee would become an organization of paint chemists and experts within the American Society for Testing Materials. It is thought such a plan of organization will enable its members to confer with reasonable frequency on technical questions. These conferences, say three times a year, will be of inestimable value in aiding the work of the committee.

In order that the work of the committee shall develop on broad lines, and be of the greatest practical value in its field of investigation, it is most desirable that the experimenters be
trained observers who appreciate the need of accurate observations and accurate methods of testing before expressing positive conclusions or recommending definite specifications. In this way the integrity and impartial position of the committee will be maintained and all interested will be assured of just consideration. This plan does not involve any suppression of facts, but rather a clear distinction between facts and conclusions. There should be no hesitation in reporting facts and recommending definite specifications when the established facts warrant positive conclusions.

It is to be hoped that manufacturing and consuming interests will recognize the importance of the work which is being done, and that they will see the advisability of helping in this work by having technical representation on the committee.

The reports of the standing sub-committees shall be presented by their respective chairmen, and in their natural sequence, at the annual meetings of the Society.

1. The Officers of Committee D-1 shall be a Chairman, a Vice-Chairman, and a Secretary, to be elected annually.

2. Members may be added to Committee D-1 at any time, by appointment by the Advisory Committee after approval by the Executive Committee of the Society.

3. The following standing sub-committees and their chairmen shall be appointed by the Chairman of Committee D-1, abolishing all old sub-committees:

   I. Advisory Committee.
   II. On Inspection of Havre de Grace Bridge.¹
   III. On Testing of Paint Vehicles.
   IV. On Inspection of Steel Plates at Atlantic City.¹
   V. On Linseed Oil.
   VI. On Definition of Terms Used in Paint Specifications.
   VII. On Influence of Pigments on Corrosion.
   VIII. On Methods of Analysis of Paint Materials.
   IX. On Varnish.
   X. On Inspection of White-Paint Test Fence at Washington, D. C.¹
   XI. On Paint Thinners Other Than Turpentine.
   XII. On Turpentine.
   XIII. On Shellac.

¹These sub-committees have been discontinued.
The chairman of each sub-committee shall be designated by the Chairman of Committee D-1.

The Chairman of Committee D-1 shall appoint such other committees as may be necessary.

4. All actions taken by Committee D-1 shall be subject to review and approval by the Executive Committee of the Society.

5. Three regular meetings of Committee D-1 shall be held: one at the annual meeting of the Society, one in the fall, and one in the spring of each year.

6. Absence from two consecutive regular meetings without notice to the chairman or secretary shall be considered as a resignation.

7. The policy of the Committee is that no reports of committee work be made public except over the chairman's signature.

REGULATIONS GOVERNING SUB-COMMITTEES.

1. Each sub-committee shall elect a secretary, who shall keep minutes of its meetings, etc., assist the chairman of the sub-committee in correspondence, notifying members of meetings, etc., and confer with the Secretary of Committee D-1 in the preparation of reports.

2. All records of sub-committees and their officers, shall ultimately be transmitted to the Secretary of Committee D-1, for filing.

3. No expense shall be incurred by any sub-committee excepting for postage or stationery, unless previously authorized by the Advisory Committee. Statements of the expenses of sub-committees shall be sent to the Secretary of Committee D-1, for payment quarterly, dating from July 1st.

4. These regulations shall go into effect at once.

REGULATIONS GOVERNING THE SAMPLING OF LIQUIDS FOR COOPERATIVE WORK.

Quantity of Sample.—All samples used for cooperative work shall consist of at least two quarts for each experimenter taking part in the work. Not less than one quart shall be sent to each experimenter and not less than one quart shall be held in reserve for each experimenter.
Preservation of Samples.—All samples shall be preserved in completely filled, suitable containers (the kind to be stated in each case).

Sample to Represent.—The sample shall truly represent the material it purports to be, and if produced in the United States shall be obtained directly at the factory where it is produced. If imported, it shall be obtained from an original unbroken container.

Supervision.—The sample shall be drawn at the factory or from the imported container under the supervision, whenever practicable, of a committee of three or more; but when it is not practicable to have a committee of three or more, one expert, who shall be in no way interested in the manufacture or sale of the particular material represented, may draw the sample. It is not necessary that the experts drawing the sample be members of Committee D-1, or of the American Society for Testing Materials. The committee or single expert drawing the sample shall see that it is placed in a suitable, filled container, properly sealed, and labeled with labels bearing the number of the sample, date and place of sampling and signatures of all members of the committee drawing same.

Information to Accompany Samples.—The committee or individual drawing the sample shall obtain as much information as possible regarding the sample, such as nature and source of raw material used in its preparation, method of manufacture, date and place of manufacture or importation, consular certificate, etc. This information shall be explicit and shall include the name and official position of the person or persons giving such information. This information shall be transmitted in letter form to the chairman of the sub-committee to whom the samples are to be sent.

Duty of Chairman of Sub-Committee or other Member of Committee D-1 having Charge of Cooperative Work on Liquids.—He shall verify the seals on the packages of samples and assure himself that they have been received in good condition, shall see that they are properly resampled into suitable containers of not less than one quart, which shall be properly sealed for distribution to those cooperating in the tests. He shall see that all samples sent out are in completely filled containers, and that
a reserve stock at least equal in volume to all sent out is preserved in one or more completely filled and properly sealed containers. He shall compile all information available regarding the history of the samples, which shall be furnished to all cooperators, either before or after the work on the samples is reported, but before any reports are presented for consideration to the whole committee.

The labels and seals used on all original samples shall be as follows:

**AMERICAN SOCIETY FOR TESTING MATERIALS.**

Committee D-1.

Sample of .......................................................... No. ..............
Taken at .......................................................... on ...................... 19 ..............

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to the regulations governing samples of liquids for cooperative work by Committee D-1.

(Signed) ........................................................................
........................................................................
........................................................................

On samples sub-divided by the chairman of the sub-committee the same seals shall be used; but the label need only bear the name of the material and number of the sample, with such additional information as may be deemed advisable by the chairman of the sub-committee making the distribution.
REGULATIONS GOVERNING COMMITTEE D-11
ON RUBBER PRODUCTS.
SUPPLEMENTARY TO REGULATIONS GOVERNING STANDING COMMITTEES.

ARTICLE I.
OFFICERS AND THEIR ELECTION.

SECTION 1. The executive direction of Committee D-11 shall be vested in an Advisory Committee, which shall consist of the officers of the Committee, the chairmen of the sub-committees, and any member of the Committee not otherwise eligible serving on at least three sub-committees.

Sec. 2. The officers of Committee D-11 shall be a Chairman and a Secretary.

Sec. 3. Any member of the Committee shall be eligible for office; except that the Chairman shall be elected from the representatives of non-producing interests, as provided in the "Regulations Governing Standing Committees."

Sec. 4. The term of office shall be two years; and officers shall be eligible for re-election.

Sec. 5. The officers shall be elected at a meeting of the Committee held at the time of the Annual Meeting of the Society in the even-numbered years.

Sec. 6. (a) A Committee on Nomination of Officers, composed of the chairmen of all existing sub-committees, and under the chairmanship of one of its members to be designated by the Chairman of Committee D-11, shall organize immediately following the March meeting of Committee D-11 in the even-numbered years, and shall nominate to Committee D-11, at the time of the meeting for election, one member for Chairman and one member for Secretary. Any member of the Committee on Nominations shall be eligible for office.

(690)
(b) Other nominations may be made on the floor of the meeting.

Sec. 7. Chairmen of sub-committees shall be appointed by the Chairman of Committee D-11.

Article II.

Members.

Section 1. Members may be added to Committee D-11 at any time by appointment by the Advisory Committee after approval by the Executive Committee of the Society, in accordance with "Regulations Governing Standing Committees."

Article III.

Meetings.

Section 1. Committee Meetings.—Regular meetings of Committee D-11 shall be held in New York, on the first or second Tuesday of March, and at the Annual Meeting of the Society prior to the presentation of the annual report of the Committee.

Sec. 2. Sub-Committee Meetings.—(a) Regular meetings of sub-committees shall be held immediately preceding the dates of the regular meetings of the Committee. Special meetings of sub-committees may be held in the first week of any month on two weeks' notice from the chairman of the sub-committee.

(b) When the chairman of a sub-committee desires to call a meeting of his sub-committee, he shall so notify the Secretary, stating the date and hour and place. The Secretary shall prepare a schedule of sub-committee meetings with a view of avoiding conflicts, and this schedule shall be printed in the circular letter announcing the meeting of the Committee.

