SUBCOMMITTEE ON MATERIALS
2016 Annual Meeting – Greenville, SC
Monday August 1, 2016
11:30 AM – 12:30 PM EST

TECHNICAL SECTION 4f

Structural Components and Concrete Reinforcement
Meeting Minutes

I. Call to Order and Opening Remarks
- iPad attendance is being passed around
- TS 4h is being absorbed into this tech section

II. Roll Call

The list of all attendees is attached.

Voting Members:

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<td>William Bailey</td>
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Friends and Non-Voting Members:

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III. Approval of Technical Section Minutes

Minutes of the August 5, 2015 TS 4f meeting in Pittsburgh, PA were approved at the mid-year web meeting held January 20, 2016.

Minutes from the January 20, 2016 mid-year web meeting need approval. Motion made by VA to accept as written, seconded by PA. All were in favor of passing the minutes.

IV. Old Business

A. SOM Ballot Items

1. Had four items on a reconfirmation ballot (M102, M202, M203, M275, and T253). All items passed but there were several comments provided mentioning newer ASTM versions to consider for equivalency. This is a work in progress.

2. T253 was reconfirmed but the National Concrete Consortium Group was reviewing the standard to bring it up to date and has since provided a revised standard for TS4f consideration. These revisions were included on technical section ballot SOM_TS4f-16-02 that closed 6/30/16.

B. TS Ballots


   This ballot consisted of five items all of which centered on revisions to MP18, Standard Specification for Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels.
   All five items each received 13 affirmatives, 1 negative (Alaska), and 2 no-votes.
   Comments were received by Alaska, Missouri and Pennsylvania.
Since these ballot items were the result of work done by the members of Task Force 2015-01, the comments were turned over to task force chair Bill Bailey of Virginia for his consideration.

The one negative received for each of the five items was from Alaska and the comment provided for each was: Having worked on turning MP18 into a usable Standard I had always assumed (incorrectly) that the corrosion test methods house in MP18 Appendix would be first assigned provisional numbers (including the Macrocell Slab Chloride Threshold Test) as placeholders for MP18 to be balloted as a Standard. After MP18 transitioned into a Full Standard I assumed that after each Provisional Test Method became a Full Test Method the Standard’s Provisional Test Method Numbering would be changed by the TS Chair editorially. The TS ballot does not address the Macrocell Slab Chloride Threshold Test and does not reflect the others using the Provisional Numbering system. We may have a "chicken or the egg" issue.

Mr. Bailey has contacted Alaska about the comment to better explain the rationale behind the way the standards were balloted. Additionally he has worked with industry representatives to address the comments from Missouri and Pennsylvania.

**Action needed:** TS 4f needs to consider the comments provided and take action on the negative vote for each of these five standards in consideration for moving some or all of them to the full SOM ballot.

This task force was led by Bill Bailey (VA) along with some others plus industry. They did a lot of work this past year. The task force split out sections of it into their own potential standards. It was received pretty well by the states. Bill worked with AK, which allowed them to withdraw their negative. No other negatives. AK, MO, PA provided comments. All comments that came back were editorial. Once these editorial changes are made, these standards can be taken to the SOM ballot. VA makes a motion to move MP18 and the other standards (T MP18a.1, T MP18a.2, T MP18a.3, and T MP18b.1) to full SOM ballot, seconded by RI. All were in favor.

**Follow-up note from Chair: Alaska sent me an email withdrawing the negatives.**

Within some of the appendixes, there were some tests associated with ranking chromium alloy steels. States can refer to this for classifying the materials they use. Tombstone test and microcell test gave a way to determine the chromium alloy usage. These tests were sent out for TS ballot. FL makes the motion, GA seconded it to have this standard go to concurrent ballot. This is T MP18a.4. All were in favor of this motion.

See attachment for MP18 and responses to all comments.

2. **SOM_TS4f-16-02 – Closed June 30, 2016.** This ballot consisted of five items:

   **Item 1: MP XYZ** – Is a proposed new standard to have equivalence to ASTM A1064 with some key differences. ASTM A1064 is Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete. ASTM A1064 was the result of a combination of four wire standards and the new MP XYZ is to combine the equivalent four AASHTO standards in a similar manner.
Affirmative votes - 12 with comments from Kansas, Missouri, Pennsylvania
Negative votes – 0
No-votes – 3
PA provided many editorial comments. There have been some recent updates to ASTM A1064. PA would like to have information to include carbon and magnesium frequencies. Once this TS receives comments from Robert Sarcinella, a call will be scheduled to have this standard move forward to TS ballot. See attachment.

Item 2: M254, Corrosion-Resistant Coated Dowel Bars, was reviewed by industry representative Steve Tritsch of JC Supply on behalf of CRSI and he provided extensive revisions for consideration.

Affirmative votes – 10 with comments from Kansas, Virginia
Negative votes – 2 from Missouri, Pennsylvania
No-votes – 3 with comments from California, International Zinc Association

The Chair is not ready to move forward with this standard. MO would like to withdraw their negative since they learned since then what changes were made to the standard. PA still has their negative. See attachment.

Item 3: T253, Coated Dowel Bars, was also reviewed and revised by Mr. Tritsch.

Affirmative votes – 9 with comments from Kansas
Negative votes – 3 from Missouri, Pennsylvania, Virginia
No-votes – 3 with comments from California, International Zinc Association

Chair sent them to CRSI for review. MO would like to withdraw their negative. See attachment.

Item 4: During the mid-year web meeting the TS voted to sunset M270 since the industry standard is ASTM A709 and there is no significant difference between the two standards.

Affirmative votes – 11 with no comments
Negative votes – 1 from Pennsylvania
No-votes – 3 with a comment from California

PA would like to withdraw their negative. This standard can move to the full SOM standard to sunset this standard. Motion made VA to move it to SOM ballot, seconded it by PA. See attachment.

Item 5: Illinois did an extensive review of M31 and made proposed revisions to bring it up to date. Additionally, since several states use ASTM A706 and there is no AASHTO equivalent for it the equivalent portions of ASTM A706 were added to this M31 revision.

Affirmative votes – 12 with comments from Kansas, Missouri, Pennsylvania
Negative votes – 0
No-votes – 3
This standard was sent to KY, MO, and PA for review to see if IL’s revisions take care of their negatives. Motion made by VA to take this standard to a full SOM ballot, seconded it by FL. All were in favor. See attachment.

C. Task Force Reports

Task Force 2015-01 – Revisions to MP18, Standard Specification for Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels. Task force chair, Bill Bailey of Virginia, has done extensive work on this standard with lots of industry input along the way. At the mid-year web meeting it was reported that annexes were going to be removed from MP18 since they are test methods and not specifications. These revised documents then had task force review and were eventually included as a TS ballot (SOM_TS4f-16-01).

Bill Bailey would like continue this task force until it becomes a full standard.

V. New Business
A. Research Proposals

1. 20-7 RPS – None submitted
2. Full NCHRP RPS – None submitted

B. AMRL/CCRL - Observations from Assessments?

C. NCHRP Issues?

D. Correspondence, calls, meetings

Chair had discussion with Robert Sarcinella of AASHTO about a possible specification for the proper way to document the “Buy America” requirements for steel and iron products. Sarc would help develop the document and would like to have SOM TS4f backing to then approach the FHWA with the proposal. This would really help the states, the FHWA and the manufacturers.

OK thinks this would be a complicated task. Every FHWA office in each state requires something differently. FL would like for FHWA to weigh in to tell the states what kind of detail needs to be included to meet the Buy America requirements. A joint task force with NTPEP was put together. Volunteers are as follows FL, OK, PA, AL and SC. NTPEP will reach out to the Reinforcing Steel and Guardrail/Guiderail technical committees to get more volunteers. (SOM_TS 4f-1-2016)

E. Proposed New Standards

Weld pull test from T244 came from TS 4a. NV made revisions for consideration. This standard now has to go out for TS ballot. ACPA helped PA put this standard together. This would be added as an appendix document.
F. Proposed New Task Forces

A joint task force with NTPEP was put together. Volunteers are as follows FL, OK, PA, AL and SC. NTPEP will reach out to the Reinforcing Steel and Guardrail/Guiderail technical committees to get more volunteers. (SOM_TS 4f-1-2016)

G. Standards Requiring Reconfirmation

**M227** – Will be sent out for reconfirmation

**M 54** - Had a suggested editorial revision from New Jersey. Made the change and will be sending it out for reconfirmation

**MP 22**- Changes came from RI. They would like to have it be a concurrent ballot item. This was sent out to the TS members. These revisions need additional review.

H. SOM Ballot Items (including any ASTM changes/ equivalencies)

Chair needs to investigate ASTM equivalency updates for a number of the standards.

VI. Open Discussion

Merrill Zwanka gave an Award of Appreciation to Bill Bailey for all of the work he did with the task force he led this year.

VII. Adjourn
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KY TC
KY Transportation Cabinet
TX DOT
LA DOTD
DE DOT
Consultant
AZ DOT
US Foundry
Interplastic
Raba Kistner Infrastructure
Region Manager Rinker Pipe
SC DOT
MS DOT
American Concrete Pipe Association
NYS DOT
National Msrketing Specialist- AZZ
MS DOT
National Concrete Pavement Technology Center
EJ
Revisions to MP18 per Task Force recommendations

Item Number: 1

Description:

TS Ballot Item to move MP 18M/MP 18-15 Standard Specification for Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels to a full specification standard.

This provisional standard has reached its 8 year time limit as a provisional standard. A task force has reviewed this provisional standard and separated the provisional specification portion of MP 18 from the provisional test methods that were included in the standard as annexes. The major adjustments were to Section 11 and 17 which referenced the annexes A1, A2, A3 and B1. The grade 75 steel was increased to grade 80 to correspond with ASTM changes and Section 23, Storage and Handling, was added. The task force is recommending to the technical section that the specification portion of MP 18 is ready to be elevated to a full specification standard.

Decisions:

Affirmative: 13 of 16
Negative: 1 of 16
No Vote: 2 of 16

Ballot Item Number 1 – “MP 18” Affirmative with comments

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<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
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<tr>
<td>Pennsylvania Department of Transportation (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>1. In Section 1.1, Note 2, add a comma after the word &quot;conditions&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>2. In Section 4.2.1, Note 5, this Note 5 appears to be mandatory and this should probably not be a Note. Recommend to add the language contained in this Note 5 to the end of existing language in Section 4.2.1.</td>
<td>Deleted Note 5 and Revise Section 4.2.1 to read: Certified mill test reports are required.</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>3. In Section 5.1, revise first part of sentence from &quot;The steel reinforcement bars and dowels&quot; to &quot;The steel bars for concrete reinforcement and dowels&quot; to be consistent with the title of this standard.</td>
<td>Accepted and revised Section 5.1 to “The steel reinforcement bars and dowels conforming to this standard shall be rolled from…”</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>4. In Table 1, should there be a section for ferritic stainless steels? The proposed ballot item #2 (MP 18a.1 - Sensitivity of Stainless Steel to Intergranular Attack) references test requirements for &quot;ferritic stainless steels&quot; in MP 18a.1 Sections 2.2, 3.2, 4.2, 5.3, 6.2 and 7.2, but this MP 18M/M 18, Table 1 does not include &quot;ferritic stainless steels&quot;.</td>
<td>The overall plan for MP 18 is to include all types of stainless steels that are commercially available. Table 1 is the best guess, at the present time, of the types of...</td>
</tr>
</tbody>
</table>
steels that manufacturers are making for construction. Ferritic Stainless bars (series 400) were not recommended as a possible stainless steel alloy for construction three years ago by industry. If ferritic stainless steels move into the marketplace an agency can request they be included in Table 1 at that time. It seemed wise at the time MP 18 a.1 was developed to add test requirements for all types of stainless steels.

| Penn DOT (Timothy L Ramirez) (tramirez@pa.gov) | 5. In Section 9.3, Note 6, revise from "T244" to "T 244" (i.e., add a space between the "T" and "244"). Accepted and made editorial revision |
| Penn DOT (Timothy L Ramirez) (tramirez@pa.gov) | 6. In Section 14.1, revise from "T244" to "T 244" (i.e., add a space between the "T" and "244"). Accepted and made editorial revision |
| Penn DOT (Timothy L Ramirez) (tramirez@pa.gov) | 7. In Section 19.1, revise from "Sections 6.2" to "Sections 6.3" to be consistent with the referenced sections in Section 18.1 and to reference tests performed by the purchaser in Section 6.3 rather than tests performed by the manufacturer in Section 6.2. Revised Section 18.1 to add reference to Section 6.2; and included reference to Section 6.3 in Section 19.1. |
| Penn DOT (Timothy L Ramirez) (tramirez@pa.gov) | 8. In Section 22.2, revise from "Only-for" to "Only-For". Revise Section 22.2. to: Only For United States Government Procurement |
| Penn DOT (Timothy L Ramirez) (tramirez@pa.gov) | 9. In Section 23.1, Note 10, the language in this note seems and probably should be mandatory and therefore should not be a Note. Deleted “Note 10” leaving the language in note 10 as part of Section 23.1 |
| Penn DOT (Timothy L Ramirez) (tramirez@pa.gov) | 10. In Section 23.1, Note 10, revise from "reinforcement and bars from other grades of steel reinforcement and bar material" to "bars for concrete reinforcement and dowels from other grades of steel bar for concrete reinforcement and dowels" to be consistent with the title of this section. Revised Section 23.1 sentence 2 to "bars for concrete reinforcement and dowels from other grades of steel bar for concrete reinforcement and dowels" |

Ballot Item Number 1 – “MP 18” Negative Vote

<table>
<thead>
<tr>
<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
</tr>
</thead>
</table>
| Alaska Department of Transportation and Public Facilities (Michael San Angelo, P.E.) (michael.sanangelo@alaska.gov) | Having worked on turning MP18 into a usable Standard I had always assumed (incorrectly) that the corrosion test methods house in MP18 Appendix would be first assigned provisional numbers (including the Macrocell Slab Chloride Threshold Test) as placeholders for MP18 to be balloted as a Standard. After MP18 transitioned into a Full Standard I assumed that after each Provisional Test Method became a Full Test Method the Standard’s Provisional Test Method Numbering would be | Email Bill Bailey to Mike San Angelo 06-17-16  
- Asked Mike to withdrawing at least the negative on 5) MP 18 and 1) MP 18a.2 because these two standards have in my opinion both severed there time as provisional standards (8 |
changed by the TS Chair editorially. The TS ballot does not address the Macrocell Slab Chloride Threshold Test and does not reflect the others using the Provisional Numbering system. We may have a "chicken or the egg" issue.

### Ballot Item Number 2 – “MP18a.1”

<table>
<thead>
<tr>
<th>Item Number:</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>TS Ballot Item to move Annex A1 of MP 18 now called: T MP18a.1 Standard Method of Test for Sensitivity of Stainless Steel to Intergranular Attack to a full test standard. This Annex was included in MP18 as a short term corrosion test that can be requested by purchaser to assure quality of stainless steels when the provisional standard specification was expanded to include stainless steels. Adjustments were made to Section 1 to match AASHTO style and formatting. The task force is recommending to the technical section that this test portion of MP 18 is ready to be elevated to a full standard method of test.</td>
</tr>
</tbody>
</table>

| Decisions: | Affirmative: 13 of 16  
Negative: 1 of 16  
No Vote: 2 of 16 |

### Ballot Item Number 2 – “MP18a.1” Affirmative with comments

<table>
<thead>
<tr>
<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missouri Department of Transportation (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>)</td>
<td>Affirmative vote with an editorial comment: Assuming the designation (T MP18a.1) will be changed, if approved.</td>
<td>Yes, this is a temporary designation used by the task force to signify that this new standard is a Test (T) from the provisional specification MP18 and it is the first test in the appendix 1 (a.1).</td>
</tr>
<tr>
<td>Pennsylvania Department of</td>
<td>Affirmative with comments:</td>
<td>Accepted, made editorial revision and</td>
</tr>
</tbody>
</table>
1. In Section 1.1, last sentence, revise from "These tests, however, are" to "These tests are". It does not seem necessary to include the word "however". The overall plan for MP 18 is to include all types of stainless steels that are commercially available. Table 1 is the best guess, at the present time, of the types of steels that manufacturers are making for construction. Ferritic Stainless bars (series 400) were not recommended as a possible stainless steel alloy for construction three years ago by industry. If ferritic stainless steels move into the marketplace an agency can request they be included in Table 1 at that time. It seemed wise at the time MP 18a.1 was developed to add test requirements for all types of stainless steels.

2. In Sections 2.2, 3.2, 4.2, 5.3, 6.2, and 7.2, "ferritic steels" are referenced, but ferritic steel is not referenced in the proposed MP 18M/M 18, Table 1 (ballot item #1). The overall plan for MP 18 is to include all types of stainless steels that are commercially available. Table 1 is the best guess, at the present time, of the types of steels that manufacturers are making for construction. Ferritic Stainless bars (series 400) were not recommended as a possible stainless steel alloy for construction three years ago by industry. If ferritic stainless steels move into the marketplace an agency can request they be included in Table 1 at that time. It seemed wise at the time MP 18a.1 was developed to add test requirements for all types of stainless steels.

3. In Sections 3.3, 4.3, 5.4, 6.3, and 7.3, revise all locations from "ferritic-austenitic (duplex)" to "duplex (austenitic-ferritic)" to be consistent with the order of the words "duplex", "austenitic" and "ferritic" in MP 18M/M 18, Table 1 and within Section 2.2 of this ballot item in reference to ASTM A923 which agrees with the order of the words "duplex", "austenitic" and "ferritic" in MP 18M/M 18, Table 1. Accepted and made editorial revision.

4. Before Section 8, recommend adding a new Section for Precision and Bias and then having the language in this new Section reference any Precision and Bias estimates in the referenced ASTM A262, ASTM A763, and ASTM A923. No P&B is available in any of these 3 standards but these ASTM standards each contain a specific section for precision and bias to indicate if precision and bias is available or not.

Precision & Bias statements are being determined for a couple of methods in A262 that involve weight loss determinations but the visual evaluations methods have no P&B statements. There are no P&B for either A763 or A923 at the present time. For exact language of precision & bias statements see MP 18a.1 Section 8.

5. In Section 8.1, add "austenitic stainless steel", "ferritic stainless steel", "duplex austenitic-ferretic stainless steel", and "intergranular attack". Added these keywords to Section 8.1
Having worked on turning MP18 into a usable Standard I had always assumed (incorrectly) that the corrosion test methods house in MP18 Appendix would be first assigned provisional numbers (including the Macrocell Slab Chloride Threshold Test) as placeholders for MP18 to be balloted as a Standard. After MP18 transitioned into a Full Standard I assumed that after each Provisional Test Method became a Full Test Method the Standard’s Provisional Test Method Numbering would be changed by the TS Chair editorially. The TS ballot does not address the Macrocell Slab Chloride Threshold Test and does not reflect the others using the Provisional Numbering system. We may have a "chicken or the egg" issue.

Email: Bill Bailey to Mike San Angelo 06-17-16
- I do not consider MP 18 a.1 or MP 18 a.3 to fit into the category of evolving or undergoing a number of changes in the next year or next few years. They are tests that Industry and DOT are using now.

Email: Michael San Angelo to Merrill Zwanka 07-15-2016
- Michael San Angelo withdrew his negatives.
- The Task force took up the Macrocell slab chloride test in July.

### Ballot Item Number 3 – “MP18a.2”

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
</tr>
</thead>
</table>
| 3           | TS Ballot Item to move Annex A2 of MP 18 now called: T MP18a.2 Standard Method of Test for Comparative Qualitative Corrosion Characterization of Steel Bars Used in Concrete Reinforcement (Linear Polarization Resistance and Potentiodynamic Polarization Tests) to a full test standard.  
This Annex has been included in MP18 as a qualitative corrosion test to check resistance of steel to chloride attack for steels in the provisional... |
standard specification. Originally this test was used to demonstrate A1035 steel’s improved resistance to chloride attack. This Annex has been in the provisional standard for 8 years. Adjustments were made to Section 1 to match AASHTO style and formatting.

The task force is recommending to the technical section that this test portion of MP 18 is ready to be elevated to a full standard method of test.

Decisions:
Affirmative: 13 of 16 –
Negative: 1 of 16 -
No Vote: 2 of 16

Ballot Item Number 3 – “MP18a.2” Affirmative with comments

<table>
<thead>
<tr>
<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missouri Department of Transportation (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>)</td>
<td>Assuming the designation (T MP18a.2) will be changed, if approved.</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania Department of Transportation (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>1. On 1st and 2nd pages of this standard, revise the title from &quot;Steel Bars used in Concrete Reinforcement&quot; to &quot;Steel Bars used for Concrete Reinforcement&quot; to be consistent with use of &quot;for&quot; in the title of MP 18M/MP 18.</td>
<td>T “MP18a.2” is a designation until a T number has been assigned by AASHTO</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>2. In Section 1.1, last sentence, revise from &quot;The test methods evaluates&quot; to &quot;The test methods evaluate&quot; (i.e., delete the &quot;s&quot; from &quot;evaluates&quot;) for better readability.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>3. In Section 3.6, revise from &quot;Section A2.5.4&quot; to &quot;Section 5.4&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>4. In Section 5.1.1, add a comma after each of the words &quot;machined&quot; and &quot;specimen&quot; for better readability.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>5. In Section 5.3.1, last line, revise from &quot;atwo&quot; to &quot;a two&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>6. In Section 5.3.2, this subsection does not appear to be necessary any longer since it references &quot;electrical insulation&quot; which is a reference to the &quot;heat shrink tubing&quot; in Section 5.3.1 that was deleted in favor of a &quot;two part epoxy&quot;.</td>
<td>Accepted and made Suggested Change &quot;electrical insulation&quot; to “two part epoxy coating per Section 5.3.1”</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>7. In Section 5.3.4, it references &quot;the specimen shall be repolished&quot;. Will this repolishing adversely affect the two part epoxy? It seems as though it might compared to the heat shrink tubing from</td>
<td>Accept and made Suggested Change “repolished” to “repolished with care not to damage the two part epoxy coating…”</td>
</tr>
<tr>
<td>1. <strong>5.4.1.1</strong></td>
<td><strong>8.</strong> In Section 5.4, 2nd sentence, add a comma after the word &quot;Ideally&quot;.</td>
<td><strong>Accepted and made editorial revision</strong></td>
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<tr>
<td>2. <strong>5.4.1.1</strong></td>
<td><strong>9.</strong> In Section 5.4.1.1, is this 30 minute exposure intended to be done before the two part epoxy coating is applied to the specimen or after the two part epoxy is applied? The referenced Section 5.1 is just machining and polishing and does not include the application of the two part epoxy referenced in Section 5.3.1. Not sure if the order is a little messed up here or if Section 5.3 should also be referenced in this subsection..</td>
<td><strong>Accepted and made Suggested Change “…Section 5.1…” to “…Sections 5.1 and 5.3”…”</strong></td>
</tr>
<tr>
<td>3. <strong>5.4.1.4</strong></td>
<td><strong>10.</strong> In Section 5.4.1.4, 2nd sentence, revise from &quot;corrosion resistant steel (CRS)&quot; to &quot;corrosion resistant reinforcement (CRR)&quot; and revise from &quot;between the CRS&quot; to &quot;between the CRR&quot; to maintain consistency with Sections 1.1 and 7.1 where &quot;Corrosion Resistant Reinforcement (CRR)&quot; is utilized</td>
<td><strong>Accepted and made editorial revision</strong></td>
</tr>
<tr>
<td>4. <strong>5.4.1.4</strong></td>
<td><strong>11.</strong> In Section 5.4.1.4, 2nd sentence, it states &quot;shall be performed for two different pH levels (e.g., pH = 13 and pH = 10)&quot;. Are these just examples of two different pH levels (e.g., means 'for example') or are they the specific two different pH levels to use as both Sections 1.2.1 and 6.1 specifically reference pH = 13 and pH = 10 for polarization resistance. Since Section 5.4.1.4 is the specific polarization resistance procedure, it is recommended to specifically reference these two different pH levels, pH = 13 and pH =10, and not indicate that they are just examples.</td>
<td><strong>Accepted and made the Suggest Change “…pH levels (e.g., pH = 13 and pH = 10)…” to “…pH levels, pH = 13 and pH =10…”</strong></td>
</tr>
<tr>
<td>5. <strong>5.4.1.4</strong></td>
<td><strong>12.</strong> In Section 5.4.1.4, Note 2, revise from &quot;CRS&quot; to &quot;CRR&quot; for consistency with Sections 1.1 and 7.1.</td>
<td><strong>Accepted and made editorial revision</strong></td>
</tr>
<tr>
<td>6. <strong>Table 1</strong></td>
<td><strong>13.</strong> In Table 1, first column for pH, revise from &quot;1310&quot; to &quot;13&quot; in table row 1 and &quot;10&quot; in table row 2.</td>
<td><strong>Accepted and made change so that Row 1 is shown to be pH 13 and Row 2 is shown to be pH 10</strong></td>
</tr>
<tr>
<td>7. <strong>5.4.2.1</strong></td>
<td><strong>14.</strong> In Section 5.4.2.1, it states &quot;After preparing the test sample as described in Section 5.1&quot;, but should this also reference Section 5.3 (for the two part epoxy) as Section 5.1 is only the machining and polishing of the test sample. This comment is similar to comment #9 above.</td>
<td><strong>Accepted and made the Change “Section 5.1” to “Sections 5.1 and 5.3”</strong></td>
</tr>
<tr>
<td>8. <strong>5.4.2.5</strong></td>
<td><strong>15.</strong> In Section 5.4.2.5, 3rd sentence or 4th line, revise from &quot;CRS&quot; to &quot;CRR&quot; to maintain consistency with Sections 1.1 and 7.1 where</td>
<td><strong>Accepted and made editorial revision</strong></td>
</tr>
<tr>
<td>Comment</td>
<td>Description</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>16. In Section 5.4.2.1, Note 6, revise from &quot;CRS&quot; to &quot;CRR&quot; to maintain consistency with Sections 1.1 and 7.1 where &quot;CRR&quot; is utilized. Accepted and made editorial revision.</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>17. In Section 6.1, revise from &quot;Table A1.1&quot; to &quot;Table 1&quot;. Accepted and made editorial revision.</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>18. In Section 6.1, revise from &quot;CRS&quot; to &quot;CRR&quot; to maintain consistency with Sections 1.1 and 7.1 where &quot;CRR&quot; is utilized. Accepted and made editorial revision.</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>19. In Section 6.2, revise from &quot;CRS&quot; to &quot;CRR&quot; to maintain consistency with Sections 1.1 and 7.1 where &quot;CRR&quot; is utilized. Accepted and made editorial revision.</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>20. Before Section 7, add a new Section for &quot;Precision and Bias&quot; and indicate whether or not P&amp;B estimates are available. The task force working on MP18a.4 agreed that something like the following would be acceptable: 7. Precision and Bias Statement 7.1 No precision and bias statement has been developed for this test method. The thought was that this statement could also be applied to MP 18 a.2.</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (David H. Kuniega) (<a href="mailto:dkuniega@pa.gov">dkuniega@pa.gov</a>)</td>
<td>1. Further detail on the time length of this testing? Bill Hartt answering question on time length of testing - Specimen preparation time would be the same for both test procedures (Rp and PDP). Machining from rebar stock, specimen polishing, electrical lead attachment, and specimen coating: One hour plus coating drying time. Setup of electrochemical cell and specimen conditioning: 1.5 hours. Conduct of Rp experiment: One-half hour, Conduct of PDP experiment: One hour. If the Rp experiment is performed first, then the PDP could follow using the same experimental setup and specimen; however, each PDP should employ a newly prepared specimen.</td>
<td></td>
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</tbody>
</table>
Ballot Item Number 3 – “MP18a.2” – Negative Vote

**Agency (Individual Name)**
Alaska Department of Transportation and Public Facilities (Michael San Angelo, P.E.) (michael.sanangelo@alaska.gov)

**Comments**
Having worked on turning MP18 into a usable Standard I had always assumed (incorrectly) that the corrosion test methods house in MP18 Appendix would be first assigned provisional numbers (including the *Macrocell Slab Chloride Threshold Test*) as placeholders for MP18 to be balloted as a Standard. After MP18 transitioned into a Full Standard I assumed that after each Provisional Test Method became a Full Test Method the Standard’s Provisional Test Method Numbering would be changed by the TS Chair editorially. The TS ballot does not address the *Macrocell Slab Chloride Threshold Test and does not reflect the others using the Provisional Numbering system. We may have a "chicken or the egg" issue.*

**Response Attachment**
- Email Bill Bailey to Mike San Angelo 06-17-16
  - Asked Mike to withdrawing at least the negative on 5) MP 18 and 1) MP 18a.2 because these two standards have in my opinion both severed there time as provisional standards (8 years).
- Email Michael San Angelo to Merrill Zwanka 07-15-2016
  - Michael San Angelo withdrew his negatives.
  - The Task force took up the Macrocell slab chloride test in July.

Ballot Item Number 4 – “MP18a.3”

**Item Number:** 4

**Description:**
**TS Ballot Item to move Annex A3 of MP 18 now called: T MP18a.3 Standard Method of Test for Comparative Qualitative Corrosion Characterization of Uncoated Chromium-Alloyed Steel Bars Used in Concrete Reinforcement (Florida Tombstone Test) to a full Test standard.**

This Annex was included in MP18 as a qualitative long term corrosion test that provides an agency the means of evaluating and comparing the relative corrosion resistance of different types of steel reinforcement when the provisional standard specification was expanded to include stainless steels. Adjustments were made to Section 1 to match AASHTO style and formatting. A Significance and Use section plus a Summary of the Method section were developed from the note in this annex (A3) to MP 18. A reference mix design and an example mix design were added in Section 7.

The task force is recommending to the technical section that this test portion of MP 18 is ready to be elevated to a full standard method of test.

**Decisions:**
- **Affirmative:** 13 of 16
- **Negative:** 1 of 16
- **No Vote:** 2 of 16

Ballot Item Number 4 – “MP18a.3” Affirmative with comments

**Agency (Individual Name)**

**Comments**
<p>| Missouri Department of Transportation (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>) | 1) Assuming the designation (T MP18a.3) will be changed, if approved. | AASHTO Publication staff will give this test method the next available T number if it passes SOM ballot. |
| MODOT (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>) | 2) Section 1.3 should be italics to match other AASHTO Test Methods | AASHTO publications have locked formatting so authors could not make this change. |
| MODOT (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>) | 3) Section 3.2, the first sentence, recommend removing the word &quot;proposed&quot;. | Accepted and made editorial revision |
| Pennsylvania Department of Transportation (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>) | 1. On 1st and 2nd pages of this standard, revise the title from &quot;Steel Bars Used in Concrete Reinforcement&quot; to &quot;Steel Bars Used for Concrete Reinforcement&quot; (i.e., replace &quot;in&quot; with &quot;for&quot;) for consistency with title of MP 18M/MP 18 where &quot;for&quot; is utilized. | Accepted and made editorial revision |
| Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>) | 2. In Section 1.1, 1st sentence, revise from &quot;This method&quot; to &quot;This test method&quot;. | Accepted and made editorial revision |
| Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>) | 3. In Section 1.1, 1st sentence, revise from &quot;means of comparing the corrosion&quot; to &quot;means of evaluating and comparing the relative corrosion&quot;. | Revised to read: This test method provides a procedure for evaluating and comparing the relative corrosion… |
| Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>) | 4. In Section 1.1, if comment #3 revision is accepted, the 2nd sentence, which starts &quot;The following test procedure...&quot; should be completely deleted. The existing 1st and 2nd sentences are very similar and it seems one could be modified and the other deleted. | Accepted the suggested revision to eliminate the second sentence. The first paragraph now reads: “1.1. This test method, the Florida tombstone test, provides a procedure for evaluating and comparing the relative corrosion resistance of different types of steel reinforcement. This test is designed for assessing the corrosion resistance of uncoated chromium-alloyed reinforcing steel bars as compared to carbon steel bars or other selected reference bars if indicated by the purchaser.” |
| Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>) | 5. In Section 1.1, Note 1, revise from &quot;applications, however it&quot; to &quot;applications; however, it&quot; to correct the punctuation. | Accepted and made editorial revision |
| Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>) | 6. In Section 1.1, Note 1, last line, revise from &quot;corrosion applications&quot; to &quot;corrosion susceptible applications&quot;. | Accepted and made editorial revision |
| Penn DOT (Timothy L Ramirez) | 7. In Section 2.1, add &quot;T 22&quot;, and &quot;T 121&quot; as these are | Accepted, will make the change to AASHTO |</p>
<table>
<thead>
<tr>
<th>(<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</th>
<th>AASHTO equivalents to the ASTM Standards &quot;C39/C39M&quot;, C138/C138M listed in Section 2.2.</th>
<th>methods in the Section 2.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>8. In Section 2.2, delete &quot;C39/C39M&quot; and C138/C138M&quot; since adding the AASHTO equivalents &quot;T 22&quot; and &quot;T 121&quot; in Section 2.1.</td>
<td>Accepted, will make the change to AASHTO methods in the Section 2.2</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>9. In Section 2.3, the listed &quot;Other Documents&quot; should be moved to the end of the standard and placed in a new Section titled &quot;10. REFERENCES&quot;. This new Section should be located after the current Section 9 - KEYWORDS.</td>
<td>Accepted, moved the other documents to a Section titled References (Section 11) at the end of the Test Standard.</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>10. In Section 3.2, line 4, revise from &quot;AASHTO M 31&quot; to &quot;M 31M/M 31&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>11. In Section 3.2, line 6, revise from &quot;mild corrosion resistant&quot; to &quot;mild corrosion resistance&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>12. In Section 3.2, next to last line, add two commas, one after the word &quot;steels&quot; (i.e., &quot;steels, 18 percent&quot;) and one after the word &quot;steel&quot; (i.e., &quot;steel, will&quot;).</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>13. In Section 5.6, 3rd line from end, revise from &quot;as specified in Section 20.1.6&quot; to &quot;as specified in M 18M/M 18, Section 20.1.6&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>14. In Section 7.1.1, there are two references to &quot;ASTM #7 or #8&quot;. Are these correct or should they be &quot;AASHTO No. 7 or No. 8&quot;?</td>
<td>Will change to AASHTO #7 and #8</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>15. In Section 7.1.1, the two references to the particular fractions (i.e., &quot;3/8 to 1/2 inch&quot; and &quot;No. 4 to 3/8 inch&quot;) and the reference to &quot;#7&quot; and &quot;#8&quot; aggregate does not seem to cleanly match up with the sieve size fractions and aggregate referenced in Section 5.6, lines 6 and 7 where it states &quot;The aggregate materials contain 50 percent each of No. 4 aggregate and 3/8 aggregate sieved out of No. 68 aggregate&quot;. It seems that Sections 5.6 and 7.1.1 aggregate sieve size fractions and aggregate size should match. The sentence in Section 5.6 that provides the sieve size fraction and aggregate size, if it is correct, may need revised to indicate the &quot;No. 4 sieve fraction and 3/8 inch sieve fraction sieved out of a No. 68 aggregate&quot;.</td>
<td>The sentence in Section 5.6 on lines 6 and 7 was changed to read: “The coarse aggregate fraction of concrete mix will contain 50 percent 3/8 to 1/2 inch particles and 50 percent No. 4 aggregate to 3/8 inch aggregate particles sieved out of a standard AASHTO aggregate gradation.”</td>
</tr>
</tbody>
</table>
Penn DOT (Timothy L Ramirez) (tramirez@pa.gov)

16. In Section 7.1.2.1, lines 3, 4, and 5, revise three (3) locations from "(Specific Gravity x.xx)" to "(Specific Gravity x.xxx)" as aggregate specific gravities from T 84 and T 85 are both to be reported to the nearest 0.001.

Accepted and made editorial revision

Penn DOT (Timothy L Ramirez) (tramirez@pa.gov)

17. In Section 7.8, line 2, revise from "zero, and indication of" to "zero, an indication of".

Accepted and made editorial revision

Penn DOT (Timothy L Ramirez) (tramirez@pa.gov)

18. In Section 8.1, revise from "Table A1" to "Table 1".

Accepted and made editorial revision

Penn DOT (Timothy L Ramirez) (tramirez@pa.gov)

19. In Section 8.2.1, revise from "(i.e. AASHTO M 31)" to "(i.e., M 31M/M 31)"

Accepted and made editorial revision

Penn DOT (Timothy L Ramirez) (tramirez@pa.gov)

20. Before existing Section 9 - KEYWORDS, add a new Section for "PRECISION AND BIAS" and indicate whether or not precision estimates are available.

Added a new Section 9 Precision and Bias and the following statement in Section 9.1 “There is no precision and bias statement for this test method at this time. The test is a long term performance test comparing the time to initiate corrosion of different chromium alloyed steel reinforcing bars and dowels to a standard non alloyed steel bar M 31M/M 31 or other alloyed bar selected as the internal standard. The test results are non-quantitative.”

Ballot Item Number 4 – “MP18a.3” Negative Vote

<table>
<thead>
<tr>
<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
</tr>
</thead>
</table>
| Alaska Department of Transportation and Public Facilities (Michael San Angelo, P.E.) (michael.sanangelo@alaska.gov) | Having worked on turning MP18 into a usable Standard I had always assumed (incorrectly) that the corrosion test methods house in MP18 Appendix would be first assigned provisional numbers (including the Macrocell Slab Chloride Threshold Test) as placeholders for MP18 to be balloted as a Standard. After MP18 transitioned into a Full Standard I assumed that after each Provisional Test Method became a Full Test Method the Standard’s Provisional Test Method Numbering would be changed by the TS Chair editorially. The TS ballot does not address the Macrocell Slab Chloride Threshold Test and does not reflect the others using the Provisional Numbering system. We may have a "chicken or the egg" | Email: Bill Bailey to Mike San Angelo 06-17-16
- I do not consider MP 18 a.1 or MP 18 a.3 to fit into the category of evolving or undergoing a number of changes in the next year or next few years. They are tests that Industry and DOT are using now.

Email: Michael San Angelo to Merrill Zwanka 07-15-2016
- Michael San Angelo withdrew his negatives. |
<table>
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<tr>
<th>Item Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>5</td>
<td>TS Ballot Item to move Annex B1 of MP 18 now called: T MP18b.1 Standard Method of Test for X-Ray Fluorescence Test for Iron-based Alloy Identification to a full Test standard.</td>
</tr>
</tbody>
</table>

- The Task force took up the Macrocell slab chloride test in July.
This Annex was included in MP18 as a test method to quickly identify the composition of iron-based alloys using a field-ready, hand-held XRF. This method is intended to be used to verify the type of stainless steel alloy reinforcing bars on a project. Adjustments were made to Section 1 to match AASHTO style and formatting. A Significance and Use, Calibration and standardization, Procedure and Report and Interpretation of Results sections were developed in greater detail than what originally appeared as Annex B1 in MP 18.

The task force is recommending to the technical section that this test portion of MP 18 is ready to be elevated to a full standard method of test.

<table>
<thead>
<tr>
<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
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</thead>
<tbody>
<tr>
<td>Missouri Department of Transportation (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>)</td>
<td>Affirmative vote with the following editorial comments: 1) Assuming the designation (T MP18b.1) will be changed, if approved.</td>
<td>Yes, The designation will be changed by the publication staff if this standard passes SOM ballot.</td>
</tr>
<tr>
<td>MODOT (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>)</td>
<td>2) Section 7.3.3 has no information following the heading. Appears information was either left out or the heading was placed inadvertently.</td>
<td>Thanks for pointing this out. Section 7.3.3 has information following it now.</td>
</tr>
<tr>
<td>MODOT (Brett Steven Trautman) (<a href="mailto:brett.trautman@modot.mo.gov">brett.trautman@modot.mo.gov</a>)</td>
<td>3) Section 9.1 has been deleted but the next section is numbered 9.2. Has Section 9.1 been deleted by accident or is something else suppose to be added in its place.</td>
<td>This has been corrected in the version for SOM ballot. Thanks for pointing this out.</td>
</tr>
<tr>
<td>Pennsylvania Department of Transportation (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>1. If this test method is mainly for use of the handheld XRF Spectrometer, I recommend revising the title on 1st and 2nd pages of this standard from &quot;X-Ray Fluorescence Test for Iron-based Alloy Identification&quot; to &quot;Identification of Iron-Based Alloy Steel Bars for Concrete Reinforcement or Dowels by Handheld X-Ray Fluorescence (XRF) Spectrometer&quot;.</td>
<td>Accepted and made revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>2. In Section 1.1, revise from &quot;This method&quot; to &quot;This test method&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>3. In Section 1.1, revise from &quot;iron-based alloys.&quot; to &quot;iron-based alloy steel bars for concrete reinforcement or dowels using an X-Ray Fluorescence (XRF) Spectrometer&quot;</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>4. In Section 3, recommend setting first paragraph as Section 3.1</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>5. In Section 3, line 2, revise from &quot;hand-held XRF&quot; to &quot;handheld XRF Spectrometer&quot; to be consistent with existing text in Section 4.1 where it utilizes &quot;handheld X-ray fluorescence&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>6. In Section 3, suggest clarifying the last half of the last sentence which states &quot;and sent to the laboratory for testing to ensure that the alloy of the reinforcing steel bar specified is used on a project&quot;. Is this laboratory testing intended to be other tests, such as, tensile tests, bend tests, dimensions, etc. or is this laboratory testing additional XRF or other chemical testing to verify the alloy? This is not very clear here as to what this &quot;sent to laboratory for testing&quot; is specifically referring to and this last half of this sentence should probably be further clarified. The portable XRF spectrometer can be used in the laboratory or on a project. When different alloys are used on a project, the XRF can distinguish between black steel and 1035 steel. The XRF can also distinguish between different stainless steel alloys. The XRF is portable so it can be used in the field as well as the laboratory to identify/verify the alloy. To clarify Section 3 Significance and Use, Section 3.1 was changed to read: “This method is used to quickly identify the composition of iron-based alloys using a field-ready, handheld XRF spectrometer. The alloy type for reinforcing steel bars can be identified and sorted in the field using the XRF spectrometer. This spectrometer may also be used to verify the alloy of reinforcing bars submitted to the laboratory for testing from a project.”</td>
<td></td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>7. In Section 4.1, line 2, revise from &quot;X-ray fluorescence analyzer&quot; to &quot;X-ray fluorescence spectrometer&quot; to coincide with terminology utilized in Section 4.1 and to not use &quot;analyzer&quot; as the text in Section 4.1, line 2, already indicates &quot;to analyze&quot;. Accepted and made editorial revision</td>
<td></td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>8. In Section 4.1, last line, revise from &quot;alloy of iron-based alloys&quot; to &quot;alloy of iron-based steels&quot;. As written, alloy is used twice and this suggested revision would agree with suggested comment #1 above. Accepted and made editorial revision</td>
<td></td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>9. In Section 4.1, Note 1, suggest rewording note completely to read &quot;It is recommended to follow all manufacturer's or agency's safety precautions when using the XRF Spectrometer.&quot; Accepted Note now reads: “Follow all manufacturer's or agency's safety precautions when using the XRF Spectrometer.”</td>
<td></td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>10. In Section 5.1, revise from &quot;The test surface must be&quot; to &quot;The test surface of the iron-based alloy steel bar must be&quot;. Accepted and made editorial revision</td>
<td></td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>11. In Section 6.1, line 3, revise from &quot;should have an NIST&quot; to &quot;should have a NIST&quot;. Accepted and made editorial revision</td>
<td></td>
</tr>
<tr>
<td>Penn DOT(Timothy L Ramirez)</td>
<td>12. In Section 7.1, revise two locations from &quot;XRF&quot; to &quot;XRF&quot;. Accepted and made editorial revision</td>
<td></td>
</tr>
<tr>
<td>(<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>Spectrometer&quot; to coincide with terminology used in the test apparatus Section 4.1.</td>
<td>Accepted and made editorial revision</td>
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<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>13. In Section 7.2, revise from &quot;with the manufacturer's&quot; to &quot;with the XRF Spectrometer manufacturer's&quot; to provide clarity that the term &quot;manufacturer's&quot; is not the manufacturer of the iron-based alloy steel bar</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>14. In Section 7.2, revise from &quot;with the manufacturer's&quot; to &quot;with the XRF Spectrometer manufacturer's&quot; to provide clarity that the term &quot;manufacturer's&quot; is not the manufacturer of the iron-based alloy steel bar</td>
<td></td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>15. In Section 7.3.1, line 1, revise from &quot;XRF&quot; to &quot;XRF Spectrometer&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>16. In Section 7.3.1, last 2 lines, revise from &quot;If results are acceptable&quot; to &quot;If the XRF Spectrometer results are within acceptable tolerances&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>17. In Section 8.1, first line, revise from &quot;XRF&quot; to &quot;XRF Spectrometer&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>18. In Section 8.1, last line, revise from &quot;MP18M/MP 18&quot; to &quot;MP 18M/MP 18 (i.e., add space between first &quot;MP&quot; and &quot;18&quot;)&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>19. In Section 9.2, line 2, revise from &quot;MP18M/MP 18&quot; to &quot;MP 18M/MP 18 (i.e., add space between first &quot;MP&quot; and &quot;18&quot;)&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>20. In Section 9.3, line 1, revise from &quot;XRF Instrument&quot; to &quot;XRF Spectrometer&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>21. In Section 9.3, Note 2 Line 1, revise from &quot;XRF&quot; to &quot;XRF Spectrometer&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT (Timothy L Ramirez) (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>22. In Section 9.3, Note 2 Line 2, revise from &quot;your analyzer&quot; to &quot;an XRF Spectrometer&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT - Timothy L Ramirez (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>23. In Section 9.3, Note 2 next to last line, revise from &quot;detector&quot; to &quot;XRF Spectrometer&quot;.</td>
<td>Inserted XRF Spectrometer in front of word detector for clarification.</td>
</tr>
<tr>
<td>Penn DOT - Timothy L Ramirez (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>24. In Section 9.3, Note 2 last line, revise from &quot;XRF instruments&quot; to &quot;XRF Spectrometers&quot;.</td>
<td>Accepted and made editorial revision</td>
</tr>
<tr>
<td>Penn DOT - Timothy L Ramirez (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>25. In Section 9.3, Note 2 next to last line, revise from &quot;from the metal&quot; to &quot;from the iron-based alloy steel bar&quot; and revise from &quot;the metal surface&quot; to &quot;the surface of the iron-based alloy steel bar&quot;.</td>
<td>Did not accept this suggested revision. Think the way it is written is a better description of the interaction of the detector, gas around the detector and the surface of the metal.</td>
</tr>
<tr>
<td>Penn DOT - Timothy L Ramirez (<a href="mailto:tramirez@pa.gov">tramirez@pa.gov</a>)</td>
<td>26. In Section 11.1, suggest adding &quot;iron-based alloy steel&quot;.</td>
<td>Accepted “iron-based alloy steel” has been</td>
</tr>
</tbody>
</table>
Penn DOT (David H. Kuniega)  
(dkuniega@pa.gov)

1. Use of x-ray emitting equipment in many cases will add administration, licensing and oversight by regulating agencies specifically in each state.

This depends on the individual state and the regulating agency in each state.

Penn DOT (David H. Kuniega)  
(dkuniega@pa.gov)

2. Clarify whether the intent is to use XRF as an initial screen to identify the alloy, so that further performance testing can be conducted in a lab setting.

The intent is to use the handheld XRF as a verification of the alloy in the field and in the lab. See #6 suggested clarification.

Ballot Item Number 5 – “MP18b.1” – Negative Vote

<table>
<thead>
<tr>
<th>Agency (Individual Name)</th>
<th>Comments</th>
<th>Response Attachment</th>
</tr>
</thead>
</table>
| Alaska Department of Transportation and Public Facilities (Michael San Angelo, P.E.)  
(michael.sanangelo@alaska.gov) | Having worked on turning MP18 into a usable Standard I had always assumed (incorrectly) that the corrosion test methods house in MP18 Appendix would be first assigned provisional numbers (including the Macrocell Slab Chloride Threshold Test) as placeholders for MP18 to be balloted as a Standard. After MP18 transitioned into a Full Standard I assumed that after each Provisional Test Method became a Full Test Method the Standard’s Provisional Test Method Numbering would be changed by the TS Chair editorially. The TS ballot does not address the Macrocell Slab Chloride Threshold Test and does not reflect the others using the Provisional Numbering system. We may have a "chicken or the egg" issue. | Email: Michael San Angelo to Merrill Zwanka 07-15-2016  
• Michael San Angelo withdrew his negatives.  
• The Task force took up the Macrocell slab chloride test in July. |
Standard Specification for

Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels

AASHTO Designation: MP 18M/MP 18-15¹
1. SCOPE

1.1. This specification covers uncoated, corrosion-resistant, deformed and plain chromium alloyed, billet-steel concrete reinforcement and dowel bars in cut lengths or coils, where corrosion-resistant performance may be essential (Notes 1 and 2). The standard sizes and dimensions of deformed bars and their number designations shall be those listed in Table 2 for millimeter-kilogram bars. [Table 3 for inch-pound bars].

   **Note 1**—For coils of deformed bars, the capacity of industrial equipment limits the maximum bar size that can be straightened.

   **Note 2**—The degree of corrosion resistance needed specified for both concrete reinforcement or and dowel bars is typically dependent on both the type of structure, project’s expected in-service environmental conditions, and the concrete’s material properties in which they are embedded.

1.2. Bars are of three minimum yield levels: 420 MPa [60,000 psi], 520–550 MPa [75,000–80,000 psi], and 690 MPa [100,000 psi], designated as Grade 420 [60], Grade 520–550 [75–80], and Grade 690 [100], respectively.

1.3. Hot-rolled plain rounds, in sizes up to and including 50–57 mm [2–2.25 in.] in diameter in coils or cut lengths, when specified for dowels, spirals, and structural ties or supports, shall be furnished under this specification in Grade 420 [60], Grade 520–550 [75–80], and Grade 690 [100] (Note 3). For ductility properties, test provisions of the nearest nominal diameter deformed bar size shall apply. Those requirements providing for deformations and marking shall not be applicable (Note 3).

   **Note 3**—The weight for plain rounds smaller than 10 mm [⅜ in.] in diameter shall be computed on the basis of the size in ASTM A510/A510M.

   **Note 4**—When welding of the material listed in this specification is required, it should be in conformance with AWS D1.4 *Structural Welding Code—Reinforcing Steel* and the applicable sections of AWS D1.6 *Structural Welding Code—Stainless Steels*. If the material is not addressed in these specifications, the manufacturer of the steel should be contacted to obtain a welding procedure for the particular application.