Article IV.

Attendance at Meetings.

Section 1. Committee Meetings.—The Secretary of the Committee shall keep a roll of the members of the Committee and shall record at each meeting of the Committee the members
in attendance. If a member, or his authorized representative, is absent from two consecutive meetings, without notice to the Secretary assigning satisfactory reasons for the same the Secretary shall notify the member that unless he advises that he wishes to continue as a member of the Committee, with assurance that he will in the future be in position to attend the meetings of the Committee or otherwise to take an active part in its work, his name will be dropped from the roll of membership. Such notices shall be sent out by the Secretary only on the approval of the Chairman of the Committee.

Sec. 2. Sub-Committee Meetings.—The chairman of each sub-committee shall keep a roll of the members of the sub-committee, and shall record at each meeting of the sub-committee the members in attendance. If a member, or his authorized representative, is absent from two consecutive meetings of the sub-committee without notice to the chairman of the sub-committee assigning satisfactory reasons for the same, the chairman shall notify the Secretary of the Committee. The Secretary shall then notify the member that unless he advises that he wishes to continue as a member of the sub-committee, with assurance that he will in future be in position to attend the meetings of the Committee or otherwise to take an active part in its work, his name will be dropped from the roll of membership of the sub-committee. Such notices shall be sent out by the Secretary only on the approval of the Chairman of the Committee.

Article V.

Sub-committees.

Section 1. The chairman of a sub-committee shall have authority to appoint, at his discretion, a vice-chairman, a secretary and sub-committees of the sub-committee, and to plan and direct the work of the sub-committee.

Sec. 2. (a) All specifications for any given product shall be drafted by the sub-committee in charge of specifications for that product.

(b) Any sub-committee considering the drafting of specifications for a general class of material involving a special class of material, specifications for which are in the charge of another
sub-committee, shall consult with that sub-committee with the object of having the specifications for that special class of material expanded if they are not sufficiently general to cover the proposed new requirements.

(c) Sub-committees in charge of specifications for given products shall cooperate, whenever necessary, with other sub-committees, with the object of having the specifications for given products such that they can be included in any other specification involving such products, either by full quotation, or merely by reference to the specifications covering such products individually.

Sec. 3. The chairman of each sub-committee shall submit to the Committee at each regular meeting a report of the progress of the work assigned to that sub-committee. Such report shall be made by the chairman in person, and a copy filed with the Secretary; except when the chairman is absent from a meeting, in which case the report of the sub-committee shall be made by some member of the sub-committee designated by the chairman of the sub-committee in writing to the Secretary, which member shall be in position to explain all items contained in the said report. Record of failure to submit such reports shall be entered in the minutes of each meeting.

Sec. 4. If a sub-committee fails to present a report through its chairman, or as otherwise provided in Section 3, at two consecutive meetings of the Committee, the Secretary shall notify the chairman and the members of the sub-committee that they shall show cause to the Advisory Committee why the sub-committee should not be reorganized or discharged. Such notices shall be sent out by the Secretary only on the approval of the Chairman of the Committee.

Sec. 5. The chairman of any sub-committee, or some officer of the same, after the completion of a subject referred to the sub-committee, shall transmit all correspondence filed on that subject to the Secretary of the Committee.
BASIS OF COOPERATION BETWEEN VARIOUS GOVERNMENT BRANCHES AND THE STANDING COMMITTEES OF THE SOCIETY.

For the information of the membership at large, and especially the standing committees, the Executive Committee has authorized the following announcements, in alphabetical order, of the conditions under which certain government branches are prepared to cooperate with the work of the standing committees, these announcements having been prepared by, or with the approval of, the directing heads of the government branches concerned:

Bureau of Chemistry.—This Bureau is equipped to do all kinds of chemical work and to participate in cooperative work whenever it can be done within the scope of the functions of the Bureau and under the law, inasmuch as the activities of the Bureau are specifically prescribed by acts of Congress. This cooperative feature would include the investigations under way and such as might be undertaken in connection with the work of the Bureau along the lines of its natural growth and development.

In so far as the Bureau has equipment suitable to carry on investigations and cooperative work on such subjects as are related to chemistry, and with which the American Society for Testing Materials is directly concerned, and where the proper authorization exists and funds are available or the purpose, it would be glad to be of assistance to the committees of the Society.

Bureau of Mines.—The Bureau of Mines may make tests of fuels, explosives and certain mining appliances, such as lamps, timbering, etc. When such work is performed other than for the Government of the United States or state governments, a reasonable fee to cover the necessary expenses is charged.

The Bureau is prepared to cooperate, and will welcome opportunities for cooperation, with committees of the American
Society for Testing Materials to the extent of being represented on such committees as are concerned in tests or investigations of fuels, explosives or miners' lamps, and will conduct investigations or tests concerning any phase of these which may be brought to its attention by your committees as needing solution, providing it concerns subjects in which the Bureau is interested on behalf of increasing safety in mining or use of fuels purchased for or belonging to the United States.

_Bureau of Standards._—The Bureau of Standards is equipped to conduct investigations covering the standardization of weights and measures, electrical measurements, the determinations of heat constants and temperature measurements, optical properties of materials, chemical problems, investigations of structural and engineering materials, and metallurgical investigations. In addition to general research investigations, it studies problems which arise in the preparation of specifications or the development of methods of testing required in the determination of the qualities of materials. Much of the work is closely allied to the work of the standing committees of the American Society for Testing Materials, and it is the desire of the Bureau to cooperate in those investigations where the Bureau is equipped for them. Investigations may be referred to the Bureau which fall within the authorized scope of its functions, and will be taken up as far as equipment and funds will permit.

_Forest Products Laboratory._—It is the aim of the Forest Products Laboratory to promote economy and efficiency in the utilization of wood and in the processes by which forest materials are converted into commercial products. Investigations at the laboratory are being made along the following lines:

- Mechanical and physical properties of woods and derived products.
- Principles of seasoning and kiln drying.
- Decay, preservative treatment, and fireproofing of wood.
- Manufacture of pulp and paper.
- Distillation and chemical constituents of forest products.
- Specifications and grading rules for forest products.
- Efficient design or composition of articles obtained or manufactured from forest products.
Design of apparatus, specifications for material, and improving of processes to promote a more efficient and closer utilization of forest products.

In order to further the application of the work of the laboratory it is necessary to correlate the results of all technical investigations with the uses of the products and to make all information available to the public.

The laboratory, in all matters within its scope, will be glad to cooperate with the American Society for Testing Materials so far as funds and equipment are available.

Office of Public Roads and Rural Engineering.—The Office of Public Roads and Rural Engineering will cooperate with the American Society for Testing Materials along all lines of laboratory or field work relating to road materials. The Office has all the necessary equipment for making such tests. The Office can also cooperate along any reasonable lines of field investigations.

Watertown Arsenal.—The laboratory of the Watertown Arsenal is equipped for conducting physical tests of metals and materials, including impact and repeated stress tests; metallographic examinations of metals, chemical analysis, pyrometric work and investigations on the manufacture and heat treatment of steels. The testing laboratory is limited by law to investigate tests and tests of material in connection with the manufacturing work of the Ordnance Department, except as modified by authority to make tests of materials for private parties paying the cost of the test. Within these limits the Watertown Arsenal will be glad to cooperate with the standing committees of the American Society for Testing Materials.
REGULATIONS GOVERNING THE FORM BUT NOT THE SUBSTANCE OF STANDARDS.

Adopted, 1912; Revised, 1913.

1. These Regulations shall not be retroactive with respect to existing standards, although they may be applied to such standards on the recommendation of, or with the consent of, the standing committee concerned.

2. These Regulations have been adopted with the understanding (1) that the standing committees shall make an earnest effort to comply with these Regulations; (2) that departures from these Regulations shall not be made by the standing committees except on what they believe to be strong grounds; (3) that the judgment of the standing committees concerning such departures shall, in general, be regarded as conclusive; but that in case of disagreement on matters which the Advisory Committee of Committee E-5 may regard as of sufficient importance, it shall have the right to appeal to the Executive Committee of the Society, whose decisions in all such matters shall be final.

3. These Regulations shall be subject to annual review and revision by Committee E-5.

(A) ARRANGEMENT, LETTERING AND NUMBERING.

4. The material in each standard shall be grouped under sub-titles, numbered consecutively by Roman numerals. The principal divisions under a sub-title shall be designated by upper-case italic letters, in parentheses: (A), (B), (C), etc.