1.4. This specification is applicable for orders in either SI units (as Specification MP 18M) or in inch-pound units (as Specification MP 18). SI units and inch-pound units are not necessarily equivalent. Inch-pound units are shown in brackets in the text for clarity, but they are the applicable values when the material is ordered to MP 18.
2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
- M 31/M 31, Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- T 244, Mechanical Testing of Steel Products
- T 285, Bend Test for Bars for Concrete Reinforcement
- T MP18a.1 -- Sensitivity of Stainless Steel to Intergranular Attack
- T MP18a.2 -- Comparative Qualitative Corrosion Characterization of Steel Bars Used in Concrete Reinforcement (Linear Polarization Resistance and Potentiodynamic Polarization Tests)
- T MP18a.3 -- Comparative Qualitative Corrosion Characterization of Uncoated Chromium Alloyed Steel Bars Used in Concrete Reinforcement (Florida Tombstone Test)
- T MP18a.4 -- Macrosegregation Slab Chloride Threshold Test
- T MP18b.1 -- X-Ray Fluorescence Test for Iron Based Alloy Identification

2.2. ASTM Standards:
- A276/A276M, Standard Specification for Stainless Steel Bars and Shapes
- A484/A484M, Standard Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
- A510/A510M, Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel, and Alloy Steel
- A700, Standard Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment
- A751, Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- A955/A955M, Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement
- A1035/A1035M, Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement
- E29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.3. Military Standards:
- MIL-STD-129, Marking for Shipment and Storage
- MIL-STD-163, Steel Mill Products Preparation for Shipment and Storage

2.4. Federal Standard:
- Fed. Std. No. 123, Marking for Shipment (Civil Agencies)

2.5. AWS Standards:
- AWS D1.4, Structural Welding Code—Reinforcing Steel
- AWS D1.6, Structural Welding Code—Stainless Steels

3. TERMINOLOGY

3.1. Description of Terms Specific to This Standard:
3.1.1. corrosion-resistant—a relative term indicating resistance to the several forms of corrosion in various environments or corroding media, often compared to the resistance of uncoated plain carbon steels in the same environment or media.

3.1.2. deformed bar—steel bar with protrusions; a bar that is intended for use as reinforcement in reinforced concrete construction.

3.1.2.1. Discussion—The surface of the bar is provided with lugs or protrusions that inhibit longitudinal movement of the bar relative to the concrete surrounding the bar in such construction. The lugs or protrusions conform to the provisions of this specification.

3.1.3. deformations—protrusions on a deformed bar.

3.1.4. plain bar—steel bar without protrusions.

3.1.5. rib—longitudinal protrusion on a deformed bar.

3.1.6. lot—bars of one bar number, heat number, and pattern of deformation contained in an individual shipping release or shipping order.

3.1.7. heat—a batch of steel produced to meet specified physical and chemical properties. A unique heat number is assigned by the manufacturer to identify each batch of steel.

3.1.8. Uncoated Corrosion Resistant Reinforcement (CRR)—concrete reinforcing bar materials, because of their chemical composition and or microstructure, provide enhanced corrosion resistance properties.

4. ORDERING INFORMATION

4.1. Orders for deformed or plain chromium-alloyed steel billet-steel bars for concrete reinforcement under this specification should include the following information:

4.1.1. Quantity (mass) [weight];

4.1.2. UNS number of the alloy, Type or Common Name (see Table 1);

4.1.3. Size (diameter) or bar designation number (see Table 2 for mm-kg bars or Table 3 for in-lb bars);

4.1.4. Cut length or coils;

4.1.5. Deformed or plain;

4.1.6. Grade;

4.1.7. Packaging (see Section 22); and

4.1.8. AASHTO designation and year of issue.

4.2. The purchaser shall have the option to specify additional requirements, including but not limited to, the following:

4.2.1. Certified mill test reports are required;
4.2.2. Comparative corrosion performance data in accordance with Supplemental Annex A Section 11 only when specified in the purchase order;

4.2.3. Special bar markings;

4.2.4. Other special requirements, if any.

**Note 5**—A typical ordering description is as follows: 10 tonnes, uncoated, corrosion resistant, deformed and plain chromium-alloyed, billet steel bars for concrete reinforcement and dowels, UNS S31653, No. 25, 18 m long, deformed, Grade 520, in secured lifts, to MP 18M—. Certified mill test reports are required. [10 tons, uncoated, corrosion-resistant, deformed and plain chromium-alloyed, billet steel bars for concrete reinforcement and dowels, UNS S31653, No. 8, 60 ft 0 in. long, deformed, Grade 75 in secured lifts, to MP 18—. Certified mill test reports are required.]

5. **MATERIALS AND MANUFACTURE**

5.1. The steel reinforcement bars for concrete reinforcement and dowels conforming to this standard shall be rolled from individual heats that are properly identified and documented heats of mold cast or strand cast steel using any commercially accepted steelmaking process.

6. **CHEMICAL REQUIREMENTS**

6.1. The chemical analysis of each heat shall be determined in accordance with ASTM A751. The manufacturer shall make the analysis on test samples taken preferably during the pouring of the heat. The percentages of carbon, chromium, copper, manganese, molybdenum, nickel, nitrogen, phosphorus, silicon, sulfur, sulfur, nitrogen, manganese, phosphorus, silicon, chromium, nickel, copper, molybdenum and vanadium shall be determined and reported as required in Section 20.

6.2. The analysis of the heat shall be made by the manufacturer and shall conform to the analysis tolerances specified in Table 1 of ASTM A484/A484M when compared to the chemistry reported in Annex A2, Section A2.6.3.

6.2.1. A product check made by the purchaser shall conform to the analysis tolerances specified in Table 1 of ASTM A484/A484M when compared to the chemistry reported in Annex A2, Section A2.6.3.

6.3. The chemical composition as shown by heat analysis shall meet the requirements as shown in the following Table 1.
<table>
<thead>
<tr>
<th>UNS Designation</th>
<th>Type or Common Name</th>
<th>Composition, %&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Other Elements&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Carbon (C)</td>
<td>Manganese (Mn)</td>
</tr>
<tr>
<td><strong>Austenitic Stainless Steels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S24000</td>
<td>XM-29</td>
<td>0.08</td>
<td>11.50–14.50</td>
</tr>
<tr>
<td>S24100</td>
<td>XM-28</td>
<td>0.15</td>
<td>11.00–14.00</td>
</tr>
<tr>
<td>S30400</td>
<td>304</td>
<td>0.08</td>
<td>2.00</td>
</tr>
<tr>
<td>S30453</td>
<td>304LN</td>
<td>0.030</td>
<td>2.00</td>
</tr>
<tr>
<td>S31603</td>
<td>316L</td>
<td>0.030</td>
<td>2.00</td>
</tr>
<tr>
<td>S31653</td>
<td>316LN</td>
<td>0.030</td>
<td>2.00</td>
</tr>
<tr>
<td><strong>Duplex (Austenitic-Ferritic) Stainless Steels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S31803</td>
<td>2205</td>
<td>0.030</td>
<td>2.00</td>
</tr>
<tr>
<td>S32100</td>
<td>410</td>
<td>0.040</td>
<td>4.0–6.0</td>
</tr>
<tr>
<td>S32200</td>
<td>2205</td>
<td>0.030</td>
<td>2.00</td>
</tr>
<tr>
<td>S32304</td>
<td>2304</td>
<td>0.030</td>
<td>2.50</td>
</tr>
<tr>
<td><strong>Patented Dual-Phase Other Chromium Alloyed Steels</strong>&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K81550</td>
<td>A1010 Duracorr</td>
<td>0.025</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Unlisted elements are governed by ASTM A276/A276M for Austenitic and Duplex stainless steel products listed in Table 1.

<sup>b</sup> Single values are maximum weight percentages except where noted.

<sup>c</sup> These alloys have a single producer.

<sup>d</sup> Minimum Cr value of 9.2% in ASTM A1035CS steel demonstrated to conform to AASHTO TP MP18a.2 requirements for ratio of polarization resistance (R_p) and pitting potential. Meet the requirements of ASTM A1035/A1035M.
7. **REQUIREMENTS FOR DEFORMATIONS**

7.1. Deformations shall be spaced along the bar at substantially uniform distances. The deformations on opposite sides of the bar shall be similar in size, shape, and pattern.

7.2. The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45 degrees. Where the line of deformations forms an included angle with the axis of the bar from 45 to 70 degrees inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the line of deformation is greater than 70 degrees, a reversal in direction is not required.

7.3. The average spacing or distance between deformations on each side of the bar shall not exceed seven tenths of the nominal diameter of the bar.

7.4. The overall length of deformations shall be such that the gap between the ends of the deformations on opposite sides of the bar shall not exceed 12.5 percent of the nominal perimeter of the bar. Where the ends terminate in a longitudinal rib, the width of the longitudinal rib shall be considered the gap. Where more than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25 percent of the nominal perimeter of the bar; furthermore, the summation of gaps shall not exceed 25 percent of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.14 times the nominal diameter.

7.5. The spacing, height, and gap of deformations shall conform to the requirements prescribed in Table 2 [Table 3].

**Table 2**—Deformed Bar Designation Numbers, Nominal Masses, Nominal Dimensions, and Deformation Requirements, SI Units

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Nominal Mass, kg/m</th>
<th>Diameter, mm</th>
<th>Cross-Sectional Area, mm²</th>
<th>Perimeter, mm</th>
<th>Maximum Average Spacing</th>
<th>Minimum Average Height</th>
<th>Maximum Gap (Chord of 12.5% of Nominal Perimeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.560</td>
<td>9.5</td>
<td>71</td>
<td>29.9</td>
<td>6.7</td>
<td>0.38</td>
<td>3.6</td>
</tr>
<tr>
<td>13</td>
<td>0.994</td>
<td>12.7</td>
<td>129</td>
<td>39.9</td>
<td>8.9</td>
<td>0.51</td>
<td>4.9</td>
</tr>
<tr>
<td>16</td>
<td>1.552</td>
<td>15.9</td>
<td>199</td>
<td>49.9</td>
<td>11.1</td>
<td>0.71</td>
<td>6.1</td>
</tr>
<tr>
<td>19</td>
<td>2.235</td>
<td>19.1</td>
<td>284</td>
<td>59.8</td>
<td>13.3</td>
<td>0.97</td>
<td>7.3</td>
</tr>
<tr>
<td>22</td>
<td>3.042</td>
<td>22.2</td>
<td>387</td>
<td>69.8</td>
<td>15.5</td>
<td>1.12</td>
<td>8.5</td>
</tr>
<tr>
<td>25</td>
<td>3.973</td>
<td>25.4</td>
<td>510</td>
<td>79.8</td>
<td>17.8</td>
<td>1.27</td>
<td>9.7</td>
</tr>
<tr>
<td>29</td>
<td>5.060</td>
<td>28.7</td>
<td>645</td>
<td>90.0</td>
<td>20.1</td>
<td>1.42</td>
<td>10.9</td>
</tr>
<tr>
<td>32</td>
<td>6.404</td>
<td>32.3</td>
<td>819</td>
<td>101.3</td>
<td>22.6</td>
<td>1.63</td>
<td>12.4</td>
</tr>
<tr>
<td>36</td>
<td>7.907</td>
<td>35.8</td>
<td>1006</td>
<td>112.5</td>
<td>25.1</td>
<td>1.80</td>
<td>13.7</td>
</tr>
<tr>
<td>43</td>
<td>11.38</td>
<td>43.0</td>
<td>1452</td>
<td>135.1</td>
<td>30.1</td>
<td>2.16</td>
<td>16.5</td>
</tr>
<tr>
<td>57</td>
<td>20.24</td>
<td>57.3</td>
<td>2581</td>
<td>180.1</td>
<td>40.1</td>
<td>2.59</td>
<td>21.9</td>
</tr>
</tbody>
</table>

*a Bar numbers approximate the number of millimeters of the nominal diameter of the bar.

*b The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same mass per meter as the deformed bar.
Table 3—Deformed Bar Designation Numbers, Nominal Weights, Nominal Dimensions, and Deformation Requirements, U.S. Customary Units

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Nominal Weight, lb/ft</th>
<th>Nominal Diameter, in.</th>
<th>Cross-Sectional Area, in.²</th>
<th>Perimeter, in.</th>
<th>Maximum Average Spacing</th>
<th>Minimum Average Height</th>
<th>Maximum Gap (Chord of 12.5% of Nominal Perimeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.376</td>
<td>0.375</td>
<td>0.11</td>
<td>1.178</td>
<td>0.262</td>
<td>0.015</td>
<td>0.143</td>
</tr>
<tr>
<td>4</td>
<td>0.668</td>
<td>0.500</td>
<td>0.20</td>
<td>1.571</td>
<td>0.350</td>
<td>0.020</td>
<td>0.191</td>
</tr>
<tr>
<td>5</td>
<td>1.043</td>
<td>0.625</td>
<td>0.31</td>
<td>1.963</td>
<td>0.437</td>
<td>0.028</td>
<td>0.239</td>
</tr>
<tr>
<td>6</td>
<td>1.502</td>
<td>0.750</td>
<td>0.44</td>
<td>2.356</td>
<td>0.525</td>
<td>0.038</td>
<td>0.286</td>
</tr>
<tr>
<td>7</td>
<td>2.044</td>
<td>0.875</td>
<td>0.60</td>
<td>2.749</td>
<td>0.612</td>
<td>0.044</td>
<td>0.334</td>
</tr>
<tr>
<td>8</td>
<td>2.670</td>
<td>1.000</td>
<td>0.79</td>
<td>3.142</td>
<td>0.700</td>
<td>0.050</td>
<td>0.383</td>
</tr>
<tr>
<td>9</td>
<td>3.400</td>
<td>1.128</td>
<td>1.00</td>
<td>3.544</td>
<td>0.790</td>
<td>0.056</td>
<td>0.431</td>
</tr>
<tr>
<td>10</td>
<td>4.303</td>
<td>1.270</td>
<td>1.27</td>
<td>3.990</td>
<td>0.889</td>
<td>0.064</td>
<td>0.487</td>
</tr>
<tr>
<td>11</td>
<td>5.313</td>
<td>1.410</td>
<td>1.56</td>
<td>4.430</td>
<td>0.987</td>
<td>0.071</td>
<td>0.540</td>
</tr>
<tr>
<td>14</td>
<td>7.65</td>
<td>1.693</td>
<td>2.25</td>
<td>5.32</td>
<td>1.185</td>
<td>0.085</td>
<td>0.648</td>
</tr>
<tr>
<td>18</td>
<td>13.60</td>
<td>2.257</td>
<td>4.00</td>
<td>7.09</td>
<td>1.58</td>
<td>0.102</td>
<td>0.864</td>
</tr>
</tbody>
</table>

a Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars.
b The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight per foot as the deformed bar.

8. MEASUREMENTS OF DEFORMATIONS

8.1. The average spacing of deformations shall be determined by measuring the length of a minimum of ten spaces and dividing that length by the number of spaces included in the measurement. The measurement shall begin from a point on a deformation at the beginning of the first space to a corresponding point on a deformation after the last included space. Spacing measurements shall not be made over a bar area containing bar marking symbols involving letters or numbers.

8.2. The average height of deformations shall be determined from measurements made on not fewer than two typical deformations. Determinations shall be based on three measurements per deformation, one at the center of the overall length and the other two at the quarter points of the overall length.

8.3. Insufficient height, insufficient circumferential coverage, or excessive spacing of deformations shall not constitute cause for rejection unless it has been clearly established by determinations on each lot tested that typical deformation height, gap, or spacing do not conform to the minimum requirements prescribed in Section 7. No rejection may be made on the basis of measurements if fewer than ten adjacent deformations on each side of the bar are measured.

9. TENSILE REQUIREMENTS

9.1. The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 4 [Table 5].

9.2. Unless otherwise specified, the yield point or yield strength, unless a distinct yield point is noted during the tensile test, shall be determined by the offset method (0.2 percent) described in Section 14.2 of T 244. When material is furnished in coils, the test sample must be straightened prior to placing it in the jaws of the tensile machine. Straightening shall be done carefully to avoid the formation of local sharp bends and to minimize cold work. Insufficient straightening before attaching the extensometer can result in lower-than-actual yield strength readings.
9.3. The percentage of elongation shall be as prescribed in Table 4 [Table 5] when tested in accordance with Section 14.4 of T 244.

Note 5—Per T 244 Annex A1.2.1 "Selection and location of test or tests are a matter of agreement between manufacturer and purchaser.

9.3.

Table 4—Tensile Properties Requirements, SI Units

<table>
<thead>
<tr>
<th>Grade 420</th>
<th>Grade 520</th>
<th>Grade 690</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, min, MPa Tests of Full Bar Cross Section</td>
<td>620</td>
<td>690</td>
</tr>
<tr>
<td>Yield strength, min, MPa</td>
<td>420</td>
<td>520</td>
</tr>
<tr>
<td>Elongation in 203.2 mm, min %: Bar Designation No.:</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>13, 16</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>19</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>22, 25</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>29, 32, 36</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>43, 57</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 5—Tensile Properties Requirements, U.S. Customary Units

| Grade 60 | Grade 75 | Grade 100 |
| Tests of Full Bar Cross Section | 90,000 | 105,000 | 150,000 |
| Tensile strength, min, psi | 60,000 | 75,000 | 100,000 |
| Yield strength, min, psi | 9 | 7 | 7 |
| Elongation in 8 in., min %: Bar Designation No.: | 7 | 7 | 7 |
| 3 | 7 | 7 |
| 4, 5 | 7 | 7 |
| 6 | 7 | 7 |
| 7, 8 | 7 | 7 |
| 9, 10, 11 | 6 | 6 |
| 14, 18 | 6 | 6 |

10. BENDING REQUIREMENTS

10.1. The bend-test specimen shall withstand being bent around a pin without cracking on the outside of the bent portion when tested in accordance with T 285. The requirements for angle of bending and sizes of pins are prescribed in Table 6 [Table 7]. When material is furnished in coils, the test sample must be straightened prior to placing it in the bend tester.

Table 6—Bend-Test Requirements, SI Units

<table>
<thead>
<tr>
<th>Grade 420</th>
<th>Grade 520</th>
<th>Grade 690</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar Designation No.</td>
<td>Pin Diameter for Bend Tests &quot;</td>
<td>3.5d</td>
</tr>
<tr>
<td>10, 13, 16</td>
<td>3.5d</td>
<td>3.5d</td>
</tr>
</tbody>
</table>
The bend test shall be made on specimens of sufficient length to ensure free bending and with an apparatus that provides:

10.1.1. Continuous and uniform application of force throughout the duration of the bending operation.

10.1.2. Unrestricted movement of the specimen at points of contact with the apparatus and bending around a pin free to rotate.

10.1.3. Close wrapping of the specimen around the pin during the bending operation.

10.2. Other acceptable more severe methods of bend testing, such as placing a specimen across two pins free to rotate and applying the bending force with a fixed pin, may be used. When failures occur under more severe other methods, retests shall be permitted under the bend-test method prescribed in Section 10.216.3.

11. COMPARATIVE CORROSION RESISTANCE PERFORMANCE

(Annex A is nonmandatory and must be specified by the purchaser.)

11.1 AASHTO has developed several test methods to evaluate corrosion resistance of chromium alloyed bars for concrete reinforcement and dowels. The test methods listed in this section are to provide the purchaser with options for short and long term evaluations that can be used for quality control or prequalification. The purchaser shall have the option to select a test that evaluates the sensitivity of stainless steels in Table 1 to intergranular attack or the formation of a detrimental intermetallic phase by specifying TMCP18a.1. This is a short term test recommended for quality control.
11.1.1. This test is used to evaluate the sensitivity of austenitic and duplex (austenitic-ferritic) stainless reinforcing bars to intergranular attack in austenitic or ferritic stainless steels or the formation of a detrimental intermetallic phase in a duplex stainless steel.

11.1.1. This test is recommended to be performed biannually or when required by purchaser.

11.1.1. This test shall be performed biannually on randomly selected austenitic and duplex (austenitic-ferritic) stainless reinforcing steel materials listed in Table 1 or alloys with a chromium concentration greater than 12.5-wt %, as described in Annex A.

11.2. The purchaser shall have the option to evaluate the comparative corrosion resistance of steel bars used for concrete reinforcement. This is covered in Annex A, Section A2 or Section A3 (purchaser specified) by specifying a Linear Polarization Resistance and Potentiodynamic Polarization test such as T MP18a.1 or in situ tests like the Florida Tombstone Test, T MP18a.3, or Macrocell Slab-Chloride Threshold Test T MP18a.4.

11.2. The purchaser shall have the option to request comparative corrosion performance data for chromium containing steels in Table 1. The data shall be furnished, based on mutual agreement between the manufacturer and the purchaser, as described in Annex A, Section A2 or Section A3 or T MP18a.4.

Note 66 — Annex A. The comparative corrosion resistance test procedures: Tests T MP18a.1 and T MP18a.2 are short-term qualitative tests performed by exposing steel samples in an aqueous solution, whereas test T MP18a.3 and T MP18a.4 are long-term qualitative tests performed by exposing steel samples embedded in concrete. It is important for each agency to carefully consider which test or tests to perform since each test listed provides different information and requires different test durations.

12. PERMISSIBLE VARIATION IN MASS [WEIGHT]

12.1. The permissible variation shall not exceed 6 percent under nominal mass [weight] except for bars smaller than 9.5 mm [3/8 in.] plain round. The permissible variation in mass [weight] shall be computed on the basis of the permissible variation in diameter in ASTM A510M [ASTM A510]. Reinforcing bars are evaluated on the basis of nominal mass [weights]. In no case shall the over mass [overweight] of any bar be the cause for rejection.

12.2. The specified limit of variation shall be evaluated in accordance with ASTM E29 (rounding method).

13. FINISH

13.1. The bar shall be free of detrimental surface imperfections.

13.2. Austenitic and duplex (austenitic-ferritic) stainless steel reinforcing bars listed in Table 1 shall be pickled and free of visible corrosion. Patented dual-phase other chromium alloyed steels reinforcing bars listed in Table 1 shall be pickled and free of visible corrosion if required by ASTM specifications or specified by the purchaser.

Note 77—Pickling may cause hydrogen embrittlement with higher grade steel strengths.

13.3. The overall surface color between different types of bars listed in Table 1 can vary, but on each bar the surface color should be uniform and free of any areas of discoloration.
13.4. Seams or surface irregularities shall not be cause for rejection, provided the weight, dimensions, cross-sectional area, and tensile properties are not less than the requirements of this specification.

13.5. Surface imperfections other than those specified in Section 13.4 shall be considered detrimental when specimens containing such imperfections fail to conform to either tensile or bending requirements. Examples include but are not limited to laps, seams, scabs, slivers, cooling or casting cracks, and mill or guide marks (Note 88).

Note 88—Deformed bars intended to be mechanically spliced may require a certain degree of roundness in order for the splices to adequately achieve strength requirements.

14. TEST SPECIMENS

14.1. Tension test specimens, per T 244 Annex A9, shall be the full section of the bar as rolled. The unit stress determinations on full-sized specimens shall be based on the nominal bar area.

14.2. The bend-test specimens shall be the full section of the bar as rolled.

15. NUMBER OF TESTS

15.1. For bar sizes No. 10 to 36 [No. 3 to 11], inclusive, one tension test and one bend test shall be made of the largest size rolled from each heat. If, however, material from one heat differs by three or more designation numbers, one tension and one bend test shall be made from both the highest and lowest designation number of the deformed bars rolled.

15.2. For bar sizes No. 43 and No. 57 [No. 14 and No. 18] bars, one tension test and one bend test shall be made of each size from each heat.

16. RETESTS

16.1. If any tensile property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle third of the gauge length, as indicated by scribe marks on the specimen before testing, a retest shall be allowed.

16.2. If the results of an original tension specimen fail to meet the specified minimum requirements and are within 14 MPa [2000 psi] of the required tensile strength, within 7 MPa [1000 psi] of the required yield pointstrength, or within 2 percentage units of the required elongation, a retest shall be permitted on two random specimens for each original tension specimen failure from the lot. If all results of these retest specimens meet the specified requirements, the lot shall be accepted.

16.3. If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in Sections 16.4 and 16.7, retest shall be permitted on two random specimens from the same lot. If the results of both test specimens meet the specified requirements, the lot shall be accepted. The retest shall be performed on test specimens that are at air temperature but not less than 16°C [60°F].

16.4. If a mass [weight] test fails for reasons other than flaws in the specimen as described in Section 16.7, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

16.5. If any test specimen fails because of mechanical reasons such as failure of testing equipment or improper specimen preparation, it may be discarded and another specimen taken.
16.6. If an Annex A.2a Linear Polarization Resistance and Potentiodynamic Polarization test, T
MP18a.2 corrosion resistance test fails for reasons other than flaws as described in Section 16.7, a
retest shall be permitted on two random specimens from the same lot. Both retest specimens shall
meet the requirements of this specification.

16.7. If any test specimen develops reveals internal flaws during tensile testing, it may be discarded and
another specimen of the same size bar from the same heat may be substituted.

17. INSPECTION

17.1. 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 that concern
the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable
facilities to satisfy him that the material is being furnished in accordance with this specification.
All tests (except product analysis) 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.

17.2. For Government Procurement Only—Except as otherwise specified in the contract, the contractor
is responsible for the performance of all inspection and test requirements specified herein and may
use his own or any other suitable facilities for the performance of the inspection and test
requirements specified herein, unless disapproved by the purchaser at the time of purchase. The
purchaser shall have the right to perform any of the inspections and tests at the same frequency as
set forth in this specification, where such inspections are deemed necessary to assure that material
conforms to prescribed requirements.

17.3. A product check on the type of stainless steel alloys may be verified using a field-ready handheld
X-Ray Fluorescence instrument for Alloy Identification T MP18b.1. The operator performing the
verification should be experienced in running the X-Ray instrument.

18. REJECTION

18.1. Unless otherwise specified, any rejection based on tests made in accordance with Sections 6.2, 6.3,
9.1 and 10.1 shall be reported to the manufacturer within 15 working days from the receipt of
samples by the purchaser.

18.2. Material that which has been tested for conformance at the manufacturing plant or accepted upon
written certification, but shows injurious defects subsequent to its acceptance at the
manufacturer’s works will be rejected, and the manufacturer shall be notified.

19. REHEARING

19.1. Samples tested in accordance with Sections 6.2, 6.3, 9.1 and 10.1 that which represent rejected
material shall be preserved for 2 weeks from the date rejection is reported to the manufacturer. In
case of dissatisfaction with the results of the tests, the manufacturer may make claim for a
rehearing within that time.

20. TEST REPORTS

20.1. Test reports should include the following:
20.1.1. Steel description, using UNS designation when possible;

20.1.2. Chemical analysis, including percentages of carbon, chromium, copper, manganese, molybdenum, nickel, nitrogen, phosphorus, silicon, sulfur-sulfur, nitrogen, manganese, phosphorus, silicon, chromium, nickel, copper, molybdenum and vanadium;

20.1.3. Tensile properties;

20.1.4. Bend test;

20.1.5. Corrosion resistant test results for sensitivity of stainless steel products in Table 1 to intergranular attack or the formation of a detrimental intermetallic phase—Annex AT MP18a.1 (if requested); and

20.1.6. Comparative Corrosion Resistance Test Results—Linear Polarization Resistance and Potentiodynamic Polarization Test, T MP18a.2 or in situ tests like the Florida Tombstone Test, T MP18a.3 Annex A and Macrocell Slab Chloride Threshold Test T MP18a.4 (Purchaser specified) with chemical analysis tolerances conforming to Section 6.2.Table 1 in this specification.

21. MARKING

21.1. When loaded for mill shipment, bars of one grade and type of alloy shall be properly separated into a bundle and tagged with the manufacturer’s heat or test identification number.

21.2. Each producer shall identify the symbols of his marking system.

21.3. All bars produced to this specification, except plain round bars, which shall be tagged for grade, shall be identified by a distinguishing set of marks legibly rolled into the surface of one side of the bar to denote, in the following order:

21.3.1. Point of Origin—Letter or symbol established as the producer’s mill designation.

21.3.2. Size Designation—Arabic number corresponding to bar designation number of Table 2 [Table 3].

21.3.3. Type of Steel—Letters “CS” indicating that the bar was produced to this specification or it is recommended that the purchaser verify the chemical composition of the steel using the method described in Annex B.

21.3.4. Minimum Yield Designation—For Grade 420 [60] bars, either the number 4 [60] or a single continuous longitudinal line through at least five spaces offset from the center of the bar side. For Grade 520-550 [7580] bars, either the number 5-6 [7580] or two three continuous longitudinal lines through at least five spaces offset each direction from the center of the bar. For Grade 690 [100] bars, either the number 6-7 [100] or three four continuous longitudinal lines through at least five spaces offset each direction from the center of the bar.

21.3.5. It shall be permissible to substitute a metric size bar of Grade 420 for the corresponding inch-pound size bar of Grade 60, a metric size bar of Grade 520 for the corresponding inch-pound size bar of Grade 75, and a metric size bar of Grade 690 for the corresponding inch-pound size bar of Grade 100.
22. PACKAGING

22.1. When Unless otherwise specified in the purchaser's specified in the purchase order or contract, packaging, packing, marking and loading shall be in accordance with the procedures recommended by ASTM A700.

22.2. Only For United States Government Procurement — When specified in the contract or order, and for direct procurement by or direct shipment to the U.S. government, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

23. STORAGE AND HANDLING

23.1. Store and handle materials in a manner that avoids mechanical damage, corrosion, and contamination with dirt or other deleterious substances so as to preserve the materials quality and fitness for work. Store materials so they can be easily inspected; segregate AASHTO MP 18M/MP 18 bars for concrete reinforcement and dowels from other grades of bars for concrete reinforcement and dowels.

Note 9 — Covered storage is recommended to prevent surface degradation for all material per this specification that is expected to be exposed to a wet environment for a total 2-month period or longer starting from shipment of bars from manufacturer and continuing until bars are installed.

23.24. KEYWORDS

23.1.24.1. Alloy steel bars; concrete reinforcement; uncoated corrosion-resistant; deformations (protrusions); dowels X-Ray.

Standard Method of Test for

Sensitivity of Stainless Steel to Intergranular Attack

AASHTO Designation: TP xxxMP18a.1-xxx
Standard Method of Test for

Sensitivity of Stainless Steel to Intergranular Attack

AASHTO Designation: TP xxxMP18a.1-xx

1. SCOPE

This method covers the procedures to be used to evaluate the sensitivity of stainless steel products in Table 1 of MP 18M/MP 18 to intergranular attack in austenitic or ferritic stainless steels or the formation of a detrimental intermetallic phase in a duplex stainless steel. It is important to note that these tests evaluate certain detrimental effects that can occur in stainless steels that could reduce the functional life of the steel. These tests are not designed for estimating the service life of stainless steel products in MP 18M/MP 18 Table 1 embedded in concrete.

ANNEX A—CORROSION RESISTANCE TESTING

(Mandatory Information If Specified by the Purchaser)

1.1. The This

1.2. This corrosion test listed in A1 shall be performed biannually or when requested by purchaser on reinforcing steel materials listed in MP 18M/MP 18 Table 1 with a chromium concentration greater than 12.5-wt %, with the results available to the customer on request. The tests listed in A2 TP xxx or A3 TP xxx this specification shall apply only when specified in the purchase order.

1.3. The values stated in either SI or inch-pound units shall be regarded separately as standard. The inch-pound units are shown in brackets. The values stated might not be exact equivalents; therefore, each system must be used independently of the other.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use, and the purchase order shall indicate if required.

A1.1.1.1.4. This method covers the procedures to be used to evaluate the sensitivity of stainless steel products in Table 1 to intergranular attack in austenitic or ferritic stainless steels or the formation of a detrimental intermetallic phase in a duplex stainless steel. It is important to note that these tests evaluate certain detrimental effects that can occur in stainless steels that could reduce the functional life of the steel. These tests listed in A1, however, are not designed for estimating the service life of stainless steel products in MP 18M/MP 18 Table 1 embedded in concrete.

A1.2. REFERENCED DOCUMENTS:

2.1. AASHTO Standards:

- MP 18M/MP 18, Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels
- TP xxx, [new title of former MP 18M/MP 18 Annex A2]
A1.2.1.2.2. ASTM Standards:


A1.3. TEST APPARATUS:

A1.3.1. For austenitic stainless steel, guidance is provided in ASTM A262.

A1.3.2. For ferritic stainless steels, guidance is provided in ASTM A763.

A1.3.3. For ferritic/austenitic (duplex) stainless steels, guidance is provided in ASTM A923.

A1.4. TEST SPECIMENS:

A1.4.1. For austenitic stainless steel, guidance is provided in ASTM A262.

A1.4.2. For ferritic stainless steels, guidance is provided in ASTM A763.

A1.4.3. For ferritic/austenitic (duplex) stainless steels, guidance is provided in ASTM A923.

A1.5. PROCEDURE:

A1.5.1. Testing should be conducted according to the type of stainless steel as follows:

A1.5.2. Austenitic stainless steels shall be tested in accordance with Practice E, in conjunction with Practice A, of Specification ASTM A262.

A1.5.3. Ferritic stainless steels shall be tested in accordance with Practice Y or Z, in conjunction with Practice W, of Specification ASTM A763. The stainless steel UNS designation and Table 2 in ASTM A763 shall be used to determine the best test practice, Y or Z.

A1.5.4. Duplex austenitic/ferritic stainless steels shall be tested in accordance with Test Method C, in conjunction with Test Method A, of Specification ASTM A923.

A1.6. CALCULATIONS:

A1.6.1. For austenitic stainless steel, guidance is provided in ASTM A262.

A1.6.2. For ferritic stainless steels, guidance is provided in ASTM A763.

A1.6.3. For ferritic/austenitic (duplex) stainless steels, guidance is provided in ASTM A923.
A1.7.1 For austenitic stainless steel, guidance is provided in ASTM A262. Results from this test should be recorded and provided to the purchaser if requested.

A1.7.2 For ferritic stainless steels, guidance is provided in ASTM A763. Results from this test should be recorded and provided to the purchaser if requested.

7.3 For duplex austenitic/ferritic stainless steels, guidance is provided in ASTM A923. Results from this test should be recorded and provided to the purchaser if requested.

8. PRECISION & BIAS

8.1 For austenitic stainless steel, precision and bias statements are being determined within ASTM A262 for the practices involving weight loss evaluations. There is no information on precision and bias statements for the visual evaluations methods A and F within ASTM A262 as the test results are non-quantitative.

8.2 For ferritic stainless steels, there are no precision & bias statements provided in ASTM A763. Depending on the test and alloy, evaluations are accomplished by weight loss determination, microscopical examination, or bend tests. The microscopical examination and bend tests are non-quantitative.

8.3 For duplex austenitic/ferritic stainless steels, a precision and bias is not provided within ASTM A923. The tests do not determine the precise nature of the detrimental phase but rather the presence or absence of an intermetallic phase to the extent that it is detrimental to the toughness and corrosion resistance of the material. These are qualitative tests. Either a detrimental phase is present or not. The test results are non-quantitative.

9. KEYWORDS

Stainless Steel Reinforcing Bars, Austenitic Stainless Steel, Ferritic Stainless Steel, Duplex austenitic/ferritic Stainless Steel, Corrosion Test, Intergranular Attack
Standard Method of Test for

Comparative Qualitative Corrosion Characterization of Steel Bars Used in Concrete Reinforcement (Linear Polarization Resistance and Potentiodynamic Polarization Tests)

AASHTO Designation: TP xxxMP18a.2-xxx
Standard Method of Test for

Comparative Qualitative Corrosion Characterization of Steel Bars Used in Concrete Reinforcement (Linear Polarization Resistance and Potentiodynamic Polarization Tests)

AASHTO Designation: TP xxxMP18a.2-xx

1. SCOPE

A1. TEST METHOD FOR COMPARATIVE QUALITATIVE CORROSION CHARACTERIZATION OF STEEL BARS USED IN CONCRETE REINFORCEMENT (LINEAR POLARIZATION RESISTANCE AND POTENTIODYNAMIC POLARIZATION TESTS)

Note A2.11—The following two test methods are for assessing the corrosion resistance of uncoated corrosion-resistant reinforcing (CRR) steel bars as compared to carbon steel bars, or other selected reference bars if indicated by the purchaser.

The two test methods evaluate the corrosion performance of the uncoated CRR bars as a function of (1) pH of the environment and (2) concentration of chloride ions, in particular the \([\text{Cl}^-]/[\text{OH}^-]\) threshold ratio.

A1.1. Scope:

A1.1.1.1. This test method describes procedures to evaluate the comparative qualitative corrosion performance of uncoated Corrosion Resistant Reinforcing (CRR) MP 18M/MP 18 alloy steel bars to those of M 31M/M 31 or other selected reference bars, utilizing electrochemical polarization resistance and potentiodynamic polarization measurements in various test solutions. The test methods evaluate the corrosion performance of the uncoated CRR bars as a function of (1) pH of the environment and (2) concentration of chloride ions, in particular the \([\text{Cl}^-]/[\text{OH}^-]\) threshold ratio.

A1.1.2. Bars tested in accordance with these test procedures shall be characterized as corrosion-resistant when both:

A1.1.2.1. The ratio of the polarization resistance \(R_p\) measured at pH = 10 to the polarization resistance measured at pH = 13 is greater than or equal to \((\geq) 0.5\), i.e., \([R_p \text{ at (pH = 10)}/R_p \text{ at (pH = 13)}] \geq 0.5\), and

1.2. The measured pitting potential is greater than or equal to \((\geq) 250\) mV vs. Ag/Ag Cl reference electrode at a \([\text{Cl}^-]/[\text{OH}^-]\) ratio equal to 2.
1.3 The values stated in either SI or inch-pound units shall be regarded separately as standard. The inch-pound units are shown in brackets. The values stated might not be exact equivalents; therefore, each system must be used independently of the other.

1.4 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

A1.1.2.2

A1.2 REFERENCED DOCUMENTS:

A1.2.1 AASHTO Standard:

- M 31M/M 31, Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- MP 18M/MP 18, Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed Billet-Steel Bars for Concrete Reinforcement and Dowels

A1.2.2 ASTM Standards:

- G3, Standard Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing
- G5, Standard Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements
- G59, Standard Test Method for Conducting Potentiodynamic Polarization Resistance Measurements
- G102, Standard Practice for Calculation of Corrosion Rates and Related Information from Electrochemical Measurements

A1.3 TEST EQUIPMENT AND MATERIALS:

A1.3.1 Containers—500-mL capacity polypropylene (PP) beaker, or equivalent. The solutions used are characterized by a high pH value, hence, glass containers shall not be used.

A1.3.2 Voltmeter—High impedance voltmeter (at least one Mohm), measuring to 0.001 mV.

A1.3.3 Potentiostat—Potentiostat with 20 V compliance voltage (e.g., Gamry Instruments series G 750).

A1.3.4 Reference Electrode (i.e., saturated Ag/AgCl reference electrode or Accumet #13-620-52 Calomel Reference Electrode)—The reference electrode should be used with a salt bridge or luggin probe to prevent contamination and to allow it to be placed closer to the working electrode to minimize IR drops at high current densities.

A1.3.5 Conductive Threaded Rod—316SS or equivalent threaded rod is used to make the electrical connections to the bars.

A1.3.6 Test Solution—Test solution, compatible with material under test (see Section A2.5.4 for solution preparation).

A1.3.7 Counter Electrode—Shall be a noncorrosive mixed oxide coated titanium, platinum or similar material or at least two distinct noncorrosive electrodes placed symmetrically in the vessel.
A1.4.4. TEST METHOD:

A1.4.4.1. Description of Tests—Two well-established types of corrosion tests are included Linear Polarization Resistance and Potentiodynamic Polarization curves. This section presents a brief overview of each test, similar to test procedures and measurements described in ASTM G3, G59, and G102.

A1.4.4.1.1. Linear Polarization Resistance—The linear polarization resistance technique, or simply polarization resistance, involves measuring the change in the open-circuit potential of the electrolytic cell when an external current is applied to it. For a small perturbation about the open-circuit potential (OCP), there is a linear relationship between the change in applied voltage ($\Delta E$) and the change in the measured current per unit area of electrode ($\Delta i$). The ratio $\Delta E/\Delta i$ gives the polarization resistance ($R_p$) term, which is inversely related to the corrosion performance of the alloy.

A1.4.4.1.2. Potentiodynamic Polarization—In this test, the potential is made to change at a constant rate over a wide range, typically from a very cathodic to a very anodic potential, while the corrosion current density is measured. The test indicates the potential regions where there is electrode activity, and provides a variety of information about the corrosion behavior of the sample. Active, passive, and transpassive regions, for instance, can be readily identified. When chlorides are present, the test can be used to identify the concentration in which pitting corrosion is initiated.

A1.5. EXPERIMENTAL PROCEDURE:

5.1. Steel Sample Preparation—:

5.1.1. Test samples of approximately 1-in. length and 5/16-in. diameter must be machined, using coolant spray or copious coolant flow over the specimen, from the rebar to be tested, taking care not to overheat or unintentionally induce microstructural changes to the alloy.

5.1.2. A screw thread is drilled and tapped (e.g., 6-32 by 3/16 in.) into one end of the specimen, to enable electrical contact to be made.

5.1.3. The surface of the test specimen shall be polished with SiC paper down to 1000 grit.

A1.5.1. Electrical contact shall be made to the specimen with a 316SS or equivalent threaded rod long enough to extend outside of the electrochemical cell.

A1.5.2. Electrochemical Cell—A standard ASTM G5 three-electrode electrochemical cell arrangement shall be used. The body of the 500-600 mL cell must be made of polypropylene plastic due to the elevated pH of the test solution. The body of the cell must be made of plastic in order to avoid glass etching due to the elevated pH of the test solutions (a 500-ml PP beaker can be used, for instance). A typical setup is shown below in Figure A2.11.
5.3. **Electrochemical Cell and Sample Assembly**

5.3.1. The specimen shall be covered with a two part epoxy coating adhesive-lined dual-wall heat shrink tubing in such a way that only approximately 1/2 in. in length of the specimen is left exposed; the remaining length of the specimen as well as the contacting rod must be covered with heat shrink tubing a two part epoxy coating.

5.3.2. The electrical insulation two part epoxy coating shall be applied with care to provide a crevice-free seal.

5.3.3. The exposed surface area shall be measured and recorded.

5.3.4. Before testing, after the equipment is set up and the electrochemical cell is ready to receive the test specimen, the exposed area of the specimen shall be repolished with care not to damage the two part epoxy coating, degreased with acetone, and cleaned with methanol and deionized water.

A1.5.3.

A1.5.4. **Test Solution Preparation**—Test solution shall be prepared with deionized water and certified reagent chemicals. Ideally, the experiments should be controlled by an automated reliable potentiostatic instrument and corresponding software.

5.4.1. **Polarization Resistance**
5.4.1.1. Before performing the polarization resistance experiment, the test specimen as prepared according to the procedure in Sections A2.5.1 and 5.3 shall be placed in the electrochemical cell and exposed to the aqueous solution for 30 min.

5.4.1.2. The open circuit potential (OCP) shall be measured.

5.4.1.3. A potential variation of –15 mV to +15 mV over OCP shall be applied at a scan rate of 0.125 mV/sec, and the corresponding changes in the current density (in µA/cm²) shall be recorded.

A1.5.4.1.5.4.1.4. The polarization resistance term $R_p$ is then calculated based on this data. In order to properly evaluate the corrosion behavior of the corrosion resistant steel-reinforcement (CRSCRR), and particularly to demonstrate the fundamental difference between the CRSCRR and carbon steels, the polarization resistance tests shall be performed for two different pH levels, e.g., pH = 13 and pH = 10, while maintaining the ionic strength ($IS$) of the solutions constant. Naturally aerated aqueous solutions shall be prepared immediately before the test.

Note A2.22—Carbon steel typically loses its passive film at pH values between 11 and 10, while CRSCRR is expected to maintain its corrosion resistance at lower pH levels.

Note A2.33—A lower pH solution (i.e., pH = 9) can be used; however, the buffering capacity for such a solution is low. During testing, the pH value shall be monitored to assure that no significant drop in pH occurs.

Note A2.44—Ionic strength ($IS$) is defined as one-half the summation of the product of the concentration of each ion and its charge squared, as shown in the equation $IS = \frac{1}{2} \sum c_i z_i^2$ (Lehmann et al., 1996).\(^1\)

Table A2.11 illustrates the composition of aqueous test solutions.

<table>
<thead>
<tr>
<th>pH</th>
<th>NaOH (mol/l)</th>
<th>IS</th>
<th>NaOH (g/l)</th>
<th>K₂SO₄ (mol/l)</th>
<th>K₂SO₄ (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>0.1</td>
<td>0.1</td>
<td>4.0</td>
<td>—</td>
<td>0.0333</td>
</tr>
<tr>
<td>10</td>
<td>0.0001</td>
<td>0.1</td>
<td>0.004</td>
<td>5.8042</td>
<td>—</td>
</tr>
</tbody>
</table>

5.4.2. Potentiodynamic Polarization:

5.4.2.1. After preparing the test sample as described in Sections A4.5.1 and 5.3 the specimen shall be immediately placed in the electrochemical cell and conditioned at –1200 mV (vs. Ag/AgCl reference electrode) for 2 min in order to reduce any possible air-formed oxide film.

5.4.2.2. Then the potential shall be gradually increased from –1200 mV at a scan rate of 1 mV/s.

5.4.2.3. If a cyclic scan is desired, the potential shall be taken to the beginning of the transpassive region (about +550 mV vs. Ag/AgCl when no chlorides are present) or to the pitting potential if pitting initiates at a potential below the transpassive potential, and reversed back to the starting potential.

A1.5.4.2. In the presence of chlorides, the onset of pitting corrosion is detected by a shift of the transpassive region to lower potential values during the forward (anodic) scan. This new potential value is referred to as the pitting potential (for a particular chloride concentration). Pitting corrosion is initiated when a chloride threshold value (as represented by the ratio between Cl⁻ and OH⁻ ions prepared in solution) is exceeded.

5.4.2.4. A simulated concrete pore solution with a constant [OH⁻] (0.55M KOH + 0.16M NaOH, as described by Taylor, 1997)\(^2\) shall be prepared. The concentration of Cl⁻ ions shall be changed to a
desired level by adding NaCl salt (see Table A2.2 for examples). In order to verify and demonstrate the enhanced corrosion performance of CRS-CRR in highly aggressive environments, the potentiodynamic polarization curves shall be measured in at least two environments: (1) simulated concrete pore solution with no chlorides and (2) same aqueous solution with a high concentration of chlorides (e.g., ratio [Cl–]/[OH–] = 2 or higher).

**Note A2.55**—Carbon steel rebar typically presents chloride threshold ratios [Cl–]/[OH–] between 0.2 and 0.85, with 0.6 being the most commonly referenced value. Table A2.2 below illustrates the chemical composition of simulated concrete pore test solutions.

<table>
<thead>
<tr>
<th>[Cl–]/[OH–]</th>
<th>KOH (mol/l)</th>
<th>NaOH (mol/l)</th>
<th>OH– (mol/l)</th>
<th>NaCl (mol/l)</th>
<th>KOH (g/l)</th>
<th>NaOH (g/l)</th>
<th>OH– (g/l)</th>
<th>NaCl (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.55</td>
<td>30.86</td>
<td>0.16</td>
<td>6.40</td>
<td>0.71</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1</td>
<td>0.55</td>
<td>30.86</td>
<td>0.16</td>
<td>6.40</td>
<td>0.71</td>
<td>0.71</td>
<td>0.71</td>
<td>41.49</td>
</tr>
<tr>
<td>2</td>
<td>0.55</td>
<td>30.86</td>
<td>0.16</td>
<td>6.40</td>
<td>0.71</td>
<td>1.42</td>
<td>1.42</td>
<td>82.98</td>
</tr>
<tr>
<td>3</td>
<td>0.55</td>
<td>30.86</td>
<td>0.16</td>
<td>6.40</td>
<td>0.71</td>
<td>2.13</td>
<td>2.13</td>
<td>124.48</td>
</tr>
</tbody>
</table>

**Note A2.66**—The two sets of tests described above can clearly demonstrate the corrosion behavior of a selected CRS-CRR and show how it compares to regular carbon steel rebar when test parameters, such as pH values and [Cl–] levels (both considered excessively aggressive in the case of carbon steels), are controlled.

### REPORT:

**A1.6.1 Polarization Resistance**—Report the polarization resistance $R_p$ at pH = 10 and $R_p$ at pH = 13 for test solutions prepared in accordance with Table A1.11 for the comparison bar material (M 31M/M 31) and the uncoated CRS-CRR test bar material. Evaluate the ratio of $R_p$(pH = 10)/$R_p$(pH = 13).

**A1.6.2 Potentiodynamic Polarization**—Report the transpassive or pitting potential in mV vs. Saturated Ag/AgCl electrode used in the test at [Cl–]/[OH–] = 0 and [Cl–]/[OH–] = 2 for test solutions prepared in accordance with Table A2.2 for the comparison bar material (M 31M/M 31) and the uncoated CRS-CRR test bar material.

**6.3 Chemical Constituents**—Report chemical analysis percentages for the following elements: carbon, chromium, copper, manganese, molybdenum, nickel, nitrogen, phosphorus, silicon, sulfur, and vanadium.

### 7. PRECISION AND BIAS STATEMENT

7.1 No precision and bias statement has been developed for this test method.

### 8. KEYWORDS

A1.6.3-8.1 Uncoated Corrosion Resistant Reinforcing (CRR) Bars, Corrosion Test, Qualitative, Corrosion Performance
Standard Method of Test for

Comparative Qualitative Corrosion Characterization of Uncoated Chromium-Alloyed Steel Bars Used in Concrete Reinforcement (Florida Tombstone Test)

AASHTO Designation: TP xxxMP18a.3-xxx

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
Standard Method of Test for

Comparative Qualitative Corrosion Characterization of Uncoated Chromium-Alloyed Steel Bars Used in Concrete Reinforcement (Florida Tombstone Test)

AASHTO Designation: TP-MP18a.3xxx-xx

1. SCOPE

A1. TEST METHOD FOR COMPARATIVE QUALITATIVE CORROSION CHARACTERIZATION OF STEEL BARS USED IN CONCRETE REINFORCEMENT (FLORIDA TOMBSTONE TEST)

(Mandatory information if specified by the purchaser)

Note A3.1—These tests listed in Section A3 are for assessing the corrosion resistance of reinforcing steel bars as compared to carbon steel bars or other selected reference bars if indicated by the purchaser. The purpose of this test method is to emphasize the key differences between the corrosion behavior of uncoated corrosion-resistant chromium alloyed reinforcing steels (CRR) as compared to carbon steel, namely the enhanced resistance to chlorides. The proposed rating system is to place steels in one of four categories or levels (0, 1, 2, and 3). There is no linear relationship between levels. It is more like a tenfold or better difference between levels. If an agency runs the test, the steels will, over time, be distinguishable by groups. The 0 level will have numbers/test values around the same as the control black steel. There will be some variability but these bars will be lower than the bars in level 1, which have mild corrosion resistant by having some amount of chromium. There will be a spread or variability depending on what alloys and percentage of alloys are introduced into the steel but after a period of time (months or years) the level 1 bars will hover around the values for ASTM A1035/A1035M. The level 2 rating will be associated with the duplex stainless steel category and the high chromium steels 18 percent chromium (stainless category rating level of 3). In laboratories performing this testing, the black bar (steels without corrosion resistant alloys) separate quickly, the ASTM A1035/A1035M types separate slower and the clad bars and stainless take an extremely long time to show a difference or separate out. The speed of the test is related to quality of concrete and whether the concrete cracks.

A1.1. Scope:

1.1. This test method, the Florida tombstone test, provides a means procedure for evaluating and comparing the relative corrosion resistance of different types of steel reinforcement. The following test procedure describes how to evaluate and compare the relative corrosion resistance of different types of reinforcement. This test is designed for assessing the corrosion resistance of uncoated chromium-alloyed reinforcing steel bars as compared to carbon steel bars or other selected reference bars if indicated by the purchaser.
Note 1: This test method was developed for use in marine substructure applications; however, it may be applied to other non-marine environments subject to deicing salts such as concrete substructure and super structure elements. Agencies should review its use related to their climatic and geographic regions in other corrosion susceptible applications.

1.2. The values stated in either SI or inch-pound units shall be regarded separately as standard. The inch-pound units are shown in brackets. The values stated might not be exact equivalents; therefore, each system must be used independently of the other.