5. The sections in each standard shall be numbered continuously by Arabic numerals. Sub-divisions under a single section shall be distinguished by lower-case italics, in parentheses: (a), (b), (c), etc. This side-lettering shall not run continuously throughout a given standard, but shall begin with (a) in each section.
698  Regulations Governing Form of Standards.

6. The general arrangement of standards shall be as follows:

   TITLE.

   Matter of an introductory or general nature (see Section 7, below).

   I. Sub-TITLE.

   (A) Principal divisions under a sub-title.

   1. Sections (numbers to run consecutively throughout the standard).

   (a) Sub-divisions of a section (letters to run consecutively throughout
       a section only).

   (B) Form and Sequence of Sub-Titles.

   7. Directly after the title of the standard insert sections
       of an introductory, descriptive or general character; for example,
       matter descriptive of the products the standards are designed
       to cover. No sub-title shall be used for such matter. Such
       terms as "introductory," "general," etc., are lacking in definite
       meaning, and may in some cases be wholly inappropriate.

   8. The matter following these opening sections (if any)
       shall be grouped in general under the following sub-titles in
       the sequence indicated:

      I.  MANUFACTURE.
      II. CHEMICAL PROPERTIES AND TESTS.
      III. PHYSICAL PROPERTIES AND TESTS.

      (A) Mechanical.
      (B) Electrical.
      (C) Magnetic.
      (D) Thermal.
      (E) Other properties and tests under appropriately descriptive headings.

     Under II and III the method of sampling and the standard
     test specimens shall be defined.

   IV. STANDARD SIZES, DIMENSIONS, WEIGHTS, GAGES, ETC.

   9. This sub-title is to be used in a form appropriate to the
      matter to which it refers and shall be followed immediately by
appropriate sections covering "permissible variations." If the matter under "permissible variations" is lengthy and contains numerous sections, an appropriate special sub-title shall be used. Such a sub-title shall also be used in case the standard contains no matter under Sub-Title IV.

V. WORKMANSHIP AND FINISH.

VI. PACKING, MARKING AND SHIPPING.

10. If the sections under Sub-Title VI are limited in a given standard to only one or two of the above three items, the sub-title shall be abridged accordingly.

VII. INSPECTION AND REJECTION.

11. The term "inspection" shall be interpreted here in the restricted sense of surface or outward inspection of the finished product.

VIII. DEFINITION OF TERMS.

12. If a standard contains numerous terms that admit of ambiguity, they shall be defined under this sub-title. If, on the other hand, a standard contains only a few such terms, they shall preferably be defined where they are first used. The definition of the same term in different standards shall, if possible, be identical.

IX. SPECIAL SUB-TITLES.

13. Sections that cannot appropriately be placed under any of the above sub-titles shall be grouped under special sub-titles, inserted in their most logical position. Such special sub-titles shall be indicative of the contents of the sections to which they pertain. The use of such sub-titles as "General," "Miscellaneous," etc., shall be avoided.

14. In so far as the above standard sub-titles are used, the sequence in which they are given above shall, if possible, be adhered to.
(C) Marginal Headings.

15. Every numbered section shall have a marginal heading in bold-face type, briefly indicative of its content.

16. The sequence of matter under a given sub-title shall be left to the judgment of the committee concerned. In so far as possible, the same sequence of marginal headings shall be observed in different specifications prepared by a given committee. The requirements for standards prepared by different committees vary so widely, that it is not considered practicable to extend this provision to the work of different committees. The Secretary of the Society shall endeavor, however, to secure such uniformity between standards prepared by different committees.

(D) Specified Values.

17. "Desired values" rather than "permissible limits" shall be given, followed by a statement with respect to "permissible variations." The term "permissible variations" shall be used in general, rather than the term "tolerance," except in connection with subjects in which the latter term is in better accord with recognized trade usage.

18. In so far as practicable, specified values shall be expressed in tabular form.

(E) Units of Measurement.

19. Units of measurement shall be expressed in both the English and Metric systems, if, in the judgment of the committee concerned, it is desirable to do so. Temperatures shall be expressed in Centigrade values, and also in Fahrenheit values, if, in the judgment of the committee concerned, it is desirable to do so.

(F) Standard Typography, Terms, Abbreviations, Spelling, Etc.¹

20. Committee E-5 has final authority in all matters pertaining to standard typography, terms and forms of expression, abbreviations, spelling, etc.

¹This matter has been adapted in large part from the Style Sheet of the American Society of Mechanical Engineers.
The following standards have been adopted not with the view of anticipating all possible questions that may arise as to typography, abbreviation, spelling, etc., but of providing for consistency of practice in matters of common occurrence.

21. **Abbreviations.**

When abbreviations are used, they shall conform to the following requirements. The policy will be to abbreviate too little rather than too much. Terms which seldom occur will, in general, not be abbreviated. For further rules regarding abbreviations, see "Numerals" and "Footnotes."

(a) **Units of Length.**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centimeter</td>
<td>cm</td>
</tr>
<tr>
<td>Decimeter</td>
<td>dm</td>
</tr>
<tr>
<td>Foot</td>
<td>ft</td>
</tr>
<tr>
<td>Inch</td>
<td>in</td>
</tr>
<tr>
<td>Kilometer</td>
<td>km</td>
</tr>
<tr>
<td>Linear</td>
<td>lin</td>
</tr>
<tr>
<td>Meter</td>
<td>spell out</td>
</tr>
<tr>
<td>Mile</td>
<td>spell out</td>
</tr>
<tr>
<td>Millimeter</td>
<td>mm</td>
</tr>
<tr>
<td>Yard</td>
<td>yd</td>
</tr>
</tbody>
</table>

(b) **Units of Area.**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular mil</td>
<td>cir. mil</td>
</tr>
<tr>
<td>Square</td>
<td>sq</td>
</tr>
<tr>
<td>Square foot</td>
<td>sq. ft</td>
</tr>
<tr>
<td>Square inch</td>
<td>sq. in</td>
</tr>
</tbody>
</table>

(c) **Units of Volume.**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrel</td>
<td>bbl</td>
</tr>
<tr>
<td>Bushel</td>
<td>bu</td>
</tr>
<tr>
<td>Centiliter</td>
<td>cl</td>
</tr>
<tr>
<td>Cubic</td>
<td>cu</td>
</tr>
<tr>
<td>Cubic centimeter</td>
<td>cc</td>
</tr>
<tr>
<td>Decaliter</td>
<td>dal</td>
</tr>
<tr>
<td>Decliter</td>
<td>dl</td>
</tr>
<tr>
<td>Gallon</td>
<td>gal</td>
</tr>
<tr>
<td>Hectoliter</td>
<td>hl</td>
</tr>
<tr>
<td>Liter</td>
<td>spell out</td>
</tr>
<tr>
<td>Milliliter</td>
<td>ml</td>
</tr>
</tbody>
</table>

(d) **Units of Weight.**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centigram</td>
<td>cg</td>
</tr>
<tr>
<td>Decigram</td>
<td>dg</td>
</tr>
<tr>
<td>Gram</td>
<td>gr</td>
</tr>
<tr>
<td>Gram</td>
<td>g</td>
</tr>
<tr>
<td>Kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Milligram</td>
<td>mg</td>
</tr>
<tr>
<td>Ounce</td>
<td>oz</td>
</tr>
<tr>
<td>Pound</td>
<td>lb</td>
</tr>
<tr>
<td>Ton</td>
<td>spell out</td>
</tr>
</tbody>
</table>

(e) **Units of Time.**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afternoon</td>
<td>p. m.</td>
</tr>
<tr>
<td>Day</td>
<td>spell out</td>
</tr>
<tr>
<td>Forenoon</td>
<td>a. m.</td>
</tr>
<tr>
<td>Hour</td>
<td>hr</td>
</tr>
<tr>
<td>Minute</td>
<td>min</td>
</tr>
<tr>
<td>Month</td>
<td>spell out</td>
</tr>
<tr>
<td>Second</td>
<td>sec</td>
</tr>
<tr>
<td>Week</td>
<td>spell out</td>
</tr>
<tr>
<td>Year</td>
<td>spell out</td>
</tr>
</tbody>
</table>

(f) **Electrical and Magnetic Terms.**

<table>
<thead>
<tr>
<th>Term</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampere</td>
<td>spell out</td>
</tr>
<tr>
<td>Electric horse power</td>
<td>e. h. p.</td>
</tr>
<tr>
<td>Electromotive force</td>
<td>e. m. f.</td>
</tr>
<tr>
<td>Magnetomotive force</td>
<td>m. m. f.</td>
</tr>
<tr>
<td>Ohm</td>
<td>spell out</td>
</tr>
<tr>
<td>Volt</td>
<td>spell out</td>
</tr>
</tbody>
</table>
ABBREVIATIONS (Continued).