1.3. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

A1.1.1. A1.2. REFERENCED DOCUMENTS:

A1.2.1. AASHTO Standard:
- T22 Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens
- T 121M/T 121 Standard Method of Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- T 277, Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration
- M 31M/M 31, Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- MP 18M/MP 18, Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels

A1.2.2. ASTM Standards:
- A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
- C138/C138M, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
- C876, Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete

A1.2.3. Other Documents:
3. SIGNIFICANCE AND USE

3.1. The purpose of this qualitative test method is to emphasize the key differences between the corrosion behaviors of uncoated corrosion-resistant chromium alloyed reinforcing steels (CRR) as compared to carbon steel, namely the enhanced resistance to chlorides.

3.2. The rating system is designed to place steels in one of four categories or levels (0, 1, 2, and 3). There is no linear relationship between levels. It is more like a tenfold or better difference between levels. If an agency runs the test, the steels will, over time, be distinguishable by groups. The 0 level will have numbers/test values around the same as the control M 31M/M 31 carbon steel black bar. There will be some variability but these bars will be lower than the bars in level 1, which have mild corrosion resistance by having some amount of chromium. There will be a spread or variability depending on what alloys and percentage of alloys are introduced into the steel but after a period of time (months or years) the level 1 bars will hover around the values for A1035CS alloy. The level 2 rating will be associated with the UNS S32101 type alloy steel category, while the high chromium steels, 18 percent chromium UNS S31653 alloy steel, will be associated with level 3. In laboratories performing this testing, the black bar (steels without corrosion resistant alloys) separate quickly, the low chromium types separate slower and the clad bars and higher quality stainless, or quality stainless clad, bars can take an extremely long time to show a difference or separate out. The speed of the test is related to quality of concrete and whether the concrete cracks.

4. SUMMARY OF METHOD

4.1. This test method cyclically immerses reinforcing steel bars embedded in a block of concrete referred to as a tombstone in a salt water bath for several months or years until corrosion develops.

4.2. The time to corrosion is used to separate types of alloy reinforcing bars into levels of corrosion resistance.

A1.3.5. TEST EQUIPMENT AND MATERIALS:

A1.3.1.5.1. Immersion Tanks—A suitable immersion tank will most likely be a fiberglass or plastic tank that is resistant to sodium chloride solution and has favorable impact resistance or can be easily repaired if a specimen strikes the tank. For example, the two fiberglass tanks shown in Figure A3.1 are 28 by 30 by 48 in. and hold 30 specimens each.
Figure A3.1—Tombstone Test Set-Up. The 3 percent saltwater storage tank is located in the lower left corner, with the tombstone immersion tanks adjacent to the saltwater storage tank, and the data acquisition system above the tombstone tanks (top of picture).

A1.3.2.5.2. Sample Spacers—A sample spacer provides a means of adding stability to specimens since the height of the specimen is much greater than the width. This item is not required for testing but should be considered to reduce the chance of damaging the specimens. The spacer must be resistant to saltwater and moisture. An example is shown in Figure A3.3.

A1.3.3.5.3. Sample Booster—The sample booster provides a means of lifting specimens out of residual salt water during dry periods of the wet/dry exposure cycle. It must be resistant to saltwater and moisture, as well as impact resistant or easily repaired, if specimen strikes the booster material. An example of a sample booster is shown in Figure A3.2 and Figure A3.3.

Figure A3.2—Close-Up of 1-in. Plastic Square Tube That Functions as a Sample Booster
A1.3.4.5.4. **Saltwater Test Solution**—The saltwater test solution is a 3 percent by weight sodium chloride solution. The solution volume needed depends on the size of the immersion tank. To calculate the quantity of a saltwater solution required, the bottom 6 inches of the tombstone specimens plus the height of the sample booster must be considered in conjunction with the other two dimensions of the ponding tank.

A1.3.5.5.5. **Data Acquisition System (DAS)**—The DAS will be used to monitor the voltage across a 1-ohm resistor on each block. Therefore, it is important that the DAS have sufficient channels for the number of tombstones being tested. In addition, the DAS must have high impedance terminals and, for DC voltage measurement, a maximum resolution of 1 μV at 20 mV and measurement accuracy integral time 1.67 ms ± (0.1 percent of rdg. + 25 digits) at 20 mV, all at standard operating conditions.

A1.3.6.5.6. **Test Specimens**—The rebar tested will include, in addition to the candidate bar specimens, test specimens with types 316LN (UNS S31653), either XM-28 (UNS S24100) or type 304 (UNS S30400), and ASTM A1035/A1035M #5 steel bars with each bar being in an as-received condition. Each test specimen, or tombstone, will have a single type of reinforcing steel embedded in a concrete block that meets the agency’s specified concrete mix design, except that the concrete shall only contain cement and aggregate. The coarse aggregate fraction of concrete mix will contain 50 percent 3/8 to 1/2 inch particles and 50 percent each of No.4 aggregate and to 3/8 inch aggregate particles sieved out of No.68a standard AASHTO aggregate gradation. The tombstone specimens have dimensions (shown in Figure A3.4) that will ensure rapid corrosion test results for an embedded steel type test. After the tombstone specimens have been cast and cured for 28 days, the exposed ends of the bars will be cleaned to expose the base metal, and after making the electrical connections, a two part epoxy, such as a 100 percent solids high build epoxy, will be applied to the bars and top of the specimens. The bars embedded in concrete, as shown in Figure A3.4, with the exposed bar ends connected and epoxy applied, is considered a “test specimen,” which is also known as a Florida tombstone test specimen or simply a tombstone. The three bars of each type steel in the test specimen must come from the same lot/heat and the chemical composition of the bars should be determined or verified as specified in MP 18M/MP 18 Section 20.1.6 to ensure the chemical composition testing is performed. If a purchaser is interested in modifying the bar configuration, other bar configurations are possible and discussed in the report by Hartt et al.
A1.4. TEST METHOD:

A1.4.1.6.1. Description of Tests—This test method is a low maintenance test procedure that allows for the penetration of chlorides from the surface of the concrete to the reinforcing steel through multiple sides of a test sample.

A1.5. EXPERIMENTAL PROCEDURE:

7.1. Tombstone Concrete Mix Design—The concrete used for the tombstone specimens will meet the requirements of the reference mix design below or a mix design set by the specifying agency.

7.1.1. Reference Concrete Mix design

- 635 lbs. Type I/II Cement
- 900 lbs. 3/8 to 1/2 inch coarse fraction of AASHTO #7 or #8 Limestone aggregate
- 900 lbs. No.4 to 3/8 inch coarse fraction of AASHTO #7 or #8 Limestone aggregate
- 1200 lbs. Fine aggregate - Ottawa sand
- 300 lbs. Water
6% Air
Permeability range greater than 4000 coulombs

7.1.2. Agency Mix design - An agency should select a representative mix for their geographic and climatic region. The water cement ratio for the agency should be chosen to represent the highest anticipated acceptable w/c for a project to yield realistic results. The better the quality of the concrete mix, the longer the projected time until corrosion is initiated. Therefore it is recommended not to incorporate fly ash, granulated iron blast-furnace slag, silica fume or metakaolin into the mix design.

7.1.2.1. Example typical DOT Mix design based on absolute volume method of ACI

| 635 lbs. Type I/II Cement* |
| 900 lbs. 3/8 to 1/2 inch coarse aggregate indicative to region or district (Specific Gravity x.xxx) |
| 900 lbs. No.4 to 3/8 inch coarse aggregate indicative to region or district (Specific Gravity x.xxx) |
| 1200 +/- 250 lbs. Natural sand indicative to district (Specific Gravity x.xxx) |
| 286 - 318 lbs. Water (Water-to-Cement ratio range of 0.45 to 0.50) |
| 5 - 8% Air |

* Some variability in cement content is permissible as long as the water-to-cement ratio is within the range of 0.45-0.50

A1.5.1.7.2. Tombstone Molds—An illustration of a tombstone mold is shown in Figure A3.5. These molds have two regions. The upper mold region does not receive concrete and is used to align and secure the bars prior to casting. The lower mold region is where the concrete is placed to embed the steel bars.
A1.5.3.7.3. **Casting Tombstone**—Place a single type of reinforcing steel in the tombstone molds, adjust the bar heights to ensure that the concrete cover will be consistent, and cover all bolt hardware and exposed form edges with tape, as shown in Figure A3.6.

A1.5.3.1.7.3.1. Mix and cast concrete specimens following T 121M/T 121ASTM C138/C138M, ASTM C192/C192M, and specifying agency protocol. The concrete can be placed in a single lift and consolidated by vibrating the entire form. In addition to casting tombstone specimens, 4-in cylinder specimens should also be cast for 28-day compressive strength (ASTM C39T22/C39M) and permeability (T 277) testing to confirm the concrete quality. After casting, specimens should be allowed to cure properly before performing any additional work on the specimens.

**Figure A3.5**—Illustration of Forms Used to Cast Tombstone Specimens
A1.5.4.7.4. Connections and Wiring—After the specimens have properly cured, remove specimens from the curing room and clean the exposed bar ends to remove any rust and ensure quality electrical contact between the rebar and the wire. To make connection between embedded rebar, stranded copper wire (size range: #10–#16) will be used. The connectors can be soldered or solderless. Solderless connectors are used if the connections will be unplugged and plugged frequently. Examples of solderless connectors used to couple the blocks to the data acquisition system and to connect the wire to each rebar are shown in Figure A3.7. A rivet will be used to join the solderless connector and the rebar. A hole, slightly larger than the rivet, is drilled into the end of each piece of rebar and the rivet is used to secure the solderless connector to the rebar. The size of the rivet is not as important as the fit between the rivet and the ring style solderless connector. A $\frac{3}{16}$-in. rivet, which is shown in Figure A3.8, has been used successfully. A 1-ohm resistor is placed in series between the electrically connected anode bars and cathode bar, as shown in Figure A3.9.

Figure A3.6—Photograph of Tombstone Molds That Are Ready for Concrete Casting Phase

Figure A3.7—Examples of Solderless Connectors That Can Be Used
Figure A3.8—A ¼-in. rivet positioned through a ring-style solderless connector, which will be used to connect the wires to each rebar specimen.

Figure A3.9—Illustration of tombstone wire connections.
A1.5.5.7.5. **Place Tombstone in Tank**—With the sample boosters and spacers placed appropriately, carefully lower each tombstone specimen into the immersion tank. If several tombstone specimens are cast, it is advantageous to mark the top of each specimen with a unique marking or to create a key above the immersion tank to help in identifying each specimen.

A1.5.6.7.6. **Connect Leads**—The distance between each tombstone and the data acquisition system are measured and two lead wires are cut and uniquely labeled. One wire from each pair is then connected on each side of the resistor and then wired to the data acquisition system.

A1.5.7.7.7. **Ponding Cycles:**

A1.5.7.1.7.7.1. **Initial Ponding Cycle**—During the first immersion cycle (3-14 days ponded, 4 days dry), pond the samples in water (no salt). The water level in the tank should cover the bottom 6 in. of the test specimen. During this first cycle, check for leaks, faulty wire connections, computer or data acquisition hardware/software issues and any other potential equipment related problems.

A1.5.7.2.7.7.2. **Subsequent Ponding Cycles**—During immersion test cycle two and until completion of the test, use the 3 percent saltwater solution. The saltwater level in the tank should cover the bottom 6 in. of the test specimen. The test cycle is three days ponded with salt water and four days dry. Terminate the test process at conclusion of a complete ponding and drying cycle on detection of concrete cracking or visible corrosion product bleed-out.

A1.5.8.7.8. **Data Analysis and Calculations**—Monitor macro-current using DAS and compare values to previous values to determine if macro-current is trending away from zero, and indication of macro-current activity. Activity is typically indicated by macro-current activity greater than 0.01 mA (or 0.01 mV measured across a 1-ohm resistor).

A1.5.9.7.9. **Activity Detected**—After macro-current activity is detected, begin monitoring half-cell current using a voltmeter.

A1.5.9.1.7.9.1. Using a silver/silver chloride electrode, place electrode in tank. Measure voltage following ASTM C876, with the silver/silver chloride electrode being used in place of copper/copper sulfate (CSE). **Note A3.2**—Half-cell electrode should not be left in tank for a prolonged period of time.

A1.5.9.2.7.9.2. Terminate exposure if the half-cell value is more negative than –0.35 V vs. CSE and record macro-cell and half-cell values on termination. Begin autopsy.

A1.5.10.7.1. **Autopsy**—Carefully remove concrete from rebar and visually evaluate bar condition.

A1.5.10.1.7.10.1. Gather concrete sample adjacent to bar for total chloride analysis.

A1.5.10.2.7.10.2. Gather concrete sample adjacent to bar for concrete pH analysis.

A1.5.10.3.7.10.3. Compare percent corroded surface area to qualifier bar values.

A1.5.10.4.7.10.4. Record the number of pits observed and the average value for the pit depth measurements. Pit depth measurements can be facilitated by using a pit depth gauge.

A1.5.10.5.7.10.5. Record any other unusual observations.

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A1.6.8. **REPORT:**

A1.6.1.8.1. Record all data on Table A1-1 and rank each bar according to the [Cl⁻]/[OH⁻] ratio.
Bar acceptance is based on ranking in accordance with the following:

Bars that rank the same as or worse than carbon steel (i.e. M 31M/M 31) are considered a Level 0 Bar (No Corrosion Resistance).

Bars that rank better than carbon steel and similar to ASTM A1035/A1035M bars are considered a Level 1 CRR (Improved Corrosion Resistance).

Bars that rank similar to UNS S32101 bars in Table 1 of this specification and rank better than ASTM A0135CS bars but rank less than UNS S31653 bars in Table A3.1 Summary of Tombstone Test Data are considered a Level 2 CRR (Moderate Corrosion Resistance).

Bars that rank similar to UNS S31653 bars in Table 1 Summary of Tombstone Test Data and a 316LN stainless steel in Table A3.1 are considered a Level 3 CRR (High Corrosion Resistance).

There is no precision and bias statement for this test method at this time. The test is a long term performance test comparing the time to initiate corrosion of different chromium alloyed steel reinforcing bars to a standard non alloyed steel bar M 31M/M 31 or other alloyed bar selected as the internal standard. The test results are non-quantitative.

Uncoated Corrosion Resistant Reinforcing (CRR) bars, Corrosion Test, Florida Tombstone


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<th>Microcurrent above Threshold</th>
<th>% Surface Area Corroded</th>
<th>Number of Pits</th>
<th>Average Pit Depth, mm</th>
<th>Chloride Concentration, lb/yd$^3$</th>
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Standard Method of Test for

Identification of Iron-Based Alloy Steel Bars for Concrete Reinforcement or Dowels by handheld X-Ray Fluorescence Test for Iron-based Alloy Identification(XRF) Spectrometer

AASHTO Designation: TP xxx-xxxT MP18b.1

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
Standard Method of Test for

**X-Ray Identification of Iron-Based Alloy Steel Bars for Concrete Reinforcement or Dowels by handheld X-Ray Fluorescence (XRF) Spectrometer Fluorescence Test for Iron-based Alloy Identification**

AASHTO Designation: TP-xxx-xxT MP18b.1

1. **SCOPE**

   **ANNEX B—Field Test for Alloy Identification**
   
   (Mandatory Information)

   **B1. X-RAY FLUORESCENCE TEST**

   **B1.1. Scope:**

   **B1.1.1. This method covers the procedures to be used in establishing the detectable chemical composition of the candidate reinforcement by using a field-ready, handheld X-ray fluorescence device.**

   **1.1. This test method covers the procedure to be used in identifying the alloy composition of Iron-Based Alloy Steel Bars for Concrete Reinforcement or Dowels by handheld X-Ray Fluorescence (XRF) Spectrometer iron-based alloys.**

   **1.2. The values stated in SI units are to be regarded as the standard.**

   **1.3. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.**

   **B1.2. REFERENCED DOCUMENTS:**

   **B1.2.1.1. ASTM-AASHTO Standard:**

   - MP 18M/MP 18, Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloved, Billet-Steel Bars for Concrete Reinforcement and Dowels
   - M 31M/M 31, Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   - A276/A276M, Standard Specification for Stainless Steel Bars and Shapes

   **2.2. ASTM Standards:**

   - A955/A955M, Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement,
B1.3.2.3. Other Documents:
- The XRF manufacturer’s guidelines, safety and instrument operating procedures and local documents regulating the use of low-level X-ray testing equipment.

3. SIGNIFICANCE AND USE

3.1 This method is used to quickly identify the alloy composition of iron-based alloys using a field-ready, hand-held XRF spectrometer. For example, the alloy type for reinforcing steel bars can be identified and sorted in the field using the XRF spectrometer. This spectrometer may also be used to verify the alloy of reinforcing bars submitted to the laboratory for testing from a project sampled in the field and sent to the laboratory for testing to ensure that the alloy of the reinforcing steel bar specified is used on a project.

B1.4. TEST APPARATUS:

B1.4.1. \( XRF \) Spectrometer: For this test, a commercially produced field-ready, handheld X-ray fluorescence device analyzer (spectrometer) setup and calibrated to analyze chemical elements and determine the alloy of iron-based steels is required.

Note B1—Follow all manufacturer or agency safety precautions when operating apparatus.

B1.5. TEST SPECIMENS:

B1.5.1. The test surface of the iron-based alloy must be free of corrosion, mill scale, and oils. The surface may need to be cleaned using a wire brush and a suitable solvent, and debris and reasonably clean.

B1.5.2. In addition to the test bars, standardized metal coupons of known composition are needed to verify that the XRF is operating properly and its factory calibration is currently valid.

6. CALIBRATION AND STANDARDIZATION

6.1. \( XRF \) Spectrometer—The XRF spectrometer comes from the manufacturer calibrated. A calibration standard must be purchased to verify the XRF is operating properly before and after each use. The calibration verification standard should have a NIST traceable calibration certification. It is recommended that the calibration verification standard be of a similar alloy to the one(s) tested. It is preferable that multiple calibration verification standards be on hand that cover the range of alloys being tested.

B1.6. PROCEDURE:

B1.6.1. The total test time (warm-up + calibration) is less than 10 min. Turn the XRF spectrometer on and allow time for the XRF spectrometer to go through its preprogrammed initializing and equipment check.

B1.6.2. The test is performed in accordance with the XRF spectrometer manufacturer’s guidelines, recommendations.

B1.6.3. Turn on the X-ray fluorescence analyzer.
B1.6.4. Allow 5 min for the XRF unit to warm up.

B1.6.5.7.3. Perform checks:

B1.6.5.7.3.1. Test the calibration verification standard to determine if the XRF spectrometer is capable of identifying the alloy and is providing results within the manufacturer's elemental tolerances shown on the calibration certification of the calibration verification standard. If the XRF spectrometer XRF checks results are within acceptable tolerances, proceed with analysis.

B1.6.5.7.3.2. If the XRF spectrometer results are not within acceptable tolerances, calibrate instrument and recheck the instrument may need to go back to the manufacturer for cleaning and repair.

B1.6.5.3. Alloy identification should occur within seconds of initiating analysis.

B1.6.5.4. Longer analysis time is needed for greater accuracy and tighter tolerances.
CALCULATIONS:

8.1 Calculations are not required. The XRF spectrometer provides user-ready data. The results are typically reported in percentages. This is desirable since the alloy types listed in ASTM A276, A995 and AASHTO MP 18M/MP 18 are provided in elemental percentages.

REPORT AND INTERPRETATION OF RESULTS AND REPORT

9.1 The XRF instrument will typically provide the alloy type, percent confidence of alloy ID, list of percent elements detected, and confidence limit per element detected. The elemental composition should be checked against the values listed in MP 18M/MP 18 Table 1 or appropriate documentation from the supplier. Results from this test should be recorded according to the purchaser’s guidelines.

Note 1: The XRF reports the elements detected in the sample and elements that are below the detection limit. For an element to be detected by your analyzer in a given sample, the measured concentration of the sample must be at least three times the standard deviation of the measurement. This detection limit will depend on the composition of the sample. The precision of each measurement is two times the standard deviation. An element is classified as “detected” if the measured concentration is at least 1.5 times the precision. Detected elements are displayed in percent, followed by the measurement precision. Non-detected elements are shown as < the detection limit (LOD—limit of detection) for that sample. The detection limit for a given element varies depending on the other elements in the matrix, the strength of the X-ray signal from the metal and the environment between the detector and the metal surface. The information in this note is typical of most XRF instruments, but may not apply to all manufactured models.

REPORT:

The XRF instrument will provide alloy type, percent confidence of alloy ID, list of percent elements detected, and confidence limit per element detected. The elemental composition should be checked against the values listed in MP 18M/MP 18 Table 1 or appropriate documentation from the supplier. Results from this test should be recorded according to the purchaser’s guidelines.

9.1 Report the following information:

9.1.1 Sample identification:

9.1.2 Alloy:

9.1.3 Percent confidence of alloy ID:

9.2 Elements analyzed expressed in percent and as screened to clearly identify the alloy per ASTM A276, A995 and AASHTO MP 18M/MP 18. Typically, the elements that will be used to identify an alloy will be manganese, chromium, nickel, molybdenum.

9.3 The XRF instrument spectrometer will typically provide the alloy type, percent confidence of alloy ID, list of percent elements detected, and confidence limit per element detected. The elemental composition should be checked against the values listed in MP 18M/MP 18 Table 1 or appropriate documentation from the supplier. Results from this test should be recorded according to the purchaser’s guidelines.

Note 2: The XRF spectrometer reports the elements detected in the sample and elements that are below the detection limit. For an element to be detected by your analyzer, the XRF
spectrometer in a given sample, the measured concentration of the sample must be at least three
times the standard deviation of the measurement. This detection limit will depend on the
composition of the sample. The precision of each measurement is two times the standard
deviation. An element is classified as “detected” if the measured concentration is at least 1.5 times
the precision. Detected elements are displayed in percent, followed by the measurement precision.
Non-detected elements are shown as < the detection limit (LOD – limit of detection) for that
sample. The detection limit for a given element varies depending on the other elements in the
matrix, the strength of the X-ray signal from the metal and the environment between the XRF
instrument spectrometers, but may not apply to all manufactured models.

10. PRECISION AND BIAS

10.1. Precision—The research required to develop precision estimates has not been conducted.

10.2. Bias—The research required to establish the bias has not been conducted.

11. KEYWORDS

81.8.1-11.1. X-ray fluorescence; XRF spectrometer, iron-based alloy steel bars.
Standard Method of Test for

Macrocell Slab –Chloride Threshold Test

AASHTO Designation: T- MP18a4
Standard Method of Test for

Macrocell Slab – Chloride Threshold Test

AASHTO Designation: T- MP18a4

1. SCOPE

1.1. This test method describes procedures to measure the chloride threshold concentration to initiate active corrosion of reinforcing bars in concrete using a macrocell slab type specimen.

1.2. Test measurement of chloride threshold concentration can be used to project service life of various reinforced concrete structural members when placed in corrosive environments.

2. REFERENCED DOCUMENTS

2.1 AASHTO Standards:

- T 277, Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration
- M 31M/M 31, Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- MP 18M/MP 18, Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels
- M 43 Sizes of Aggregate for Road and Bridge Construction
- M 85 Portland Cement
- R 39 Making and Curing Concrete Test Specimens in the Laboratory
- T 22 Compressive Strength of Cylindrical Concrete Specimens
- T 119M/T 119 Slump of Hydraulic Cement Concrete
- T 121M/T 121 Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- T 152 Air Content of Freshly Mixed Concrete by the Pressure Method
- T 196M/T 196 Air Content of Freshly Mixed Concrete by the Volumetric Method

2.2 ASTM Standards

- C33 / C33M Specification for Concrete Aggregates
- C1152/C1152M Test Method for Acid-Soluble Chloride in Mortar and Concrete
- G193 - Standard Terminology and Acronyms Relating to Corrosion

3. TEST EQUIPMENT AND MATERIALS

3.1 Voltmeter—High impedance voltmeter (at least one Mohm) capable of measuring 0.001 mV.

3.2 Reference Electrode—Saturated calomel electrode, as defined in ASTM G193.

3.3 Resistor—10-ohm (± 0.3 ohm) electrical resistor.

Note 1: Owner may also select a 100 Ohm resistor— noting that a 100 Ohm resistor will be more sensitive than a 10 Ohm, recognizing for a given current the measured voltage drop (the product of resistance and current) will be ten times higher. It should also be noted that a 100 Ohm resistor has a higher load on the circuit, so the current flows less easily.

3.4 Terminal Box—Terminal boxes house the electrical connection to the reinforcing bars.

3.5 Wire—16-gauge [1.5 mm²] insulated copper wire is used to make the electrical connections to the bars.

3.6 Epoxy Sealer—A two-part epoxy sealer shall be used to cover the sides of the specimens and the electrical connections. It shall be applied in accordance with manufacturer’s recommendations.

3.7 Concrete Mix—Cement shall be Type I or II per Specification M85. Coarse aggregate shall conform to ASTM Specification C33 and Classification M43, with nominal maximum size between 9.5 and 12.5 mm [⅜ and ½ in.] (See Section 4.9)

3.8 Sodium Chloride Solution—3.0 wt. % sodium chloride solution is prepared by adding 30 g [1 oz.] of NaCl to 970 g [34 oz.] of distilled or deionized water.

3.9 Plastic Dams, 100-mm [4.0-in.] wide and 150-mm [6.0-in.] long with a minimum height of 75 mm [3.0 in.] for placement on the test specimens. The wall thickness shall be 3 ±1 mm [⅛ ± 1/32 in.]

3.10 Marine (medium or high strength) polyurethane adhesive - for sealing the outside of the plastic dam to the top of the concrete specimen.
Note 2—The user shall determine an adhesive that is appropriate for a marine environment.