(g) Units of Power.
Brake horse power....... b. h. p.
Horse power............. h. p.
Indicated horse power ... i. h. p.
Kilowatt................ kw.
Watt..................... spell out

(h) Units of Heat.
British thermal unit...... B. t. u.
Calorie.................... cal.
Centigrade¹............... C.
Degree¹........................ °
Fahrenheit¹................... F.

(i) Miscellaneous Technical Terms.
Birmingham wire gage..... B. w. g.
Browne & Sharpe (gage) . . B. & S.
Degree (angular measure) . deg.
Diameter..................... spell out
Revolutions per minute... r. p. m.
Specific gravity.......... sp. gr.
Tensile strength......... tens. str.
United States (gage)..... U. S.

(j) Miscellaneous General Terms.
Figure..................... Fig.
Number...................... No.
Per......................... spell out
Per centum................ per cent
Proceedings............... Proc.
Plate....................... spell out
Table....................... spell out
Transactions............... Trans.
Volume..................... Vol.

(k) Use abbreviations only after nouns denoting a definite quantity, except in tabular work. For example: "The tensile strength is 45,000 lb. per sq. in."; but "The tensile strength in pounds per square inch is ......."

(l) When terms are used in an abstract or descriptive sense, they shall not be abbreviated. For example, use "the magnetomotive force is applied"; not, "the m.m.f. is applied."

(m) Use a period after each abbreviation, except after per cent, and as noted in Paragraph (o).

(n) All abbreviations shall be used in the singular. Thus, "two inches" shall be abbreviated "2 in."; not "2 ins."

(o) Compound Words.—The abbreviations for compound words, when used, shall be formed by connecting the abbreviations of the separate words by a hyphen, omitting the period preceding the hyphen. Thus, "ft-lb., watt-hr., kw-hr., m-kg.," etc.

(p) Symbols.—Avoid the use of symbols. Do not use (') or (") in either text or tables; their use is permissible in illustrations. The symbol (%) shall not be used in the text, but may be used in tables when lack of space requires it. See Paragraph (r).

¹ See paragraph (r), p. 703.
(q) The word "percentage" shall be used when not following a number. Thus, "the percentage of carbon shall be"; not, "the per cent of carbon shall be." But, "0.35 per cent of carbon."

(r) After numerals, use the following abbreviations: "62° F., 36° C." In expressions like the following, omit the degree mark after the first figure: "75 to 80° C." In a table heading, use "Temperature, deg. Fahr.," or "deg. Cent."

(s) In expressing dimensions, use the following form: "2 by 4 in. in section;" not "2 x 4 in. in section," nor "2 in. by 4 in. in section."

(t) Spell out the names of the months: as, "January 25." Do not use the form "January 25th."

(u) In text, do not abbreviate "namely" and "that is."

(v) Spell out names of companies, railroads, etc., using the ampersand (&) only between proper names. Abbreviate "Company" in firm names. For example: "Brown & Sharpe Manufacturing Co.;" "Philadelphia & Reading Railway Co.;" but, "American Steel and Wire Co."

(w) In giving a title, use Dr., Prof., Genl., etc., where initials or full name is given; spell out where surname only is given.

22. Numerals.

(a) Roman numerals will be used in designating tables and plates: thus, "Table VI;" not "Table 6." Arabic numerals will be used in designating figures: thus, "Fig. 3;" not "Fig. III."

(b) Spell out all numbers from one to twelve, with the following exceptions:

1. Use numerals when the quantity is partly or wholly fractional: as, 1.15, 1 1/2, 1/8.

2. Use numerals when followed by an expression having a standard abbreviation: as, 1 in., 6 lb., etc.; except where the statement is vague in nature, in which case neither numerals nor abbreviations shall be used: as, "about six pounds," etc.

3. If for any reason the standard abbreviation of the expression following the number is not used, or if the
expression does not admit of abbreviation (as ohm, ton, etc.) the use of numerals shall be optional, unless covered in the following paragraphs.

4. In contrasted statements, if some numbers must be numerals, use numerals for all: as, "2 miles and 16 miles."

5. In a series of connected numerical statements implying precision, use numerals: as, "2 years, 5 months, 3 days." The use of numerals (especially the "1") is not recommended for numbers occurring in precise statements similar to the following: "By connecting the two test coils;" "shall consist of two equal and uniformly wound solenoids," etc.

6. Use numerals after abbreviations: as, Vol. 6, Fig. 2, etc.

(c) Use numerals for all numbers exceeding twelve, with the following exceptions:

1. Do not begin a sentence with a numeral.
2. Round numbers used in an indefinite sense shall be spelled out: as, "A hundred feet or so," etc.
3. Numbers shall be spelled out when used in the following manner: fifteen 2-in. rods," etc.

(d) In expressing percentages, precise figures, etc., use decimals: as, "4.5 per cent"; not "4\frac{1}{2} per cent."

(e) In decimal numbers having no units, a cipher shall be placed before the decimal point: as, "0.65 in."; not ".65 in."

(f) Omit unnecessary ciphers in sums of money: as, "$3"; not "$3.00."

(g) In pointing off numbers of more than four figures, use commas in the text (1,234,567) and spaces in tabular matter (1 234 567). Numbers of four figures shall not be pointed off in either text or tabular matter (1234), except when they occur in a table containing any number of more than four figures.

(h) Always use numerals for the day of the month when the month is given (January 25, 1913) and for the time of day (2.30 p. m.).
23. Spelling and Punctuation.

(a) Simple Words.—The following spelling shall be used:

<table>
<thead>
<tr>
<th>Word</th>
<th>Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>aging</td>
<td>fulfill</td>
</tr>
<tr>
<td>briquette</td>
<td>gage</td>
</tr>
<tr>
<td>center</td>
<td>gasoline</td>
</tr>
<tr>
<td>crystallin</td>
<td>glycerin</td>
</tr>
<tr>
<td>disk</td>
<td>iodine</td>
</tr>
<tr>
<td>embed</td>
<td>insure</td>
</tr>
<tr>
<td>fiber</td>
<td>mold</td>
</tr>
<tr>
<td>formulas</td>
<td></td>
</tr>
</tbody>
</table>

(b) Compound Words.—The following spelling shall be used:

Spell with hyphen.

<table>
<thead>
<tr>
<th>Word</th>
<th>Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>cold-roll</td>
<td>re-anneal</td>
</tr>
<tr>
<td>cross-section</td>
<td>re-treat</td>
</tr>
<tr>
<td>one-half</td>
<td>rough-forg</td>
</tr>
<tr>
<td>open-hearth</td>
<td>stop-cock</td>
</tr>
</tbody>
</table>

Spell without hyphen when used as noun.

<table>
<thead>
<tr>
<th>Word</th>
<th>Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>cast iron</td>
<td>plaster of Paris</td>
</tr>
<tr>
<td>crank shaft</td>
<td>testing machine</td>
</tr>
<tr>
<td>drop test</td>
<td>water bath</td>
</tr>
<tr>
<td>engine bolt</td>
<td>wrought iron</td>
</tr>
<tr>
<td>piston rod</td>
<td></td>
</tr>
</tbody>
</table>

Spell as one word.

<table>
<thead>
<tr>
<th>Word</th>
<th>Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>cooperate</td>
<td>reheat</td>
</tr>
<tr>
<td>eyebob</td>
<td>reroll</td>
</tr>
<tr>
<td>firebox</td>
<td>retest</td>
</tr>
<tr>
<td>fireproof</td>
<td>reweigh</td>
</tr>
<tr>
<td>footnote</td>
<td>sinkhead</td>
</tr>
<tr>
<td>limewater</td>
<td>staybolt</td>
</tr>
<tr>
<td>quicklime</td>
<td></td>
</tr>
</tbody>
</table>

(c) Compound adjectives shall be hyphenated; as “2-in. gage,” “cast-iron cylinder,” “500-horse-power (or 500-h.-p.) motor,” “0.20-per-cent-carbon steel,” etc. Such expressions as the following shall be written without the hyphen after the first numeral: “2 and 6-in. specimens.”