3.11 Rebar Test Specimens—The tested rebars will include both the selected candidate test bar specimens conforming to AASHTO MP 18 Table 1 and an uncoated comparator “black steel” AASHTO M 31 bar. All rebar test specimens shall be No. 16 [# 5] steel bars as-received from the manufacturer under normal delivery conditions.

Note 3 All reinforcing bars shall be as sold and provided by the manufacturer i.e. with or without mill scale.

4 TEST SPECIMEN PREPARATION

4.1 A minimum of three reinforced and three non-reinforced specimens shall be prepared. The two specimen types are identical except for reinforcement. The test specimen shall be: 114 mm [4.5 in.] wide, 152 mm [6.0 in.] high, and 280 mm [11.0 in.] long ± 6 mm [0.25 in.] for any dimension. Reinforced test specimens shall contain one No. 16 [# 5] bar in the top mat electrically connected across a 10-ohm (± 0.3 ohm) resistor to four No. 16 [# 5] bars in the bottom mat. The concrete cover to the top and bottom steel shall be 25 ± 1 mm [1 ± 0.04 in.]. Figure 1 schematically illustrates the geometry for reinforced specimens.

4.2 No. 16 [# 5] bars shall be cut to length of 381 mm [15.0 in].

4.3 Sharp edges on the ends of the bars shall be removed.

4.4 The ends of the bars shall be drilled and tapped to receive a 10-mm [\( \frac{3}{8} \)-in.] long 10-24 threaded stainless steel bolt. The bolt is used to make an electrical connection during the testing period.

4.5 The bars shall be cleaned with hexane to remove dust and oil.

4.6 If form release oil is to be used, it should be applied to the test specimen forms prior to the placement of the bars in the forms.

4.7 The bars shall be attached to the forms using marine adhesive per Section 3.10 with the specimens cast with concrete mix as indicated in Section 4.9. Place the bars in the molds so that approximately 40 mm [1.5 in.] of the bars are protected within each exit end from the concrete (minimizes edge effects) Both ends of each bar shall be coated with a two part epoxy for a distance of 62 mm [2.5 inches], except sufficient space shall be left uncoated at one end of each bar to attach the grounding clamps shown in Fig. 1. This will expose 200 mm [8.0 in.] of steel. Place the bars in the specimen formwork with the longitudinal ribs so that they are nearer the side of the beam, with both ridges equidistant from the top or bottom of the specimen.

Note 4 Caution should be made not to introduce other metals that may stay in the concrete.

4.8 Make the concrete specimens in accordance with Practice R 39, using the same source of materials. Determine the air content, using either Test Method T 152 or T 196M/T 196. The water-to-cement ratio
4.9. Macrocell Slab Concrete Mix Design and Casting—The concrete used for the macrocell slab specimens will meet the requirements of the reference mix design below or a mix design set by the specifying agency. Macrocell slab casting and curing shall be in accordance with 4.9.3.

4.9.1. Reference Concrete Mix:
- 288 kg [635 lbs.] Type I/II Cement
- 408 kg [900 lbs.] - 9.5 to 12.5 mm [3/8 to ½ inch] coarse fraction Limestone aggregate
- 408 kg [900 lbs.] 4.75 to 9.5 mm [No. 4 to 3/8 inch] coarse fraction Limestone aggregate
- 544 kg [1200 lbs.] Fine aggregate - Ottawa sand
- 136 kg [300 lbs.] Water
- 6% ±1% Air Content

Permeability range greater than 4000 coulombs (0.0415 Faraday)

**Note 5** Chloride-containing admixtures are not recommended for incorporation into the Reference Concrete Mix design protocol

4.9.2. Agency Mix Design - An agency should select a representative mix for their geographic and climatic region. The water-cement ratio for the agency should be chosen to represent the highest anticipated acceptable w/c for a project to yield realistic results.

**Note 6** The better the quality of the concrete mix (i.e. lower permeability slows chloride ion penetration), the longer the projected time until corrosion is initiated. Therefore, it is recommended to not incorporate fly ash, granulated iron blast-furnace slag, silica fume, or metakaolin into the mix design.

4.9.3. Macrocell slab casting and curing - The concrete shall be cast and cured using the following procedure. In addition to casting macrocell slab test specimens, three (3) 100-mm [4.0-in.] cylinder specimens shall also be cast for: 28-day compressive strength (T 22), density, air content (T 121M/T 121), and permeability (T 277) testing to confirm the concrete quality.

4.9.3.1. The concrete shall be mixed according to Practice R 39.

4.9.3.2. The specimens shall be cast in an inverted position in two layers, so that the surface to be exposed is the bottom cast surface. Each layer shall be vibrated for 30 seconds on a vibrating table with an amplitude of 0.15 mm [0.0006 in.] and a frequency of 60 Hz.

4.9.3.3. After the second layer is vibrated, the surface of the specimen shall be finished using a wooden float.

4.9.3.4. The specimens shall be cured in the forms for 24 h.

4.9.3.5. Following the form curing period, the specimens shall be removed from the molds. The specimens shall be placed in a plastic container with distilled or tap water for 25 days to affect a 100 percent relative humidity exposure condition. After the 25 days curing in the container, cure the specimens an additional 45 days in a 80% (minimum) humidity curing room to assure maturity of the concrete. Alternatively, wrap seal the specimens in plastic ensuring moisture retention and cure for 60 days outdoors protected from sunlight and within a temperature range of 7°C to 38 °C (45°F to 100°F) in lieu of the high humidity curing room.

4.10. Prior to the start of the testing period, 1.5 mm² [16-gauge] insulated copper wire shall be attached to one end of each bar in reinforced specimens using 10-mm [⅜-in.] long 10-24 threaded stainless steel bolts.

4.11. The vertical sides of the specimens shall then be coated with two layers of the epoxy sealer. The electrical connections at the bar ends shall also be thoroughly coated to prevent crevice corrosion or galvanic corrosion from occurring.

4.12. The top of the specimens shall be lightly sanded and a plastic dam per Section 3.9 shall be placed on the top of each test specimen and sealed with silicone caulk per Section 3.10.

4.13. The specimens shall be supported on two pieces of wood, at least 50 mm [2.0 in.] thick, to allow air to flow under the specimens.

4.14. The top layer of steel of reinforced specimens shall then be connected to a red binding post on the terminal box, while each of the four bottom bars are connected to a black binding post on the terminal box. The top and four bottom bars are interconnected (Fig. 2) through a 10 Ohm resistor at the terminal box.
5. TEST METHOD

5.1 The test procedure for the 4 specimens shall proceed as follows after casting and curing.

5.1.1. All specimens are to be ponded initially with either distilled or tap water for 14 days at room temperature 20 to 24°C [68 to 76°F]. Subsequently, all specimens shall be ponded with a 3.0% sodium chloride solution, also at room temperature, for three days.

5.1.2. At the completion of this time (approximately 72 hours), potential of the electrically interconnected bars shall be measured using a saturated calomel electrode (SCE) positioned in the ponding solution and a high impedance voltmeter.

5.1.3. The voltage drop across the 10-ohm resistor connecting the three mats of steel shall also be recorded for each reinforced specimen at completion of the three day ponding cycle. The negative terminal of the voltmeter shall be connected to the black binding post and the positive terminal of the voltmeter shall be connected to the red binding post.

5.1.4. The voltage drop obtained from the macrocell readings shall be converted to a corrosion rate (in µm/year) using Eq. 1.

\[
\text{Corrosion Rate} = 11.6 \frac{i_c}{A R} = 11600 \frac{V}{A R} \quad \text{Eq. 1}
\]

\(i_c\) = corrosion current density (µA/cm²),
\(V\) = voltage drop across resistor (mV),
\(R\) = resistance of the resistor (ohm), and
\(A\) = area of exposed metal at the anode bar (cm²).

Note 7 - Owner may select the following alternate corrosion rate equation:

\[
\text{mpy} = (1.44/\rho) \times \left[ \frac{1.117 n}{(\text{atomic wt. of iron})} \right] \times 10^{-5} \frac{A}{cm^2}
\]

Where:
\(\rho\) = density of iron, 7.87 g/cm³,
\(n\) = number of electrons (2),
Atomic wt. of iron = 55.85

The surface area can be determined by use of either nominal bar diameter, or by an equivalent bar diameter, based on a volume measurement, that takes into account the protrusions of the bar deformations.

5.1.4.1 A #5 bar has a nominal bar diameter of 1.59 cm with a length of 20 cm and therefore has a surface area of 99.9 cm² ≈ 100 cm².

5.1.4.2 To determine surface area, including the deformations, cut a #5 bar to a specific length (for example, 20 cm) and measure its volume to the nearest cm³. The equivalent bar diameter is therefore \(d_{equiv} = (4V/\pi L)^{0.5}\), where \(V\) is the volume and \(L\) is the length of the bar. The surface area \(A\) of the bar, including deformations, is \(A = \pi(d_{equiv})L\).

5.1.5 After the readings have been taken, a heat tent shall be placed over the specimens to maintain a temperature of 38 ± 2°C [100 ± 3°F]. The specimens shall remain under the heat tent for four days (approximately 96 hours). This cycle (3 days chloride solution ponded followed by four days dry at
38 ± 2°C [100 ± 3°F].) along with recording of potential and voltage drop measurements is repeated for 52 weeks or longer at the discretion of the testing agency.

5.1.6. If a potential of -0.280V (SCE) or more negative is recorded for two consecutive measurements, then a three inch (nominal) diameter core is to be taken from one of the non-reinforced specimens and acid soluble chloride content measured at the cover depth of the top bar in the reinforced specimens using ASTM Test Method C1152/C1152M. The determined chloride concentration defines the critical value to initiate active corrosion.

6.  REPORT

6.1. Concrete proportions, air content, slump, and water to cement (w/c) ratio for the control and test specimens,

6.2. A plot of the corrosion current and potential for each concrete specimen versus time,

6.3. A plot of the average integrated current for each condition of concrete versus time,

6.4. Time for 1) potential of specimens to reach -0.280V (SCE) and the corresponding chloride concentration determined from non-reinforced specimens at the steel cover depth at the steel cover depth and 2) macrocell current to reach 10 µA. The number and percentage of specimens for which chloride thresholds are reached should also be reported.

6.5. Results of the visual inspection of each bar, including the percentage of original exposed steel surface corroded.

6.6. Photographs of the bars at the end of the test (optional).

7.  Precision and Bias Statement

7.1. No precision and bias statement has been developed for this test method.

8.  KEYWORDS

8.1. Reinforcing Bars Corrosion Test, Chloride Threshold Concentration
Since ASTM A82, A185, A496 and A497 have been superseded by A1064, I assume this proposed specification will ultimately replace M32, M55, M225 and M221? I do not see an affirmative vote with the following comments:

1) Need to resolve the LRFD issue (ACI 318 vs. AASHTO Bridge Spec.)
2) In Section 4.1.7, it references Section 6.7.6. Section 6.7.6 does not exist in this specification. Believe Section 6.4.5.2 should be referenced.
Standard Specification for

Steel Wire and Welded Wire, Plain and Deformed, for Concrete Reinforcement

AASHTO Designation: MP XYZM/MPXYZ-16\(^1\)
ASTM Designation: A1064/A1064M-15

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
Standard Specification for

Steel Wire and Welded Wire, Plain and Deformed, for Concrete Reinforcement

AASHTO Designation: MP XYZM/MP XYZ-16
ASTM Designation: A1064/A1064M-15

1. SCOPE

1.1. This specification covers carbon-steel wire and welded wire reinforcement produced from hot-rolled rod to be used for the reinforcement of concrete. The steel wire is cold-worked, drawn or rolled, plain (non-deformed, as-drawn or galvanized), or deformed. Welded wire reinforcement is made from plain or deformed wire, or a combination of plain and deformed wire. Common wire sizes are given in Tables 9, 10, 11 and 12; Actual wire sizes are not restricted to those shown in the tables.

Note 1—Welded wire for concrete reinforcement has been described by various terms: welded wire fabric (WWF), fabric, and mesh. The wire reinforcement industry prefers the term “welded wire reinforcement” (WWR) as being more representative of the range of products being manufactured. Therefore, the term “welded wire fabric” has been replaced with the term “welded wire reinforcement” in this specification and in related specifications.

1.2. This specification is applicable for orders in either SI units (MP XYZM) or in inch-pound units (MP XYZ). The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text the inch-pound units are shown in brackets (except in Table 9 and Table 11). SI units and inch-pound units are not necessarily equivalent; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
- T 244, Mechanical Testing of Steel Products

2.2. ASTM Standards:
- A641/A641M, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
- E83, Standard Practice for Verification and Classification of Extensometer Systems

2.3. Military Standard:
- MIL-STD-129, Marking for Shipment and Storage

2.4. Federal Standard:
- Fed. Std. No. 123, Marking for Shipments (Civil Agencies)

3. TERMINOLOGY

3.1. Description of Terms Specific to This Standard:
3.1.1. convoluted wire—when wire for welded wire reinforcement is shaped into a sinusoidal wave shape, it is commonly referred to as “convoluted wire.” The wire is used in the manufacture of cages for certain applications of concrete pipe reinforcing. Only plain wire is normally subject to convolution.

3.1.2. deformed steel wire for reinforcement—as used within the scope and intent of this specification, shall mean any cold-worked or rolled, deformed steel wire intended for use as reinforcement in concrete construction, the wire surface having deformations that (1) inhibit longitudinal movement of the wire in such construction and (2) conform to the provisions of Section 5. It shall be permissible for the deformations to be raised or indented.

3.1.3. plain steel wire for reinforcement—as used within the scope and intent of this specification, shall mean any cold-drawn or rolled, steel wire intended for use as reinforcement in concrete construction, the wire being smooth without deformations.

3.1.4. size number—as used in this specification, refers to the numerical designation of the wire as tabulated in Tables 9, 10, 11 and 12.

3.1.5. welded wire reinforcement—as used within the scope and intent of this specification, welded wire reinforcement designates a material composed of cold-worked steel wire, fabricated into sheets or rolls by the process of electric-resistance welding. The finished material shall consist essentially of a series of longitudinal and transverse wires arranged substantially at right angles to each other and welded together at points of intersection.

4. ORDERING INFORMATION

4.1. It shall be the responsibility of the purchaser to specify all requirements that are necessary for the manufacture and delivery of the wire under this specification. Such requirements to be considered include, but are not limited to, the following:

4.1.1. Quantity (mass) [weight] or square area for welded wire reinforcement;

4.1.2. Name of material (cold-drawn or rolled steel wire or welded wire reinforcement, plain or deformed, for concrete reinforcement);

4.1.3. Wire size number (see Tables 9, 10, 11 and 12). When wire is ordered in sizes other than the common sizes shown, the nominal dimensions shall be developed from the applicable unit mass per meter of the section;

4.1.4. Wire spacing, and sheet or roll width and length for welded wire reinforcement;

4.1.5. Minimum yield strength or Grade;

4.1.6. Yield strength measurement (see Sections 6.1.1, 6.2.1 and 11.3); Exclusion of oversteeling, if required (see Section 6.4.5.4.2);

4.1.7. Packaging (see Section 14);

4.1.8. Request for outside inspection (if not requested, Section 13.1 applies);

4.1.9. AASHTO designation and year of issue; and

4.1.10. Special requirements, if any.
5. **MATERIALS AND MANUFACTURE**

5.1. The steel shall be made by commercially accepted processes (typically electric arc furnace or basic oxygen).

5.2. The wire shall be cold drawn or rolled from rods that have been hot rolled from billets.

5.3. Unless otherwise specified, the wire shall be supplied uncoated. When specified as galvanized, it shall be galvanized at finish size as described in ASTM A641.

5.4. The wire used in the manufacture of welded wire reinforcement shall conform to this specification either solely or in combination of plain or deformed wire, or both.

5.5. For welded wire reinforcement, the wires shall be assembled by automatic machines or by other suitable mechanical means that will assure accurate spacing and alignment of all wires of the finished welded wire reinforcement. Longitudinal and transverse wires shall be securely connected at every intersection by a process of electrical-resistance welding, which employs the principle of fusion combined with pressure.

5.6. Welded wire reinforcement shall be furnished either in flat sheets or in rolls, as specified by the purchaser.

5.7. Wire of proper grade and quality when fabricated in the manner herein required in this specification shall result in a strong, serviceable, mat-type product having substantially square or rectangular openings. It shall be fabricated and finished in a workmanlike manner, shall be free of injurious defects, and shall conform to this specification.

**Note 2**—A variation of manufacturing includes the application of one or more longitudinal convoluted wires at one edge of welded wire reinforcement for concrete pipe reinforcing cages. This shape allows the cage ends to be expanded to a larger diameter to accommodate the bell-shaped ends of concrete pipe.

6. **MECHANICAL PROPERTY REQUIREMENTS**

6.1. *General Requirements for Plain Wire:*

6.1.1. *Tension Tests:*

6.1.1.1. When tested as described in T 244, the material, except as specified in Section 6.1.1.3, shall conform to the tensile property requirements in Table 1, based on nominal area of wire.

<table>
<thead>
<tr>
<th></th>
<th>Grade 485 [70]</th>
<th>Grade 500 [72.5]</th>
<th>Grade 515 [75]</th>
<th>Grade 533 [77.5]</th>
<th>Grade 550 [80]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, min MPa [ksi]</td>
<td>550 [80]</td>
<td>568 [82.5]</td>
<td>585 [85]</td>
<td>603 [87.5]</td>
<td>620 [90]</td>
</tr>
<tr>
<td>Yield strength, min MPa [ksi]</td>
<td>485 [70]</td>
<td>500 [72.5]</td>
<td>515 [75]</td>
<td>533 [77.5]</td>
<td>550 [80]</td>
</tr>
<tr>
<td>Reduction of area, min %</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
<td>30°</td>
</tr>
</tbody>
</table>

* For material testing over 690 MPa [100 ksi] tensile strength, the reduction of area shall be a minimum of 25 percent.

6.1.1.2. For material to be used in the fabrication of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 2, based on nominal area of the wire.
Table 2—Plain Wire Tension Test Requirements [Material for Welded Wire Reinforcement]

<table>
<thead>
<tr>
<th>Size</th>
<th>Grade 450 [65]</th>
<th>Grade 485 [70]</th>
<th>Grade 500 [72.5]</th>
<th>Grade 515 [75]</th>
<th>Grade 533 [77.5]</th>
<th>Grade 550 [80]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of area, min %</td>
<td>30º</td>
<td>30º</td>
<td>30º</td>
<td>30º</td>
<td>30º</td>
<td>30º</td>
</tr>
</tbody>
</table>

Smaller than Size MW 7.7 [W1.2]

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile strength, min MPa [ksi]</th>
<th>Yield strength, min MPa [ksi]</th>
<th>Reduction of area, min %</th>
</tr>
</thead>
<tbody>
<tr>
<td>385 [56]</td>
<td>485 [70]</td>
<td>385 [56]</td>
<td>30º</td>
</tr>
</tbody>
</table>

<sup>a</sup> For material testing over 690 MPa [100 ksi] tensile strength, the reduction of area shall be a minimum of 25 percent.

6.1.1.3. When required by the purchaser, yield strength shall be determined using a Class B-1 extensometer described in ASTM E83. The yield strength shall be determined as described in T 244 at an extension under load of 0.5 percent of gauge length or by the offset method (0.2 %). It shall be permissible to remove the extensometer after the yield strength has been determined. The wire shall meet the requirements of Table 1 or Table 2, whichever is applicable.

6.1.1.4. The material shall not be required to exhibit a definite yield point as evidenced by a distinct drop of the beam or halt in the gauge of the testing machine prior to reaching ultimate tensile load. The purchaser shall have the option to accept this feature as sufficient evidence of compliance with the specified minimum yield strength tests covered in this specification.

6.1.2. Bend Tests—The bend-test specimen shall withstand being bent at room temperature through 180 degrees without cracking on the outside of the bent portion, as prescribed in Table 3.

Table 3—Plain Wire Bend-Test Requirements

<table>
<thead>
<tr>
<th>Size</th>
<th>Number of Wire</th>
<th>Pin Diameter for Bend Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW45 [W7]</td>
<td>Equal to the nominal diameter of the wire specimen</td>
<td></td>
</tr>
<tr>
<td>Larger than MW45 [W7]</td>
<td>Equal to twice the nominal diameter of the wire specimen</td>
<td></td>
</tr>
</tbody>
</table>

6.1.3. Reduction of Area Test—The reduction of area shall be determined as described in T 244, and the wire shall conform to the reduction of area requirements in Table 1 or Table 2, whichever is applicable.

6.1.4. Permissible Variation in Wire Diameter:

6.1.4.1. The permissible variation in the diameter of the wire shall conform to the requirements in Table 4.

6.1.4.2. The difference between the maximum and minimum diameters, as measured on any given cross section of the wire, shall not exceed the tolerances listed in Table 4 for the given wire size.

Table 4—Permissible Variation in Wire Diameter

<table>
<thead>
<tr>
<th>Size Number</th>
<th>Nominal Diameter, mm [in.]</th>
<th>Permissible Difference (Max-Min)/Out-of-Round, mm [in.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller than MW32 [W5]</td>
<td>smaller than 6.40 [0.252]</td>
<td>0.08 [0.003]</td>
</tr>
<tr>
<td>MW32 [W5] to MW77 [W12], incl</td>
<td>6.40 [0.252] to 9.93 [0.391], incl</td>
<td>0.10 [0.004]</td>
</tr>
<tr>
<td>Larger than MW77 [W12] to MW129 [W20], incl</td>
<td>larger than 9.93 [0.391] to 12.83 [0.505], incl</td>
<td>0.15 [0.006]</td>
</tr>
<tr>
<td>Larger than MW129 [W20]</td>
<td>larger than 12.83 [0.505]</td>
<td>0.20 [0.008]</td>
</tr>
</tbody>
</table>

Ref. Tables 9, 10, 11 and 12 for nominal diameter values
6.2. **General Requirements for Deformed Wire**:

6.2.1. **Tension Tests**:

6.2.1.1. When tested as described in T 244, the material, except as specified in Section 6.2.1.4, shall conform to the tensile property requirements in Table 5 based on the nominal area of wire.

**Table 5**—Deformed Wire Tension Test Requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile strength, min MPa [ksi]</th>
<th>Yield strength, min MPa [ksi]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 51</td>
<td>585 [85]</td>
<td>515 [75]</td>
</tr>
<tr>
<td>Grade 533</td>
<td>603 [87.5]</td>
<td>533 [77.5]</td>
</tr>
<tr>
<td>Grade 55</td>
<td>620 [90]</td>
<td>550 [80]</td>
</tr>
</tbody>
</table>

6.2.1.2. For material to be used in the fabrication of welded wire reinforcement, the tensile and yield strength properties shall conform to the requirements given in Table 6, based on the nominal area of the wire.

**Table 6**—Deformed Wire Tension Test Requirements [Material for Welded Wire Reinforcement]

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile strength, min MPa [ksi]</th>
<th>Yield strength, min MPa [ksi]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 485</td>
<td>550 [80]</td>
<td>485 [70]</td>
</tr>
<tr>
<td>Grade 500</td>
<td>568 [82.5]</td>
<td>500 [72.5]</td>
</tr>
<tr>
<td>Grade 515</td>
<td>585 [85]</td>
<td>515 [75]</td>
</tr>
<tr>
<td>Grade 533</td>
<td>603 [87.5]</td>
<td>533 [77.5]</td>
</tr>
<tr>
<td>Grade 550</td>
<td>620 [90]</td>
<td>550 [80]</td>
</tr>
</tbody>
</table>

6.2.1.3. When required by the purchaser, yield strength shall be determined using a Class B-1 extensometer as described in ASTM E83. The yield strength shall be determined as described in T 244 and an extension of 0.5 percent of gauge length or by the offset method (0.2 %). It shall be permissible to remove the extensometer after the yield strength has been determined. The wire shall meet requirements of Table 5 or 6, whichever is applicable.

6.2.1.4. The material shall not be required to exhibit a definite yield point as evidenced by a distinct drop of the beam or halt in the gauge of the testing machine prior to reaching ultimate tensile load. The purchaser shall have the option to accept this feature as sufficient evidence of compliance with the specified minimum yield strength tests covered in this specification.

6.2.2. **Bend Test**—The bend-test specimen shall withstand being bent at room temperature through 90 degrees without cracking on the outside of the bent portion, as prescribed in Table 7.

**Table 5**—Deformed Wire Bend Test Requirements

<table>
<thead>
<tr>
<th>Size</th>
<th>Number of Wire</th>
<th>Pin Diameter for Bend Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD39 [D6]</td>
<td>MD39 [D6] and smaller</td>
<td>Equal to twice the nominal diameter of the wire specimen</td>
</tr>
<tr>
<td>Larger</td>
<td>Larger than MD39 [D6]</td>
<td>Equal to four times the nominal diameter of the wire specimen</td>
</tr>
</tbody>
</table>

6.2.3. **Deformations**:

6.2.3.1. Deformations shall be spaced along the wire at a substantially uniform distance and shall be symmetrically dispersed around the perimeter of the section. The deformations on all longitudinal lines of the wire shall be similar in size and shape. A minimum of 25 percent of the total surface area shall be deformed by measurable deformations.

6.2.3.2. Deformed wire shall have two or more lines of deformations.

6.2.3.3. The average longitudinal spacing of deformations shall be not less than 3.5 nor more than 5.5 deformations per 25.4 mm [1 in.] in each line of deformations on the wire.
6.2.3.4. The minimum average height at the center of typical deformations based on the nominal wire diameters shown in Table 11 and Table 12 shall be as prescribed in Table 8:

**Table 8—Deformed Wire Min. Avg. Height of Deformations Requirements**

<table>
<thead>
<tr>
<th>Wire Sizes</th>
<th>, Percent of Nominal Wire Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD20 [D3] and smaller</td>
<td>4</td>
</tr>
<tr>
<td>Larger than MD20 [D3] through MD65 [D10]</td>
<td>4½</td>
</tr>
<tr>
<td>Larger than MD65 [D10]</td>
<td>5</td>
</tr>
</tbody>
</table>

6.2.4. Deformations shall be placed with respect to the axis of the wire so that the included angle is not less than 45 degrees or, if deformations are curvilinear, the angle formed by the transverse axis of the deformation and the wire axis shall be not less than 45 degrees. Where the line of deformations forms an included angle with the axis of the wire from 45 degrees to 70 degrees inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the included angle is greater than 70 degrees, a reversal in direction is not required.