(d) Do not hyphenate such expressions as “newly puddled iron,” where the adverb is a regular modifier of the adjective.

24. Capitals.

(a) Use capitals sparingly.

(b) Capitalize the principal words in headings, titles of books, papers, etc. (nouns, verbs, adjectives and adverbs).
(c) Use capital initial "C" for "committee" when used as a title: thus, "Committee A-1," "Committee on Papers." In all other cases use lower-case "c"; thus, "The committee recommends .......

(d) Use capital initial "B" for Bessemer; "P" for Portland.

(e) Use initial capitals in reference to volumes, figures, plates, etc.: as, Vol. 6, Fig. 2, Plate VI, Table III.

(f) Use the form "test No. 1," "specimen A," etc.

25. STANDARD TERMS AND FORMS OF EXPRESSION.

(a) The numbered sections of a standard shall be referred to as "Section 6"; the lettered sub-divisions of a section shall be referred to either as "Paragraph (a)," or "Section 6(a)." The former shall be used only when the reference occurs in the section containing the paragraph referred to; in all other cases the latter form shall be used.

(b) Use "shall" wherever the standards are to be made binding on parties of the first or second part.

(c) Use "will" wherever the standards are intended to express a declaration of purpose not mandatory upon the parties of the first or second part.

(d) Use "may" wherever the standards provide definitely for alternative courses.

(e) Use "full-size tests"; not "full-sized tests," etc.

(f) Use "gage length"; not "gaged length."

(g) Use "test specimen"; not "test piece." In case the term "test specimen" is repeated several times in the same section, the word "specimen" may be used after the first use of "test specimen."

(h) Use "3/8 in. or over in thickness"; not "3/8 in. and over."

(i) In referring to dimensions, use simply "2 in."; not "two inches (2 in.)," or "two (2) inches."

(j) Use the form "without cracking" in referring to bend tests of metals; not "without sign of cracking."

(k) Use "melt" to mean "melt of steel," "blow of steel," and "heat of steel," as distinguished from "treating-plant heat," etc.
Regulations Governing Form of Standards.

(l) Use "reduction of area"; not "reduction in area" or "contraction in area."

(m) Use "acid number," "iodine number," etc.; not "acid value," "iodine value," etc.

26. Footnotes.

(a) Use superior figures instead of asterisks, etc., except in connection with numerals, for which use letters.

(b) The names of journals, proceedings, bulletins, etc., shall be printed in italics, without quotation marks; the titles of papers and reports shall be printed in Roman and enclosed in quotation marks.

(c) Abbreviate the names of societies.

(d) When reference is made to a paper or report by title, only the initial page shall appear in the footnote. Thus:


When such titles are not given, or when reference is made to certain parts of papers, reports, etc., page numbers shall be indicated, as follows:

Railway Age Gazette, Feb. 16, 1912, pp. 280-282.

(e) When volume numbers are given, the year of publication shall appear in parentheses at the end of the footnote. Otherwise, the date of publication shall appear immediately after the name of publication. (See above examples.)

(f) Footnotes shall always appear at the bottom of the page on which the reference is made.

(g) References, by the use of such terms as ibid., etc., to previous footnotes, shall not be used unless the footnote referred to is given on the same page; otherwise the footnote in question shall be repeated.
REGULATIONS GOVERNING PAPERS, COMMITTEE REPORTS AND DISCUSSIONS.

Adopted, 1913; Revised, 1914, 1916.

Authority of Committee.—Committee E-6 on Papers and Publications has been given full authority by the Executive Committee in all matters affecting the acceptance, rejection, editing and publication of papers, committee reports and discussions.

Preprints.

Preprinting of Papers and Committee Reports.—The Committee on Papers and Publications will use its best endeavors to put the papers and committee reports to be presented at annual meetings in type for advance circulation. To render this practicable, the manuscripts should be sent to the Secretary-Treasurer at least two months in advance of the meeting at which they are to be presented. The committee will then endeavor to issue preprints to the membership at large one month in advance of the meeting. It is manifest, however, that if all papers forming part of a comprehensive program should be received only two months in advance of the meeting, it would not be practicable to have them all put in type in a single month. Authors and chairmen of committees are accordingly requested to furnish their manuscripts as far in advance of the meeting as possible.

In general, the sequence in which the papers are received will determine the sequence in which they will be printed. Manuscripts received too late for printing and advance circulation will be put in type, in so far as practicable, with a view of having them available in printed form at the meeting.

The committee reserves the right to reject papers received too late for printing and advance circulation, although exceptions may be authorized at the discretion of the committee.

Papers provisionally accepted by title only, and of which the manuscripts have not been received before the final program
Regulations Governing Papers.

Their authors shall be notified, however, that such of these papers as may subsequently be accepted will be introduced at the end of the appropriate sessions and read by title or otherwise, as time may admit.

Standards.—According to the Regulations Governing Standing Committees:  
"Any recommendations affecting standards must be transmitted to the Secretary-Treasurer of the Society at least eight weeks in advance of the date of the annual meeting, and copies of these recommendations, in printed form, must be mailed by the Secretary-Treasurer to every member of the Society not less than four weeks before the annual meeting, so that members may come to the meeting prepared to discuss such recommendations, and that members not intending to be present at the meeting may contribute discussions by letter."

Editing and Rejection of Papers.

Editing of Papers and Discussions.—The Committee on Papers and Publications will edit and revise papers for publication. If such editing and revision is not acceptable to the author, the committee will endeavor to meet the wishes of the author as far as possible, but if a revision acceptable to both the committee and the author cannot be reached, the papers shall not be presented or published.

The above provisions are applicable also to written or verbal discussion.

In the editing of matter for the publications of the Society, the requirements as to "typography, standard terms, abbreviations, spelling, etc.," contained in the Regulations Governing the Form but not the Substance of Standards, will be adhered to. It is recommended that authors assist the committee by following these requirements in the preparation of their manuscripts.

Rejection of Papers.—The rejection of papers will be determined chiefly on the following grounds:

1 See p. 669.
2 See pp. 700-707.
Regulations Governing Papers.

(a) That the subject matter does not fall within the field of the Society's activities.
(b) That the contents are of an advertising character.
(c) That the author controverts well-established facts.
(d) That the subject matter is essentially of a speculative nature.
(e) That the subject matter is not new.
(f) That the treatment is seriously defective as to literary form and structure, continuity of thought, clarity of expression, etc.

The committee reserves the right, however, to reject papers on grounds other than those above stated; for example, a paper in which sweeping generalizations are premised on manifestly inadequate data; a paper embodying trade secrets, for example, one descriptive of the properties of a product whose composition or manufacture are not disclosed; or, again, a paper containing the results of tests calculated to do injury to commercial interests, unless representatives of those interests witnessed the tests, or are given the opportunity of preparing discussions for presentation concurrently with the paper.

Presentation and Discussion of Papers and Committee Reports at Annual Meetings.

Presentation of Papers.—Papers by members in attendance at the meeting shall take precedence over papers by absent members. The latter may, at the discretion of the chair, be presented only by title. Authors will be expected to confine themselves to brief references to the principal features of their papers. In general, the time allotted to the presentation of a paper shall be limited to ten minutes. The time may be extended, however, for special reasons, at the discretion of the chair, or by vote of the meeting.

Presentation of Committee Reports.—Committee reports shall also be limited in their presentation to a brief summary of their principal features; but matters which are to be referred to letter ballot of the Society shall either be read in extenso, or acted on as printed without reading, according to the expressed sense of the meeting.
Discussions.—All written discussions shall be placed in the hands of the Secretary-Treasurer prior to the session at which they are to be presented. Such written discussions shall take precedence over oral discussions. In the presentation of written or oral discussions the speaker will in general be limited to five minutes, but this time may be extended at the discretion of the chair, or by vote of the meeting.

Publication in the Technical Press.

No paper, committee report, or written discussion shall be released for publication in the daily or technical press in advance of its presentation, except by authority of the Committee on Papers and Publications; nor after its presentation, unless it has previously been edited by the committee or the committee agrees to release it without editing.

No person shall receive monetary compensation from reprinting any paper or discussion presented before the Society, without previous authorization from the committee, and in all reprints credit shall be given to the Society.
LIST OF STANDARDS

ADOPTED BY THE

AMERICAN SOCIETY FOR TESTING MATERIALS.

These Standards are all copyrighted in the name of the American Society for Testing Materials. Permission to reprint any of these Standards can be obtained only from the Executive Committee on application to the Secretary-Treasurer.

The designations A 1, A 2, etc., of the Standards are fixed; the final numbers 14, 12, etc., indicate the year of original issue, or in the case of revision, the year of last revision. The serial designation of Standards which have for any reason been discontinued are permanently dropped. In ordering Standards, the complete serial designations A 1-14, A 2-12, etc., should be stated.

A. FERROUS METALS.

STEEL.

(See also WROUGHT IRON: A 56-15.)

STANDARD SPECIFICATIONS.

Steel Rails and Accessories.

A 1-14. For Carbon-Steel Rails.¹

Second revision adopted in 1908 (Vol. VIII, pp. 44-47).

A 2-12. For Open-hearth Steel Girder and High Tee Rails.

Adopted in 1912 (Vol. XII, pp. 122-126).

¹ These specifications were originally adopted in 1901 under the title "Standard Specifications for Steel Rails." In 1909 the latter specifications were revised and divided into two specifications entitled "Standard Specifications for Bessemer Steel Rails" and "Standard Specifications for Open-hearth Steel Rails," which were revised in 1914, and combined under the present title.
A 3–14. For Low-Carbon-Steel Splice Bars.¹
   Third revision adopted in 1913 (Vol. XIII, pp. 68–69).

A 4–14. For Medium-Carbon-Steel Splice Bars.

A 5–14. For High-Carbon-Steel Splice Bars.

A 6–14. For Extra-High-Carbon-Steel Splice Bars.
   Adopted in 1913 (Vol. XIII, pp. 139–142).

A 49–15. For Quenched High-Carbon-Steel Splice Bars.

A 50–16. For Quenched Carbon-Steel Track Bolts.
   First revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

A 51–16. For Quenched Alloy-Steel Track Bolts.
   First revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

Structural Steels.

A 7–16. For Structural Steel for Bridges.²

¹ These specifications were designated "Standard Specifications for Steel Splice Bars" till 1913, when they were revised and the present title was adopted.
² These specifications, when first adopted in 1901, were combined with the Specifications for Structural Steel for Ships under the title "Standard Specifications for Structural Steel for Bridges and Ships." In 1905, these latter specifications were made to apply to ship material only, by striking out the words "Bridges and" from the title, and revised "Standard Specifications for Structural Steel for Bridges" were adopted.
A 7–16. For Structural Steel for Bridges (Continued).
Fifth Revision adopted in 1915 (Vol. XV, Part I, pp. 82 and 111).
Sixth revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 8–16. For Structural Nickel Steel.
Adopted in 1912 (Vol. XII, pp. 135–140).
First revision adopted in 1913 (Vol. XIII, pp. 72–74).
Third revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 9–16. For Structural Steel for Buildings.
Fourth revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 10–16. For Structural Steel for Locomotives.¹
Adopted in 1912 (Vol. XII, pp. 254–257).
First revision adopted in 1913 (Vol. XIII, pp. 91–92).
Third revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 11–16. For Structural Steel for Cars.
First revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 12–16. For Structural Steel for Ships.²
Fourth revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 13–14. For Rivet Steel for Ships.²
Adopted in amended form in 1901 (Vol. I, p. 250.)

¹ These specifications were designated "Standard Specifications for Locomotive Materials: Steel Shapes, Universal Mill Plates, and Bars" till 1914, when they were revised and the present title was adopted.
² See footnote to "Standard Specifications for Structural Steel for Bridges." In 1913 the "Standard Specifications for Structural Steel for Ships" were revised and divided into two specifications, entitled "Standard Specifications for Structural Steel for Ships" and "Standard Specifications for Rivet Steel for Ships."
List of Standards.

A 13-14. For Rivet Steel for Ships (Continued).

Spring Steel and Springs.

A 14-16. For Carbon-Steel Bars for Railway Springs.
   First revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

   Adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 59-16. For Silico-Manganese-Steel Bars for Automobile and Railway Springs.
   Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

A 60-16. For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs.
   Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

A 61-16. For Helical Springs for Railways.
   Proposed and published as tentative in 1915 (Vol. XV, Part I, p. 84; 1915 Year-Book, pp. 495-505).
   Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

A 62-16. For Elliptical Springs for Railways.
   Proposed and published as tentative in 1915 (Vol. XV, Part I, p. 84; 1915 Year-Book, pp. 495-505).
   Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

Reinforcement Bars.

A 15-14. For Billet-Steel Concrete Reinforcement Bars.1
   Adopted in 1911 (Vol. XI, pp. 66-68).
   First revision adopted in 1912 (Vol. XII, pp. 161-164).
   Second revision adopted in 1913 (Vol. XIII, pp. 77-78).

1 These specifications were designated "Standard Specifications for Steel Reinforcing Bars" till 1913, when they were revised and the present title was adopted.
A 16-14. For Rail-Steel Concrete Reinforcement Bars.

Steel Blooms, Forgings and Axles.
A 17-13. For Blooms, Billets and Slabs for Carbon-Steel Forgings.
A 18-16. For Carbon-Steel and Alloy-Steel Forgings.¹
Second revision adopted in 1914 (Vol. XIV, Part I, pp. 91-93).
Third revision adopted in 1916 (Vol. XVI, Part I, pp. ——).
A 19-16. For Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars.²
First revision adopted in 1912 (Vol. XII, pp. 169-173).
Second revision adopted in 1914 (Vol. XIV, Part I, pp. 91-93).
Third revision adopted in 1916 (Vol. XVI, Part I, pp. ——).
A 20-16. For Carbon-Steel Forgings for Locomotives.³
Adopted in 1912 (Vol. XII, pp. 250-253).
First revision adopted in 1913 (Vol. XIII, pp. 90-91).
Third revision adopted in 1916 (Vol. XVI, Part I, pp. ——).
A 63-16. For Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars.
Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

¹ These specifications were designated "Standard Specifications for Steel Forgings" till 1914, when they were revised and the present title was adopted.
² These specifications were designated "Standard Specifications for Heat-Treated Carbon-Steel Axles, Shafts and Similar Objects" till 1914, when they were revised and the present title was adopted.
³ These specifications were successively designated "Standard Specifications for Annealed Steel Forgings" till 1913, and "Standard Specifications for Steel Forgings" till 1914, when they were revised, and the present title was adopted.
A 21-14. For Carbon-Steel Car and Tender Axles.\(^1\)

Second revision adopted in 1913 (Vol. XIII, pp. 78-79).

A 22-16. For Cold-Rolled Steel Axles.

Proposed in 1912 (Vol. XII, pp. 48-51).
Adopted in amended form in 1913 (Vol. XIII, pp. 156-159).
Second revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

Steel Wheels and Tires.

A 57-16. For Wrought Solid Carbon-Steel Wheels for Steam Railway Service.\(^2\)

First revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

A 25-16. For Wrought Solid Carbon-Steel Wheels for Electric Railway Service.

First revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

A 26-16. For Steel Tires.

First revision adopted in 1909 (Vol. IX, pp. 58-61).
Second revision adopted in 1913 (Vol. XIII, pp. 80-81).
Fourth revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

Steel Castings.

A 27-16: For Steel Castings.

First revision adopted in 1905 (Vol. V, pp. 53-55).

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\(^1\) These specifications were designated "Standard Specifications for Steel Axles" till 1913, when they were revised and the present title was adopted.

\(^2\) Prior to 1916, the following two specifications were in force: "Standard Specifications for Forged and Rolled, Forged, or Rolled Solid Carbon-Steel Wheels for Engine-Tender, and Passenger Service," Serial Designation, A 23; and "Standard Specifications for Forged and Rolled, Forged, or Rolled Solid Carbon-Steel Wheels for Freight-Car Service," Serial Designation: A 24. In 1916 these two specifications were revised and combined under the present title and serial designation A 57.
A 27–16. For Steel Castings (Continued).

Third revision adopted in 1913 (Vol. XIII, pp. 81–84).
Fifth revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

Steel Tubes and Pipe.
A 28–16. For Lap-Welded and Seamless Steel Boiler Tubes, Boiler Flues, Superheater Pipes, Safe Ends, and Arch Tubes for Locomotives.¹

Adopted in 1912 (Vol. XII, pp. 258–260).
First revision adopted in 1913 (Vol. XIII, pp. 84–86).
Second revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 52–15. For Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service.²


Automobile Steels (see also Spring Steel).
A 29–16. For Automobile Carbon and Alloy Steels.