6.2.5. The average spacing of deformation shall be determined by dividing a measured length (254 mm [10 in.] minimum) of the wire specimen by the number of individual deformations in any one row of deformations on any side of the wire specimens. A measured length of the wire specimen shall be considered the distance from a point on a deformation to a corresponding point on any other deformation in the same line of deformations on the wire.

6.2.6. The minimum average height of deformations shall be determined from measurements made on not fewer than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentations or raised ribs.

6.3. *Permissible Variation in Mass [Weight]:*

6.3.1. The permissible variation in mass [weight] of any deformed wire is ±6 percent of its nominal mass [weight]. The theoretical masses [weights] shown in Table 11 and Table 12, or similar calculations on unlisted sizes, shall be used to establish the variation.

6.4. *General Testing Requirements for Plain and Deformed Welded Wire Reinforcement:*

6.4.1. **Tensile**—Tensile tests shall be made on wire cut from the welded wire reinforcement and tested either across or between the welds; no fewer than 50 percent shall be across the welds. Tensile tests across the weld shall have the welded intersection located approximately at the center of the wire being tested and the cross wire forming the welded intersection shall extend approximately 25.4 mm [1 in.] beyond each side of the welded intersection.

**Note 3**—Tensile, reduction of area, and bend testing are normally done at the time the wire is produced, however the manufacturer’s finished product shall still meet the requirements of this specification.

6.4.2. **Reduction of Area**—The ruptured section of the tensile specimen shall be measured to determine this property. In the case of a specimen that has been tested across a weld, the measurement shall be made only when rupture has occurred at a sufficient distance from the center of a weld to permit an accurate measurement of the fractured section. The wire shall meet the minimum reduction of area requirements of Section 6.1.3.

6.4.3. **Bend Test**—The wire shall withstand the bend test as described in 6.1.2 and shall be performed on a specimen taken from between the welds.

6.4.4. **Weld Shear Strength**—The weld shear strength between longitudinal and transverse wires shall be tested as described in Section 7. The minimum average shear value, in Newtons, shall not be less
than 241 multiplied by the nominal area of the larger wire in square millimeters [in pounds-force, shall not be less than 35,000 multiplied by the nominal area of the larger wire in square inches], where the smaller wire has an area of 40 percent or more of the area of the larger wire. For deformed welded wire reinforcement, the smaller wire shall not be less than MD26 [D4].

6.4.4.1. Deformed welded wire reinforcement having a relationship of larger and smaller wires other than that covered in Section 6.4.4 shall meet an average weld shear strength requirement of not less than 3.6 kN [800 lbf] provided that the smaller wire is not smaller than MD26 [D4]. Plain welded wire reinforcement having a relationship of larger and smaller wires other than those covered in 6.4.4 shall not be subject to the weld shear requirement.

6.4.4.2. Weld shear tests for determination of conformance to the requirements of Section 6.4.4 shall be conducted using a weld tester as described in Section 7.

6.4.4.3. Four welds selected at random from the specimen described in Section 9.3 shall be tested for weld shear strength. The transverse wire of each test specimen shall extend approximately 25.4 mm [1 in.] on each side of the longitudinal wire. The longitudinal wire of each test specimen shall be of such length below the transverse wire so as to be adequately engaged by the grips of the testing machine. It shall be of such length above the transverse wire that its end shall be above the center line of the upper bearing of the weld tester.

6.4.4.4. The material shall be deemed to conform to the requirements for weld shear strength if the average of the four samples complies with the value stipulated in Section 6.4.4. If the average fails to meet the prescribed value, all the welds across the specimen shall then be tested. The welded wire reinforcement will be acceptable if the average of all weld shear test values across the specimen meets the prescribed minimum value.

6.4.5. Dimensions, Mass, and Permissible Variations:

6.4.5.1. Width—The width of welded wire reinforcement shall be considered to be the center-to-center distance between outside longitudinal wires. The permissible variation shall not exceed 13 mm [0.5 in.] greater or less than the specified width. In case the width of flat sheets or rolls is specified as the overall width (tip-to-tip length of cross wires), the width shall not vary more than ±25.4 mm [±1 in.] from the specified width. When measurements involve a convoluted wire, the measurement shall be made to the approximate center of the sinusoidal wave shape.

6.4.5.2. Length—The overall length of flat sheets, measured on any wire, shall vary not more than ±25.4 mm [±1 in.] or 1 percent, whichever is greater.

6.4.5.3. Overhang of the transverse wires shall not project beyond the centerline of each longitudinal edge wire more than a distance of ±25.4 [1 in.] unless otherwise specified. When transverse wires are specified to project a specific length beyond the centerline of a longitudinal edge wire, the permissible variation shall not exceed 13 mm [0.5 in.] greater or less than the specified length.

6.4.5.4. The permissible variation in diameter of any wire in the finished welded wire reinforcement shall conform to the tolerances prescribed for the wire before fabrication with the following exceptions:

6.4.5.4.1. Because of the mechanical characteristics of fabricating plain wire welded wire reinforcement, the out-of-round requirements shall not apply.

6.4.5.4.2. Unless otherwise precluded by the purchaser in their Ordering Information (ref. Section 4.1), the manufacturer will be permitted to use oversized wire (commonly referred to as "oversteeling"). The size differential shall not exceed two "W or D" size increments on sizes W/D8 and smaller and four “W or D” size increments on sizes larger than W/D8. A “W or D” size increment is a whole number increment, for example, W/D5 to W/D6, or W/D5.4 to W/D6.4, etc.
6.4.5.4.3. In all cases where such over-steeling is practiced, the manufacturer shall identify the welded wire reinforcement with the style originally ordered. In cases in which the overall weight of the order is increased by more than ten percent, the producer shall identify the welded wire reinforcement with the style actually being furnished.

6.4.5.5. The average spacing of wires shall be such that the total number of wires contained in a sheet or roll is equal to or greater than that determined by the specific spacing, but the center-to-center distance between individual members shall vary not more than 6.4 mm [0.25 in.] from the specified spacing. It is understood that sheets of welded wire reinforcement of the specified length may not always contain an identical number of transverse wires and, therefore, may have various lengths of longitudinal overhang.

7. WELD SHEAR TEST APPARATUS AND METHODS

7.1. As the welds in welded wire reinforcement contribute to the bonding and anchorage value of the wires in concrete, the weld acceptance tests shall be made in a weld tester that stresses the weld in a manner similar to which it is stressed in concrete. In order to accomplish this, the vertical wire in the weld tester shall be stressed in an axis close to its centerline. Also, the horizontal wire shall be held closely to the vertical wire, and in the same relative position, so as to prevent rotation of the horizontal wire. When the welded wire reinforcement is designed with different wire sizes, the larger diameter wire is the “vertical wire” when tested (see Figure 1).

Figure 1—Welded Wire Reinforcement Weld Tester
7.2. Figure 1 shows the details of a typical weld tester together with two anvils that make it possible to test welds for wire up to 16 mm [0.625 in.] in diameter. This weld tester can be used in most tension testing machines and shall be hung in a ball-and-socket arrangement at the center of the machine. This, or a similarly effective fixture designed on the same principle, is acceptable.

7.3. Test specimens should be inserted through the notch in the anvil using the smallest notch available in which the vertical wire will fit loosely. The vertical wire shall be in contact with the surface of the free rotating rollers while the horizontal wire shall be supported by the anvil on each side of the slot. The bottom jaws of the testing machine shall grip the lower end of the vertical wire and the load shall be applied at a rate of stressing not to exceed 690 MPa/min [100 ksi/min].

8. **WORKMANSHIP, FINISH, AND APPEARANCE**

8.1. The wire shall be free of detrimental imperfections.

8.2. Rust, surface seams, or surface irregularities shall not be a cause for rejection provided the requirements of Section 6.1.4 are met; and the minimum dimensions and mechanical properties of a hand wire-brushed test specimen are not less than the requirements of this specification.

8.3. Wire intended for welded wire reinforcement shall be sufficiently free of rust and drawing lubricant so as not to interfere with electric resistance welding.

8.4. Welded wire reinforcement of proper grade and quality, when fabricated in the manner herein required, shall result in a strong, serviceable, mesh-type product having substantially square or rectangular openings and shall conform to this specification.

9. **SAMPLING**

9.1. Test specimens for testing mechanical properties of plain and deformed wire shall be full wire sections and shall be obtained from ends of wire coils as drawn or as galvanized. The specimens shall be of sufficient length to perform testing described in Sections 6.1.1 and 6.1.2.

9.2. Test specimens for testing mechanical properties of plain and deformed welded wire reinforcement shall be obtained by cutting from the finished welded wire reinforcement a full width section, of sufficient length to perform testing described in Sections 6.1 and 6.2.

9.3. Test specimens for determining weld shear properties shall be obtained by cutting from the finished welded wire reinforcement, a full width section of sufficient length to perform testing described in Section 6.4.4.

9.4. Measurements for conformance to dimensional characteristics shall be made on full sheets or rolls.

9.5. If any test specimen exhibits obvious isolated imperfections that are not representative of the product, it shall be discarded and another specimen substituted.

10. **NUMBER OF TESTS**

10.1. *Plain and Deformed Wire:*

10.1.1. One tension and one bend test shall be made from each 9000 kg [10 tons] or less of each size of wire or fraction thereof in a lot or a total of seven samples, whichever is fewer. A lot shall consist of all the coils of a single size offered for delivery at the same time.

10.2. *Plain and Deformed Welded Wire Reinforcement:*
10.2.1. One test for conformance to tensile strength and bend requirements, and one check for conformance to dimensional characteristics shall be made for each 7000 m² [75,000 ft²] of welded wire reinforcement or remaining fraction thereof.

10.2.2. One test for conformance to weld shear strength requirement shall be made for each 28 000 m² [300,000 ft²] or remaining fraction thereof.

11. INSPECTION

11.1. 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 that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable access to the facilities to assure him or her that the material is being furnished in accordance with this specification.

11.2. The purchaser shall have the option to require a yield strength measurement to determine compliance with yield strength requirements in Section 6.1.1 and Section 6.2.1 and shall specify that the measurement be performed by the manufacturer at the manufacturer’s facilities, a recognized laboratory, or the purchaser’s representative at the manufacturer’s facilities. Such measurements shall be conducted without unnecessarily interfering with the manufacturing operations.

11.3. *For U.S. Government Procurement Only*—Except as otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the contractor may use his or her own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

12. REJECTION, REHEARING, AND RETESTS

12.1. In case a specimen fails to meet the tension or bend test, the material shall not be rejected until two additional specimens taken from other wires in the same sheet or roll have been tested. The material shall be considered as meeting the specification in respect to any prescribed tensile property, provided the tested average for the three specimens, including the specimen originally tested, is equal to or exceeds the required minimum for the particular property in question, and provided further that none of the three specimens develops less than 80 percent of the required minimum for the tensile property in question. The material shall be considered as meeting this specification with respect to bend test requirements, provided both additional specimens satisfactorily pass the prescribed bend test.

12.2. Any material that is found not to meet the requirements of this specification subsequent to its acceptance at the manufacturer’s facilities shall be subject to rejection and the manufacturer shall be promptly notified.

12.3. Welded intersections shall withstand normal shipping and handling without becoming broken, but the presence of broken welds, regardless of cause, shall not constitute cause for rejection unless the number of broken welds per sheet exceeds 1 percent of the total number of intersections in a sheet. For material furnished in rolls, not more than 1 percent of the total number of intersections in 14 m² [150 ft²] of welded wire reinforcement shall be broken. Not more than one-half the permissible maximum number of broken welds shall be located on any one wire.
12.4. In the event of rejection because of failure to meet the weld shear requirements, four additional specimens shall be taken from four different sheets or rolls and tested in accordance with Section 7. If the average of all the weld shear tests performed does not meet the requirement, the material shall be rejected.

12.5. In the event of rejection because of failure to meet the requirements for dimensions, the amount of material rejected shall be limited to those individual sheets or rolls that fail to meet this specification.

12.6. Rust, surface seams, or surface irregularities will not be cause for rejection provided the minimum dimensions, cross-sectional area, and tensile properties of a hand wire-brushed test specimen are not less than the requirements of this specification. The height of deformations above the minimum height requirements shall not be cause for rejection.

12.7. Rehearing—Rejected materials shall be preserved for a period of at least two weeks from the date of inspection, during which time the manufacturer shall be permitted to make claim for a rehearing and retesting.

13. CERTIFICATION

13.1. If outside inspection is waived, a manufacturer’s certification that the material has been tested in accordance with and meets the requirements of this specification shall be the basis of acceptance of the material. The certification shall include the specification number, year-date of issue, and revision letter, if any.

13.2. This conformance is predicated upon testing and acceptance of wire prior to fabrication, coupled with random shear testing during production. The purchaser shall be furnished a manufacturer’s certification of conformance to this standard for each production date or production lot shipped. A production lot shall not exceed 28,000 m² [300,000 ft²]. Any purchaser shall have the right to invoke any of the provisions of Section 11.4.

13.3. Test results for yield strength, tensile strength, and bend tests shall be reported for plain wire above Grade 485 [70], plain welded wire reinforcement above Grade 450 [65], deformed wire above Grade 515 [75], and deformed welded wire reinforcement above Grade 485 [70].

13.4. A material test report, certificate of inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier’s facility. The content of the EDI transmitted document must meet the requirements of the invoked AASHTO standard(s) and conform to any existing EDI agreement between the purchaser and the manufacturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

Note 5—The industry definition as invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

14. PACKAGING AND MARKING

14.1. For plain and deformed wire, the size of the wire, AASHTO specification designation, and name or mark of the manufacturer shall be marked on a tag securely attached to each coil of wire.

14.2. When welded wire reinforcement is furnished in flat sheets, it shall be assembled in bundles of convenient size containing not more than 150 sheets and securely fastened together.
14.3. When welded wire reinforcement is furnished in rolls, each roll shall be secured so as to prevent unwinding during shipping and handling.

14.4. Each bundle of flat sheets, bundle of rolls, and each roll weighing over 180 kg [400 lb] shall have attached thereto a minimum of one suitable tag bearing the name of the manufacturer, description of the material, AASHTO designation, and such other information as may be specified by the purchaser.

14.5. When specified in the contract or order, and for the direct procurement by or direct shipment to the U.S. government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for military agencies and in accordance with Fed. Std. No. 123 for civil agencies.

15. **PLAIN AND DEFORMED WIRE DIMENSIONAL REQUIREMENTS**

15.1. When wire for concrete reinforcement is ordered by size number, the relations between size number, diameter, and area shown in Tables 9, 10, 11, & 12 shall apply.

**Table 9—Dimensional Requirements for Plain Wire—SI Units [Equivalent Non-Standard Units]**

<table>
<thead>
<tr>
<th>Size Number</th>
<th>Nominal Diameter [mm]</th>
<th>Nominal Area [mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW 5</td>
<td>2.52 [0.099]</td>
<td>5 [0.008]</td>
</tr>
<tr>
<td>MW 7.7</td>
<td>3.09 [0.122]</td>
<td>7.7 [0.012]</td>
</tr>
<tr>
<td>MW 10</td>
<td>3.57 [0.140]</td>
<td>10 [0.016]</td>
</tr>
<tr>
<td>MW 15</td>
<td>4.37 [0.172]</td>
<td>15 [0.023]</td>
</tr>
<tr>
<td>MW 20</td>
<td>5.05 [0.199]</td>
<td>20 [0.031]</td>
</tr>
<tr>
<td>MW 25</td>
<td>5.64 [0.222]</td>
<td>25 [0.039]</td>
</tr>
<tr>
<td>MW 30</td>
<td>6.18 [0.243]</td>
<td>30 [0.047]</td>
</tr>
<tr>
<td>MW 32</td>
<td>6.38 [0.251]</td>
<td>32 [0.050]</td>
</tr>
<tr>
<td>MW 35</td>
<td>6.68 [0.263]</td>
<td>35 [0.054]</td>
</tr>
<tr>
<td>MW 40</td>
<td>7.14 [0.281]</td>
<td>40 [0.062]</td>
</tr>
<tr>
<td>MW 45</td>
<td>7.57 [0.298]</td>
<td>45 [0.070]</td>
</tr>
<tr>
<td>MW 50</td>
<td>7.98 [0.314]</td>
<td>50 [0.078]</td>
</tr>
<tr>
<td>MW 55</td>
<td>8.37 [0.329]</td>
<td>55 [0.085]</td>
</tr>
<tr>
<td>MW 60</td>
<td>8.74 [0.344]</td>
<td>60 [0.093]</td>
</tr>
<tr>
<td>MW 65</td>
<td>9.10 [0.358]</td>
<td>65 [0.101]</td>
</tr>
<tr>
<td>MW 70</td>
<td>9.44 [0.372]</td>
<td>70 [0.109]</td>
</tr>
<tr>
<td>MW 77</td>
<td>9.90 [0.390]</td>
<td>77 [0.119]</td>
</tr>
<tr>
<td>MW 80</td>
<td>10.10 [0.397]</td>
<td>80 [0.124]</td>
</tr>
<tr>
<td>MW 90</td>
<td>10.70 [0.421]</td>
<td>90 [0.140]</td>
</tr>
<tr>
<td>MW 100</td>
<td>11.30 [0.444]</td>
<td>100 [0.155]</td>
</tr>
<tr>
<td>MW 120</td>
<td>12.40 [0.487]</td>
<td>120 [0.186]</td>
</tr>
<tr>
<td>MW 129</td>
<td>12.85 [0.506]</td>
<td>129 [0.200]</td>
</tr>
<tr>
<td>MW 130</td>
<td>12.90 [0.508]</td>
<td>130 [0.202]</td>
</tr>
<tr>
<td>MW 200</td>
<td>16.00 [0.628]</td>
<td>200 [0.310]</td>
</tr>
<tr>
<td>MW 290</td>
<td>19.20 [0.757]</td>
<td>290 [0.450]</td>
</tr>
</tbody>
</table>

*a Table 1 represents a hard metrication of the most readily available size in the welded wire reinforcement industry. Table 9 should be used in projects that are designed using SI units. Table 10 should be used in projects designed using inch-pound units. Areas of wire should be checked with the most efficient and readily available material from producers. Other wire sizes are available, and many manufacturers can produce them in 1-mm² [0.0015-in²] increments.*
Table 10—Dimensional Requirements for Plain Wire—
Standard Units [Equivalent Non-Standard Units]

<table>
<thead>
<tr>
<th>Wire Sizes</th>
<th>Nominal Diameter, in. [mm]</th>
<th>Nominal Area, in.² [mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>W0.5</td>
<td>0.080 [2.03]</td>
<td>0.005 [3.23]</td>
</tr>
<tr>
<td>W1.2</td>
<td>0.124 [3.14]</td>
<td>0.012 [7.74]</td>
</tr>
<tr>
<td>W1.4</td>
<td>0.134 [3.39]</td>
<td>0.014 [9.03]</td>
</tr>
<tr>
<td>W2</td>
<td>0.160 [4.05]</td>
<td>0.020 [12.90]</td>
</tr>
<tr>
<td>W2.5</td>
<td>0.178 [4.53]</td>
<td>0.025 [16.10]</td>
</tr>
<tr>
<td>W2.9</td>
<td>0.192 [4.88]</td>
<td>0.029 [18.70]</td>
</tr>
<tr>
<td>W3.5</td>
<td>0.211 [5.36]</td>
<td>0.035 [22.60]</td>
</tr>
<tr>
<td>W4</td>
<td>0.226 [5.73]</td>
<td>0.040 [25.80]</td>
</tr>
<tr>
<td>W4.5</td>
<td>0.239 [6.08]</td>
<td>0.045 [29.00]</td>
</tr>
<tr>
<td>W5</td>
<td>0.252 [6.41]</td>
<td>0.050 [32.30]</td>
</tr>
<tr>
<td>W5.5</td>
<td>0.265 [6.72]</td>
<td>0.055 [35.50]</td>
</tr>
<tr>
<td>W6</td>
<td>0.276 [7.02]</td>
<td>0.060 [38.70]</td>
</tr>
<tr>
<td>W7</td>
<td>0.302 [7.67]</td>
<td>0.070 [45.16]</td>
</tr>
<tr>
<td>W8</td>
<td>0.319 [8.11]</td>
<td>0.080 [51.60]</td>
</tr>
<tr>
<td>W10</td>
<td>0.357 [9.06]</td>
<td>0.100 [64.50]</td>
</tr>
<tr>
<td>W11</td>
<td>0.374 [9.50]</td>
<td>0.110 [71.00]</td>
</tr>
<tr>
<td>W12</td>
<td>0.391 [9.93]</td>
<td>0.120 [77.40]</td>
</tr>
<tr>
<td>W14</td>
<td>0.422 [10.70]</td>
<td>0.140 [90.30]</td>
</tr>
<tr>
<td>W16</td>
<td>0.451 [11.50]</td>
<td>0.160 [103.00]</td>
</tr>
<tr>
<td>W18</td>
<td>0.479 [12.20]</td>
<td>0.180 [116.00]</td>
</tr>
<tr>
<td>W20</td>
<td>0.505 [12.80]</td>
<td>0.200 [129.00]</td>
</tr>
<tr>
<td>W22</td>
<td>0.529 [13.40]</td>
<td>0.220 [142.00]</td>
</tr>
<tr>
<td>W24</td>
<td>0.553 [14.00]</td>
<td>0.240 [155.00]</td>
</tr>
<tr>
<td>W26</td>
<td>0.575 [14.60]</td>
<td>0.260 [168.00]</td>
</tr>
<tr>
<td>W28</td>
<td>0.597 [15.20]</td>
<td>0.280 [181.00]</td>
</tr>
<tr>
<td>W30</td>
<td>0.618 [15.70]</td>
<td>0.300 [194.00]</td>
</tr>
<tr>
<td>W31</td>
<td>0.628 [16.00]</td>
<td>0.310 [200.00]</td>
</tr>
<tr>
<td>W45</td>
<td>0.757 [19.20]</td>
<td>0.450 [290.00]</td>
</tr>
</tbody>
</table>

This table represents the most recently available sizes in the welded wire enforcement industry in sizes using inch-pound units. Areas of wire should be checked with the most efficient and readily available material from producers. Other wire sizes are available, and many manufacturers can produce them in 0.0015-in.² increments.
### Table 6—Dimensional Requirements for Deformed Steel Wire for Concrete Reinforcement—SI Units

**[U.S. Customary Units]**

<table>
<thead>
<tr>
<th>Deformed Wire Size</th>
<th>(D in.²)</th>
<th>Unit Mass [Weight]</th>
<th>Diameter</th>
<th>Cross-Sectional Area</th>
<th>Min Avg Height of Deformations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(× 100)</td>
<td>kg/m [lb/ft]</td>
<td>mm [in.]</td>
<td>mm² [in.²]</td>
<td></td>
</tr>
<tr>
<td>MD 20</td>
<td>[D 3.2]</td>
<td>0.157 [0.105]</td>
<td>5.05 [0.199]</td>
<td>20 [0.031]</td>
<td>0.225 [0.0087]</td>
</tr>
<tr>
<td>MD 25</td>
<td>[D 3.9]</td>
<td>0.196 [0.132]</td>
<td>5.64 [0.222]</td>
<td>25 [0.039]</td>
<td>0.252 [0.010]</td>
</tr>
<tr>
<td>MD 26</td>
<td>[D 4.0]</td>
<td>0.204 [0.137]</td>
<td>5.75 [0.226]</td>
<td>26 [0.0404]</td>
<td>0.255 [0.0101]</td>
</tr>
<tr>
<td>MD 30</td>
<td>[D 4.6]</td>
<td>0.235 [0.158]</td>
<td>6.18 [0.243]</td>
<td>30 [0.047]</td>
<td>0.279 [0.011]</td>
</tr>
<tr>
<td>MD 35</td>
<td>[D 5.4]</td>
<td>0.275 [0.185]</td>
<td>6.68 [0.263]</td>
<td>35 [0.054]</td>
<td>0.302 [0.012]</td>
</tr>
<tr>
<td>MD 39</td>
<td>[D 6.0]</td>
<td>0.306 [0.206]</td>
<td>7.05 [0.278]</td>
<td>39 [0.0605]</td>
<td>0.316 [0.0124]</td>
</tr>
<tr>
<td>MD 40</td>
<td>[D 6.2]</td>
<td>0.314 [0.211]</td>
<td>7.14 [0.281]</td>
<td>40 [0.062]</td>
<td>0.320 [0.013]</td>
</tr>
<tr>
<td>MD 45</td>
<td>[D 7.0]</td>
<td>0.353 [0.237]</td>
<td>7.57 [0.298]</td>
<td>45 [0.070]</td>
<td>0.342 [0.014]</td>
</tr>
<tr>
<td>MD 50</td>
<td>[D 7.7]</td>
<td>0.392 [0.264]</td>
<td>7.98 [0.314]</td>
<td>50 [0.078]</td>
<td>0.360 [0.014]</td>
</tr>
<tr>
<td>MD 55</td>
<td>[D 8.5]</td>
<td>0.432 [0.290]</td>
<td>8.37 [0.329]</td>
<td>55 [0.085]</td>
<td>0.378 [0.015]</td>
</tr>
<tr>
<td>MD 60</td>
<td>[D 9.3]</td>
<td>0.471 [0.316]</td>
<td>8.74 [0.344]</td>
<td>60 [0.093]</td>
<td>0.392 [0.015]</td>
</tr>
<tr>
<td>MD 65</td>
<td>[D 10.1]</td>
<td>0.510 [0.343]</td>
<td>9.10 [0.358]</td>
<td>65 [0.101]</td>
<td>0.455 [0.018]</td>
</tr>
<tr>
<td>MD 70</td>
<td>[D 10.8]</td>
<td>0.549 [0.369]</td>
<td>9.44 [0.372]</td>
<td>70 [0.109]</td>
<td>0.470 [0.018]</td>
</tr>
<tr>
<td>MD 80</td>
<td>[D 12.4]</td>
<td>0.628 [0.422]</td>
<td>10.1 [0.397]</td>
<td>80 [0.124]</td>
<td>0.505 [0.020]</td>
</tr>
<tr>
<td>MD 90</td>
<td>[D 13.9]</td>
<td>0.706 [0.475]</td>
<td>10.7 [0.421]</td>
<td>90 [0.140]</td>
<td>0.535 [0.021]</td>
</tr>
<tr>
<td>MD 100</td>
<td>[D 15.5]</td>
<td>0.785 [0.527]</td>
<td>11.3 [0.444]</td>
<td>100 [0.155]</td>
<td>0.565 [0.022]</td>
</tr>
<tr>
<td>MD 120</td>
<td>[D 18.6]</td>
<td>0.942 [0.633]</td>
<td>12.4 [0.487]</td>
<td>120 [0.186]</td>
<td>0.620 [0.024]</td>
</tr>
<tr>
<td>MD 130</td>
<td>[D 20.1]</td>
<td>1.02 [0.686]</td>
<td>12.9 [0.507]</td>
<td>130 [0.202]</td>
<td>0.645 [0.025]</td>
</tr>
<tr>
<td>MD 200</td>
<td>[D 31.0]</td>
<td>1.57 [1.05]</td>
<td>16.0 [0.628]</td>
<td>200 [0.310]</td>
<td>0.800 [0.031]</td>
</tr>
<tr>
<td>MD 290</td>
<td>[D 45.0]</td>
<td>2.28 [1.53]</td>
<td>19.2 [0.757]</td>
<td>290 [0.450]</td>
<td>0.961 [0.0379]</td>
</tr>
</tbody>
</table>