Adopted in 1912 (Vol. XII, pp. 196–203).
Fourth revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

Boiler Steels.
A 30–16. For Boiler and Firebox Steel for Locomotives.³

Second revision adopted in 1912 (Vol. XII, pp. 152–156).

¹ These specifications were successively designated "Standard Specifications for Lap-Welded and Seamless Steel Boiler Tubes and Safe Ends, 2½ in. diameter and under" till 1913, and "Standard Specifications for Lap-Welded and Seamless Steel Boiler Tubes, Safe Ends, and Arch Tubes" till 1916, when they were revised and the present title was adopted.
² These specifications were designated "Standard Specifications for Lap-Welded and Seamless Boiler Tubes for Stationary Service" till 1916, when the title was changed to the present form at the direction of the Executive Committee.
³ These specifications were originally adopted in 1901 under the title "Standard Specifications for Open-hearth Boiler Plate and Rivet Steel." In 1902 these latter specifications were revised and divided into two specifications, entitled "Standard Specifications for Boiler and Firebox Steel" and "Standard Specifications for Boiler Rivet Steel." In 1916 the first of these specifications (now designated A 30) was revised and the present title was adopted.
A 30-16. For Boiler and Firebox Steel for Locomotives (Continued).

Third revision adopted in 1913 (Vol. XIII, p. 88).
Fifth revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

A 31-14. For Boiler Rivet Steel. ¹

First revision adopted in 1909 (Vol. IX, pp. 51-55).
Second revision adopted in 1912 (Vol. XII, pp. 157-160).

Cold-Drawn Steels.

A 32-14. For Cold-Drawn Bessemer Steel Automatic Screw Stock.


A 54-15. For Cold-Drawn Open-hearth Steel Automatic Screw Stock.

Published as tentative in amended form in 1914 (Vol. XIV, Part I, pp. 172-175; 1914 Year-Book, pp. 368-369).

Standard Tests.

A 34-14. For Magnetic Properties of Iron and Steel. ²

First revision adopted in 1912 (Vol. XII, pp. 210-214).

Standard Methods.

A 33-14. For Chemical Analysis of Plain Carbon Steel.


A 55-15. For Chemical Analysis of Alloy Steels.

Adopted in 1915 (Vol. XV, Part I, p. 87).

¹ These specifications were originally adopted in 1901 under the title "Standard Specifications for Open-hearth Boiler Plate and Rivet Steel." In 1912 these latter specifications were revised and divided into two specifications, entitled "Standard Specifications for Boiler and Firebox Steel" and "Standard Specifications for Boiler Rivet Steel." In 1916 the first of these specifications (now designated A 30) was revised and the present title was adopted.

² These tests were designated "Standard Magnetic Tests of Iron and Steel" till 1916, when the title was changed to the present form at the direction of the Executive Committee.
RECOMMENDED PRACTICE.

A 35-11. For Annealing of Miscellaneous Rolled and Forged Carbon-Steel Objects.
Adopted in 1911 (Vol. XI, pp. 86-91).

A 36-14. For Annealing of Carbon-Steel Castings.

Proposed in 1913 (Vol. XIII, pp. 188-189).

WROUGHT IRON.
(See also STEEL: A 52-15, A 53-15.)

STANDARD SPECIFICATIONS.

A 38-16. For Lap-Welded Charcoal-Iron Boiler Tubes, Boiler Flues, Safe Ends, and Arch Tubes for Locomotives.
Adopted in 1912 (Vol. XII, pp. 264-266).
First revision adopted in 1916 (Vol. XVI, Part I, pp. ———).

A 39-14. For Staybolt Iron.2
First revision adopted in 1912 (Vol. XII, pp. 261-263).

A 40-13. For Engine-Bolt Iron.2
Adopted in 1912 (Vol. XII, pp. 215-217).
First revision adopted in 1913 (Vol. XIII, p. 183).

A 41-13. For Refined Wrought-Iron Bars.2
Adopted in 1912 (Vol. XII, pp. 218-221).
First revision adopted in 1913 (Vol. XIII, p. 183).


A 56-15. For Iron and Steel Chain.

1 These specifications were designated "Standard Specifications for Lap-Welded Iron Boiler Tubes" till 1916, when they were revised and the present title was adopted.
2 These specifications supersede the "Standard Specifications for Wrought Iron," which were proposed in 1900, (Vol. I, pp. 129-134), and adopted in amended form in 1901 (Vol. I, pp. 231-235).
List of Standards.

PIG IRON, CAST IRON, AND FINISHED CASTINGS.

Standard Specifications.

A 43–09. For Foundry Pig Iron.

Proposed in 1904 (Vol. IV, p. 44).
Adopted in amended form in 1904 (Vol. IV, pp. 103–104).

A 44–04. For Cast-Iron Pipe and Special Castings.

A 45–14. For Cast-Iron Locomotive Cylinders.\(^1\)

Proposed in 1904 (Vol. IV, pp. 69–70).
Adopted in amended form in 1904 (Vol. IV, p. 69).
Revised specifications proposed in 1911 (Vol. XI, pp. 83–84).

A 46–05. For Cast-Iron Car Wheels.
Proposed in 1904 (Vol. IV, pp. 74–79).

A 47–15. For Malleable-Iron Castings.\(^2\)

Proposed in 1904 (Vol. IV, pp. 95–96).
Adopted in amended form 1904 (Vol. IV, p. 96).

A 48–05. For Gray-Iron Castings.
Proposed in 1904 (Vol. IV, pp. 97–100).

Standard Methods.

A 64–16. For Sampling and Analysis of Pig and Cast Iron.
Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

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\(^1\) These specifications were designated "Standard Specifications for Locomotive Cylinders" till 1916, when the title was changed to the present form at the direction of the Executive Committee.

\(^2\) These specifications were designated "Standard Specifications for Malleable Castings," till 1915, when they were revised and the present title was adopted.
B. NON-FERROUS METALS.

STANDARD SPECIFICATIONS.

B 1-15. For Hard-Drawn Copper Wire.
Adopted in 1909 (Vol. IX, pp. 311-318).

Adopted in 1912 (Vol. XII, pp. 277-285).
First revision adopted in 1913 (Vol. XIII, p. 201).

B 3-15. For Soft or Annealed Copper Wire.
Adopted in 1912 (Vol. XII, pp. 286-291).
First revision adopted in 1913 (Vol. XIII, p. 201).

B 8-16. For Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft.
Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

B 9-16. For High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity.
Adopted in 1916 (Vol. XVI, Part I, pp. ——).

B 4-13. For Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars.¹

B 5-13. For Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars.¹

¹These specifications were originally adopted in 1911 under the title “Standard Specifications for Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars.” In 1913 these latter specifications were revised and divided into two specifications, covering Lake and Electrolytic copper respectively.
B 6–14. For Spelter.

B 7–14. For Manganese-Bronze Ingots for Sand Castings.

C. CEMENT, LIME, GYPSUM, AND CLAY PRODUCTS.

STANDARD SPECIFICATIONS.

First revision adopted in 1908 (Vol. VIII, pp. 149–164).
Third revision adopted in 1916, to become effective January 1, 1917 (Vol. XVI, Part I, pp. ——).

C 10–09. For Natural Cement.
First revision adopted in 1908 (Vol. VIII, pp. 149–164).

C 4–16. For Drain Tile.
First revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

C 5–15. For Quicklime.

1 These specifications were designated "Standard Specifications for Manganese-Bronze Ingots." till 1914, when they were revised and the present title was adopted.  
2 These specifications were originally adopted in 1904 under the title "Standard Specifications for Cement," and were later designated C 1. In 1916, the requirements for Portland cement were revised while those for natural cement were left unchanged; the former is published under its present title and serial designation C 9, the latter under the designation C 10.
LIST OF STANDARDS.

C 6-15. For Hydrated Lime.
   Published as tentative in 1914 (Vol. XIV, Part I, pp. 213-220;
   1914 Year-Book, pp. 373-375).

C 7-15. For Paving Brick.

STANDARD TESTS.

C 2-08. For Fireproof Floor Construction.
   Proposed in 1906 (Vol. VI, pp. 126-128).
   First revision adopted in 1908 (Vol. VIII, pp. 210-212).

C 3-09. For Fireproof Partition Construction.
   Proposed in 1908 (Vol. VIII, pp. 207-209).

STANDARD DEFINITIONS.

C 8-15. Of Terms Relating to Sewer Pipe.

D. MISCELLANEOUS MATERIALS.

STANDARD SPECIFICATIONS.

D 1-15. For Purity of Raw Linseed Oil from North American Seed.
   Adopted in 1913 (Vol. XIII, pp. 399-401).
   First revision adopted in 1915 (Vol. XV, Part I, pp. 186 and
   224-232).

D 11-15. For Purity of Boiled Linseed Oil from North American Seed.

D 12-16. For Purity of Raw Tung Oil.¹
   First revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

¹These specifications were designated "Standard Specifications for Purity of Raw
Chinese Wood Oil" till 1916, when they were revised and the present title was adopted.
D 13–15. For Turpentine.


D 17–16. For Foundry Coke.

Adopted in 1916 (Vol. XVI, Part I, pp. ——).

D 10–15. For Yellow-Pine Bridge and Trestle Timbers.


**Standard Tests.**

D 2–08. For Abrasion of Road Material.


D 3–08. For Toughness of Macadam Rock.


D 4–11. For Soluble Bitumen.


D 5–16. For Penetration of Bituminous Materials.1


D 6–16. For Loss on Heating of Oil and Asphalitic Compounds.

First revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

1This test was designated "Standard Test for Penetration of Bitumen" till 1916, when it was revised and the present title was adopted.
List of Standards.

Standard Methods.

D 7–16. For Making a Mechanical Analysis of Sand or Other Fine Highway Material, except for Fine Aggregates Used in Cement Concrete.\(^1\)

Adopted in 1911 (Vol. XI, p. 249).
First revision adopted in 1916 (Vol. XVI, Part I, pp. ——).

D 18–16. For Making a Mechanical Analysis of Broken Stone or Broken Slag, except for Aggregates Used in Cement Concrete.

Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

D 19–16. For Making a Mechanical Analysis of Mixtures of Sand or Other Fine Material with Broken Stone or Broken Slag, except for Aggregates Used in Cement Concrete.

Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

D 20–16. For Distillation of Bituminous Materials Suitable for Road Treatment.

Proposed and published as tentative in 1911 (Vol. XI, pp. 241–244).
Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

D 21–16. For Sampling of Coal.

Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

D 22–16. For Laboratory Sampling and Analysis of Coal.

Adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).


\(^1\) This method was designated "Standard Method for Sizing and Separating the Aggregate in Asphalt Paving Mixtures" till 1916, when it was revised and the present title was adopted.
LIST OF STANDARDS.

STANDARD DEFINITIONS.

Published in 1914 (Vol. XIV, Part I, pp. 224-226).

D 8-15. Of Terms Relating to Materials for Roads and Pavements.¹
Adopted in 1912 (Vol. XII, p. 362).
First revision adopted in 1915 (Vol. XV, Part I, pp. 325-331).

D 9-15. Of Terms Relating to Structural Timber.²
Proposed in 1906 (Vol. VI, pp. 129-133).

E. MISCELLANEOUS SUBJECTS.

STANDARD METHODS.

E 1-16. For Testing.

I. For Tension Tests of Metals.
Second revision published as tentative in 1915 (Vol. XV, Part I, pp. 443-448); adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

II. For Compression Tests of Metals.
First revision published as tentative in 1915 (Vol. XV, Part I, pp. 443-448); adopted in amended form in 1916 (Vol. XVI, Part I, pp. ——).

¹ These definitions were designated "Standard Definitions of Terms Applicable to Materials Relating to Roads and Pavements" till 1916, when the title was changed to the present form at the direction of the Executive Committee.

² These definitions originally included "Standard Specifications for Bridge and Trestle Timbers," and were designated "Standard Specifications for Structural Timber" till the adoption, in 1910, of separate "Standard Specifications for Yellow-Pine Bridge and Trestle Timbers." Till 1915 they were designated "Standard Classification of Structural Timber," when they were revised and the present title was adopted.
III. For Transverse Tests of Metals.

IV. For Brinell Hardness Tests of Metals.

V. For Metallographic Tests of Metals.
LIST OF TENTATIVE STANDARDS
PUBLISHED BY THE
AMERICAN SOCIETY FOR TESTING MATERIALS.

The term Tentative Standards is applied to a proposed Standard which is printed in the Proceedings for one or two years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards the adoption of such Tentative Standards by formal action of the Society.

The significance of the serial designation for the Tentative Standards is as explained under the title of the preceding List of Standards, except for the addition of the letter T.

A. FERROUS METALS.

Specifications.

A 65–16 T. For Steel Track Spikes.
Proposed in 1916 (Volume XVI, Part I, pp. —).

A 66–16 T. For Steel Screw Spikes.
Proposed in 1916 (Volume XVI, Part I, pp. —).

A 67–16 T. For Steel Tie Plates.
Proposed in 1916 (Volume XVI, Part I, pp. —).

A 68–16 T. For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements.
Proposed in 1916 (Volume XVI, Part I, pp. —).

A 69–16 T. For Elliptical Springs for Automobiles.
Proposed in 1916 (Volume XVI, Part I, pp. —).

A 70–16 T. For Boiler and Firebox Steel for Stationary Service.
Proposed in 1916 (Volume XVI, Part I, pp. —).

(729)
B. NON-FERROUS METALS.

Specifications.

B 10–15 T. For the Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent.
Continued as tentative in 1916 (Volume XVI, Part I, pp. —).

B 11–16 T. For Copper Plates for Locomotive Fireboxes.
Proposed in 1916 (Volume XVI, Part I, pp. —).

B 12–16 T. For Copper Bars for Locomotive Staybolts.
Proposed in 1916 (Volume XVI, Part I, pp. —).

B 13–16 T. For Seamless Copper Boiler Tubes.
Proposed in 1916 (Volume XVI, Part I, pp. —).

B 14–16 T. For Seamless Brass Boiler Tubes.
Proposed in 1916 (Volume XVI, Part I, pp. —).

C. CEMENT, LIME, GYPSUM, AND CLAY PRODUCTS.

Definitions.

C 11–16 T. Of Terms Relating to the Gypsum Industry.
Proposed in 1916 (Volume XVI, Part I, pp. —).

Recommended Practice.

C 12–16 T. For Laying of Sewer Pipe.
Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. —).
D. MISCELLANEOUS MATERIALS.

SPECIFICATIONS.

D 23–16 T. For Selected Structural Douglas Fir Bridge and Trestle Timbers.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 24–15 T. For Southern Yellow-Pine Timber to be Creosoted.
Continued as tentative in 1916 (Volume XVI, Part I, pp. —).

D 25–15 T. For Southern Yellow-Pine Piles and Poles to be Creosoted.
Continued as tentative in 1916 (Volume XVI, Part I, pp. —).

D 26–16 T. For 2\frac{1}{2}, 3, and 3\frac{1}{2}-in. Double-Jacketed Cotton Rubber-Lined Fire Hose for Public Fire Department Use.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 27–16 T. For Insulated Wire and Cable: 30 per cent Hevea Rubber.
Proposed in 1916 (Volume XVI, Part I, pp. —).

TESTS.

D 28–16 T. For Paint Thinners Other than Turpentine.
Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. —).

D 29–16 T. For Shellac.
Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. —).
List of Tentative Standards.

D 30-16 T. For Determination of Apparent Specific Gravity of Homogeneous Coarse Aggregates.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 31-16 T. For Automobile Tire Fabrics.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 32-16 T. For Cotton Fabrics for Use in Hose, Belting, and Similar Articles.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 33-16 T. For Cotton Fabrics for Use in Bags and Bagging Material.
Proposed in 1916 (Volume XVI, Part I, pp. —).

Methods.

D 34-15 T. For Routine Analysis of White Pigments.
Continued as tentative in 1916 (Volume XVI, Part I, pp. —).

D 35-16 T. Form of Specifications for Certain Commercial Grades of Broken Stone.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 36-16 T. For Determination of Softening Point of Bituminous Materials Other than Tar Products.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 37-16 T. For Laboratory Sampling and Analysis of Coke.
Proposed in 1916 (Volume XVI, Part I, pp. —).

D 38-16 T. For Sampling and Analysis of Creosote Oil.
Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. —).

D 39-16 T. For Testing Cotton Fabrics.
Continued as tentative in amended form in 1916 (Volume XVI, Part I, pp. —).
List of Tentative Standards.

Tentative revisions have been proposed in the standards indicated below:


   The proposed revision consists in the addition of Specifications and Tests for Compressive Strength of Portland Cement Mortar.


   The proposed revision consists of the addition of certain new definitions.
## PRICE LIST OF PUBLICATIONS

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