---

a The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square millimeters.

b For sizes other than those shown above, the size number shall be the nominal cross-sectional area in square millimeters (mm²) of the deformed wire cross section, prefixed by the letters MD.

c These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 1-mm² [0.0015-in.²] increments.

d The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same mass per meter as the deformed wire.

e The cross-sectional area is based on the nominal diameter. The area in square millimeters [inches] is calculated by dividing the unit mass [weight] in kg/m [lb/ft] by 7 × 10⁻⁶ (mass of 1 mm³ of steel [0.2833 weight of 1 in.³ of steel]) or by dividing the unit mass [weight] in kg/m [lb/ft] by 0.007849 (mass of steel 1 mm² and 1 m long) [3.4 (weight of steel 1 in.² and 1 ft long)].

f The minimum average height of the deformations shall be determined from measurements made on no fewer than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentation as described in Section 6.2.6.
Table 7—Dimensional Requirements for Deformed Steel Wire for Concrete Reinforcement—U.S. Customary Units [SI Units] Wire Sizes

<table>
<thead>
<tr>
<th>Deformed Wire Size Number</th>
<th>Unit Weight [Mass], lb/ft [kg/m]</th>
<th>Diameter, in. [mm]</th>
<th>Cross-Sectional Area, in.² [mm²]</th>
<th>Min Avg Height of Deformations, in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>0.034 [0.051]</td>
<td>0.113 [2.87]</td>
<td>0.010 [6.45]</td>
<td>0.0045 [0.114]</td>
</tr>
<tr>
<td>D2</td>
<td>0.068 [0.101]</td>
<td>0.159 [4.05]</td>
<td>0.020 [12.9]</td>
<td>0.0063 [0.160]</td>
</tr>
<tr>
<td>D3</td>
<td>0.102 [0.152]</td>
<td>0.195 [4.96]</td>
<td>0.030 [19.4]</td>
<td>0.0078 [0.198]</td>
</tr>
<tr>
<td>D4</td>
<td>0.136 [0.202]</td>
<td>0.226 [5.73]</td>
<td>0.040 [25.8]</td>
<td>0.0101 [0.257]</td>
</tr>
<tr>
<td>D5</td>
<td>0.170 [0.253]</td>
<td>0.252 [6.41]</td>
<td>0.050 [32.3]</td>
<td>0.0113 [0.287]</td>
</tr>
<tr>
<td>D6</td>
<td>0.204 [0.304]</td>
<td>0.276 [7.02]</td>
<td>0.060 [38.7]</td>
<td>0.0124 [0.315]</td>
</tr>
<tr>
<td>D7</td>
<td>0.238 [0.405]</td>
<td>0.319 [8.11]</td>
<td>0.080 [51.6]</td>
<td>0.0143 [0.363]</td>
</tr>
<tr>
<td>D8</td>
<td>0.272 [0.455]</td>
<td>0.339 [8.60]</td>
<td>0.090 [56.7]</td>
<td>0.0190 [0.481]</td>
</tr>
<tr>
<td>D9</td>
<td>0.306 [0.506]</td>
<td>0.357 [9.06]</td>
<td>0.100 [64.5]</td>
<td>0.0160 [0.406]</td>
</tr>
<tr>
<td>D10</td>
<td>0.340 [0.545]</td>
<td>0.374 [9.51]</td>
<td>0.110 [71.0]</td>
<td>0.0187 [0.475]</td>
</tr>
<tr>
<td>D11</td>
<td>0.374 [0.557]</td>
<td>0.391 [9.93]</td>
<td>0.120 [77.4]</td>
<td>0.0195 [0.495]</td>
</tr>
<tr>
<td>D12</td>
<td>0.408 [0.607]</td>
<td>0.407 [10.3]</td>
<td>0.130 [83.9]</td>
<td>0.0203 [0.516]</td>
</tr>
<tr>
<td>D13</td>
<td>0.442 [0.658]</td>
<td>0.422 [10.7]</td>
<td>0.140 [90.3]</td>
<td>0.0211 [0.536]</td>
</tr>
<tr>
<td>D14</td>
<td>0.476 [0.708]</td>
<td>0.437 [11.1]</td>
<td>0.150 [96.8]</td>
<td>0.0218 [0.554]</td>
</tr>
<tr>
<td>D15</td>
<td>0.510 [0.759]</td>
<td>0.451 [11.5]</td>
<td>0.160 [103]</td>
<td>0.0225 [0.572]</td>
</tr>
<tr>
<td>D16</td>
<td>0.544 [0.810]</td>
<td>0.465 [11.8]</td>
<td>0.170 [110]</td>
<td>0.0232 [0.589]</td>
</tr>
<tr>
<td>D17</td>
<td>0.578 [0.860]</td>
<td>0.479 [12.2]</td>
<td>0.180 [116]</td>
<td>0.0239 [0.607]</td>
</tr>
<tr>
<td>D18</td>
<td>0.612 [0.911]</td>
<td>0.492 [12.5]</td>
<td>0.190 [122]</td>
<td>0.0245 [0.622]</td>
</tr>
<tr>
<td>D19</td>
<td>0.646 [0.961]</td>
<td>0.505 [12.8]</td>
<td>0.200 [129]</td>
<td>0.0252 [0.640]</td>
</tr>
<tr>
<td>D20</td>
<td>0.680 [1.01]</td>
<td>0.517 [13.1]</td>
<td>0.210 [135]</td>
<td>0.0259 [0.658]</td>
</tr>
<tr>
<td>D21</td>
<td>0.714 [1.06]</td>
<td>0.529 [13.4]</td>
<td>0.220 [141]</td>
<td>0.0265 [0.673]</td>
</tr>
<tr>
<td>D22</td>
<td>0.748 [1.11]</td>
<td>0.541 [13.7]</td>
<td>0.230 [148]</td>
<td>0.0271 [0.688]</td>
</tr>
<tr>
<td>D23</td>
<td>0.782 [1.16]</td>
<td>0.553 [14.0]</td>
<td>0.240 [154]</td>
<td>0.0277 [0.704]</td>
</tr>
<tr>
<td>D24</td>
<td>0.816 [1.21]</td>
<td>0.564 [14.3]</td>
<td>0.250 [161]</td>
<td>0.0282 [0.716]</td>
</tr>
<tr>
<td>D25</td>
<td>0.850 [1.26]</td>
<td>0.575 [14.6]</td>
<td>0.260 [167]</td>
<td>0.0288 [0.732]</td>
</tr>
<tr>
<td>D26</td>
<td>0.884 [1.32]</td>
<td>0.586 [14.9]</td>
<td>0.270 [174]</td>
<td>0.0293 [0.744]</td>
</tr>
<tr>
<td>D27</td>
<td>0.918 [1.37]</td>
<td>0.597 [15.2]</td>
<td>0.280 [180]</td>
<td>0.0299 [0.759]</td>
</tr>
<tr>
<td>D28</td>
<td>0.952 [1.42]</td>
<td>0.608 [15.4]</td>
<td>0.290 [187]</td>
<td>0.0304 [0.772]</td>
</tr>
<tr>
<td>D29</td>
<td>0.986 [1.47]</td>
<td>0.618 [15.7]</td>
<td>0.300 [193]</td>
<td>0.0309 [0.785]</td>
</tr>
<tr>
<td>D30</td>
<td>1.02 [1.52]</td>
<td>0.628 [16.0]</td>
<td>0.310 [200]</td>
<td>0.0314 [0.798]</td>
</tr>
<tr>
<td>D31</td>
<td>1.05 [1.57]</td>
<td>0.638 [16.3]</td>
<td>0.320 [206]</td>
<td>0.0319 [0.812]</td>
</tr>
<tr>
<td>D32</td>
<td>1.08 [1.62]</td>
<td>0.648 [16.6]</td>
<td>0.330 [212]</td>
<td>0.0324 [0.825]</td>
</tr>
<tr>
<td>D33</td>
<td>1.11 [1.67]</td>
<td>0.658 [16.9]</td>
<td>0.340 [218]</td>
<td>0.0329 [0.839]</td>
</tr>
<tr>
<td>D34</td>
<td>1.14 [1.72]</td>
<td>0.668 [17.2]</td>
<td>0.350 [224]</td>
<td>0.0334 [0.852]</td>
</tr>
</tbody>
</table>

a In this table only, inch-pound units are regarded as standard and SI units are shown in brackets.

b The number following the prefix indicates the nominal cross-sectional area of the deformed wire in square inches [square millimeters].

c For sizes other than those shown above, the size number shall be the number of one hundredths of a square inch in the nominal area of the deformed wire cross section prefixed by the letter D.

d These sizes represent the most readily available sizes in the welded wire reinforcement industry. Other wire sizes are available and many manufacturers can produce them in 0.0015 in.² [1 mm²] increments.

e The nominal diameter of a deformed wire is equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire.

f The cross-sectional area is based on the nominal diameter. The area in square inches [millimeters] is calculated by dividing the unit weight [mass] in lb/ft [kg/m] by 2.833 (weight of 1 in.³ of steel) [7 × 10⁻⁶ (mass of 1 mm³ of steel)], or by dividing the unit weight [mass] in lb/ft [kg/m] by 3.4 (weight of steel 1 in.² and 1 ft long) [0.007849 (mass of 1 mm² and 1 m long)].

g The minimum average height of the deformations shall be determined from measurements made on no fewer than two typical deformations from each line of deformations on the wire. Measurements shall be made at the center of indentation as described in Section 6.2.6.

16. KEYWORDS

16.1. concrete reinforcement; deformations; deformed wire; reinforced concrete; reinforcing steels; steel wire; welded wire reinforcement

1 This provisional standard was first published in 2016.
Rather than referencing A615 and A706, should M31 be referenced instead? We use calibrated electronic thickness gauges in Kansas since it is much faster with better data transfer. Does the proposed specification limit the determination of thickness to the older thumb wheel magnetic gauges?[CN]

Decision | Comments
---|---
California | No Vote | Quick Lab Chief Review...#1) We do not specify in Sect 52-2 Epoxy-Coated Reinforcement of the Standards Specifications 2010/2015 for M 254. #2) I found in some Special Provisions that M254 is mentioned in Load Transfer and this revised spec removed the portion (3.8.4 Welding) that CT referenced and comments were not visible upon initial download from the ballot system. In the future and especially when revising existing standards, it is recommended to upload the proposed revised standard in 'All Markup' mode so that the redlines and comments are visible upon initial download. #3) I switched the downloaded document from 'No Markup' mode to 'All Markup' mode. I realized that Steve Tritsch of JC Supply added comments providing the rationale to explain some of the revised proposals. Comments were not added for all of the proposed significant revisions so some of my comments below include a number of "Why?" questions. On page 1 and 2 of this standard, the ASTM designation should be revised to M 254-17 (assuming these proposed revisions will be balloted in the fall and adopted by the full SOM for publishing in 2017). In Section 1.2, it appears that the "Type" now includes consideration of the "performance" (e.g., "higher performance" and "highest performance") in addition to the previous bond strength. As a result, revise Type A and Type B to include their intended performance (i.e., "standard performance" or "moderate performance").#5) In Section 5.2, recommend the sentence be changed to the following: "The nonabraded thickness of the Type B, C, and D coating shall comply with the requirements shown in Section 6.3.3." AASHTO specifications should be referenced whenever possible. #4) In Section 5.2, recommend the sentence be changed to the following: "The nonabraded thickness of the Type B, C, and D coating shall comply with the requirements shown in Section 6.3.3." #5) AASHTO M 314 discusses the test method used to make this measurement, SSPC-PA2.

International Zinc Assn | No Vote | Title should be more clear that specification relates to organic coatings only. For example "Standard Specification for corrosion-resistant organic coated dowel bars".

Kansas | Affirmative | Rather than referencing A615 and A706, should M31 be referenced instead? We use calibrated electronic thickness gauges in Kansas since it is much faster with better data transfer. Does the proposed specification limit the determination of thickness to the older thumb wheel magnetic gauges?[CN]

Missouri | Negative | Need to resolve issues with AASHTO T253 (Item No. 3) before approving these changes to AASHTO M254. We noted the following items: in Section 1.2, the first sentence states, "The coated dowels shall be one of the two following types:". The word "two" should be replaced with the word "four" since there are four types listed.2) Type C meets "higher" performance while Type D meets the "highest" performance. Can this be better defined such as anticipated service life?3) Section 4.1 requires the steel to comply with ASTM A 615 or ASTM A 706. Recommend that AASHHTO M31 be used instead considering the proposed changes discussed in Item 5. of this ballot. AASHTO specifications should be referenced whenever possible.4) In Section 5.2, recommend the second sentence be changed to the following: "The nonabraded thickness of the Type B, C, and D coating shall comply with the requirements shown in Section 6.3.3." AASHTO M 314 discusses the test method used to make this measurement, SSPC-PA2.

Pennsylvania | Negative | Negative with comments:1. It took me a little while to realize that the uploaded m254-2016 Final Draft document included redlines and comments. It appears the document was uploaded to the ballot system in 'No Markup' mode and the redlines and comments were not visible upon initial download from the ballot system. In the future and especially when revising existing standards, it is recommended to upload the proposed revised standard in 'All Markup' mode so that the redlines and comments are visible upon initial download.2. Once I switched the downloaded document from 'No Markup' mode to 'All Markup' mode, I realized that Steve Tritsch of JC Supply added comments providing the rationale to explain some of the proposed revisions. Comments were not added for all of the proposed significant revisions so some of my comments below include a number of "Why?" questions.3) On page 1 and 2 of this standard, the ASTM designation should be revised to M 254-17 (assuming these proposed revisions will be balloted in the fall and adopted by the full SOM for publishing in 2017). In Section 1.2, it appears that the "Type" now includes consideration of the "performance" (e.g., "higher performance" and "highest performance") in addition to the previous bond strength. As a result, revise Type A and Type B to include their intended performance (i.e., "standard performance" or "moderate performance").#3) In Section 2.1, add reference to "M 31/M 31M".4) In Section 2.2, I do not like the addition of ASTM A1078 to the list of referenced documents in this standard. Addition and reference to ASTM A1078 is main reason for my negative vote. The ASTM A1078 is a relatively new standard first published by ASTM in 1973. Since we are AASHHTO, I believe we should be revising M 254 to specify exactly what we want and not be referencing a relatively new ASTM A1078 standard for corrosion resistant dowel bars. M 254 should be appropriately revised and not reference ASTM A1078.9. In Section 2.2, delete reference to "A615" and go with comment #7 above.10. In Section 3, previous Section 3.3 regarding wear due to abrasion from pavement expansion and contraction is proposed to be deleted. Comment indicates ASTM A 1078 has an abrasion requirement. Again, not sure why we are referencing ASTM A1078. Also, the abrasion resistance test in A1078 is different than the existing abrasion test specified in T 253 as pointed out in the comments from Bruce Ebersole for the T 253 ballot item (Ballot Item #3) below. There is no rational provided to support why the abrasion test referenced in ASTM A 1078 (Annex 1) is better than the current abrasion test in T 253. This is another reason for my negative vote.11. In Section 4.1, revise from "ASTM A615" to "M 31/M 31M". AASHHTO Standards should always refer to the equivalent AASHHTO standard, not an ASTM Standard.12. In Section 1.2, revise from "unless specified" to "unless otherwise specified".13. In Section 4.2, I do not like that we are referencing ASTM A 1078 here. We should be revising the requirements in M 254 to get what we want not referencing a similar specification.14. In Section 5.2, it is recommended to keep the length dimension statement and not delete it due to redundancy with other contract documents. At least the statement refers to a M 254 to where the length dimensions requirements are located.15. In Section 6, it is recommended to leave the previous Sections 6.3 and 6.4 regarding damage from welding and strength of welding, respectively, and add "unless otherwise..."
Standard Specification for

Corrosion-Resistant Coated Dowel Bars

AASHTO Designation: M 254-06 (20156)
Standard Specification for

Corrosion-Resistant Coated Dowel Bars

AASHTO Designation: M 254-06 (2015)

1. SCOPE

1.1. This specification covers the materials, manufacture, and installation of coated dowel bars to be used where corrosion-resistant performance is essential and may be used in lieu of stainless or other approved noncorrosive metals. The dowel shall consist of a steel core covered by an organic coating.

1.2. The coated dowels shall be one of the two following types:

Type A — The coating material develops sufficiently low-bond strength with concrete that a bond breaker is not required.

Type B (single layer flexible) — The coating material develops bond strength with concrete such that a bond breaker is required. The type of bond breaker used shall be as recommended by the coating manufacturer.

Type C (single layer non-flexible) — The dowel meets a higher performance criteria for long life pavements and develops bond strength with concrete such that a bond breaker may be required. The type of bond breaker used shall be as recommend by the coating manufacturer.

Type D (dual layer coating with ARO) — The dowel meets the highest performance criteria for long life pavements and develops bond strength with concrete such that a bond breaker may be required. The type of bond breaker used shall be as recommend by the coating manufacturer.

1.3. The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:

- M 255M/M 255, Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
- M 31/ M31 M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- T 253, Coated Dowel Bars

2.2. ASTM Standard:

- G12, Standard Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel (withdrawn 2013)
- A 615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- A 706 Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
- A 1078 Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement

2.3. Other Reference:

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Comment [SLT1]: Better adhesion results as reflected in disbondment test

Comment [SLT2]: Better adhesion and thicker coating

Formatted: Normal
3. GENERAL REQUIREMENTS

3.1. The coated dowels shall resist corrosion and degradation caused by roadway deicing materials and normal highway debris.

3.2. The coating shall develop low-bond strengths with portland cement concrete without a bond breaker, if Type A, or with the proper bond breaker, if Type B, Type C, or Type D.

3.3. The coating shall resist wear due to abrasion resulting from pavement expansion and contraction.

3.4.3.3. The coating used over the steel core shall be continuous on the lateral surface of the dowel. Dowels with Type C and Type D coatings shall be fully encapsulated. No cold/wet patching allowed for Type C and Type D coatings.

3.5.3.4. Test procedures as stated herein and in T 253 shall apply to both Type A, and Type B, Type C, and Type D dowels.

3.6.3.5. In the event there is any change in material composition or geometrics of the joint support system, any or all parts of the dowels and assembly are subject to retesting. The frequency of qualification testing will be determined by the purchasing agency.

3.6. The processing facilities of the manufacturer and the fabricator shall be open to inspection by the agent of the purchaser at all times during the manufacturing and fabricating of the material.

3.7. The purchaser shall specify the Type designation – Type A, Type B, Type C, or Type D.

3.8. A minimum of 24 dowel bars shall be made available for testing. Of these, a maximum of six bars may be in a basket assembly.

4. MATERIALS

4.1. The core material shall be made of steel meeting the requirements of M 255M/M 255 AASHTO M 31, ASTM A 615 or ASTM A 706. The minimum yield strength shall be 60 ksi unless otherwise specified by the purchasing agency.

4.2. The coating material shall be of organic composition with the exception of the pigment, which may or may not be present, and which may have an inorganic composition. The epoxy powder for coatings and application for Type B (single layer flexible coating) and C (single layer non-flexible coating) shall meet the minimum requirements set forth in ASTM A 1078. The top coating for Type D (dual layer coating) shall be an Abrasion Resistant Overcoat (ARO) placed over a non-flexible layer.

Note 01 – The Type B coating material may be one of the types recommended in Report No. FHWA RD-74-18 or other types approved by the purchasing agency.

5. DIMENSIONS

5.1. The core metal shall be 31.8-mm (1 1/8-in.) diameter or as specified by the purchasing agency.
5.2. The nonabraded thickness of the Type A coating shall be 0.64 ± 0.13 mm (25 ± 5 mils) and shall be determined by stripping the coating from the bar. The nonabraded thickness of the Type B, C, and D coating shall be 0.18 ± 0.05 mm (7 ± 2 mils).

5.3. Coating thickness shall be determined according to SSPC-PA2 ASTM G12 or by stripping the coating from the bar.

5.4.5.2. The dowels shall be supplied to lengths and in support assemblies or baskets as specified by the purchasing agency.

6. PHYSICAL REQUIREMENTS

6.1. The free ends of the dowels shall be saw cut and free of burrs and projections. Sharp edges from saw cutting shall be removed for Type C and Type D dowels prior to coating application.

6.2. Dowel coatings shall be free from contamination, perforations, cracks, and holidays (pinholes not visually discernible). Checking for holidays shall be performed by the electric-resistance process. A 67.5-V holiday detector shall be used, as recommended by the manufacturer of the test equipment, for the determination of holidays.

6.3. Any damage that results from welding or mechanical fixation to achieve a fixed-end condition shall not extend more than 25.4 mm (1 in.) in from the weld or point of fixation.

6.4. Welding to achieve a fixed-end condition shall be sufficiently strong to maintain dowel alignment under the forces imposed by concrete placement and construction practices.

6.5.6.3. When tested in accordance with T 253, the dowel bars shall have the following properties:

6.5.1. Load Deflection—The relative deflection shall not exceed 0.25 mm (0.10 in.) at the 1815-kg (4000-lb) load for any of the three specimens tested.

6.5.2.6.3.1. Pullout—The maximum pullout load shall not exceed 1360 kg (3000 lb) for any specimens, and no specimen shall show any corrosion, tears, or perforation due to the pullout and subsequent freeze-thaw testing.

6.5.3. Abrasion—The coating shall not have been worn away, perforated, or wrinkled, and none of the three specimens shall show depth or wear exceeding 70 percent of the original coating thickness. Thickness shall be determined according to Section 5.3 of this specification.

6.5.4. Corrosion—No corrosion shall be apparent on any of the specimens when viewed under five-power magnification.

6.5.5. Chemical Resistance—The coating shall not blister, soften, disbond, develop holidays, nor exhibit any undercutting at the drilled holes.

6.5.6. Cathodic Disbonding—No film failure shall take place during the first 1 h of testing. Such film failure would be evidenced by the evolution of hydrogen gas at the cathode or appearance of corrosion products of steel at the anodes except that such hydrogen evolution or corrosion products at the intentionally cut 6.4-mm (1/4-in.) holes will not be considered as basis for rejection. However, no undercutting shall be permitted during the remainder of the test period at the intentionally cut 6.4-mm (1/4-in.) holes in either the anode or cathode.

6.5.7.6.3.2. Coating Hardness—The hardness of the coating shall exceed the Knoop Hardness Number of 16.
6.3.3. *Coating Impact Resistance*—No shattering or disbonding of the coating shall occur except at the impact area (area permanently deformed by the tup). The following table presents the epoxy coating requirements for thickness, cathodic disbondment, and patched ends.

Table 1 - Requirements by Coating Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Thickness, min</th>
<th>Cathodic Disbondment, radius</th>
<th>Patched End Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>min 10 mils</td>
<td>&lt; 4 mm radius</td>
<td>&gt; 5 mils* N/A</td>
</tr>
<tr>
<td>C</td>
<td>min 10 mils</td>
<td>&lt; 2 mm radius</td>
<td>N/A</td>
</tr>
<tr>
<td>D</td>
<td>min 10 mils</td>
<td>N/A</td>
<td>N/A &gt;10 mils &gt;10 mils</td>
</tr>
<tr>
<td>Type C</td>
<td>min 10 mils</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Top ARO</td>
<td>min 10 mils</td>
<td>&lt; 1 mm radius</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* When required by the agency

6.5.8. **Unless waived by the agency**

7. **SAMPLING**

7.1. The purchasing agency shall specify required sampling for dowels and/or baskets. A minimum of 24 dowel bars, of which up to 6 may be in a basket assembly, shall be furnished by the manufacturer for testing and verification of the materials and process. The specimens shall be made available to the testing laboratory 120 days prior to their first intended use. When fixed mechanical assembly is being used, a complete assembly with dowels shall be made available upon request by the purchasing agency.

8. **DOCUMENTATION**

8.1. Tests performed according to this specification shall be the responsibility of the manufacturers and/or coating applicator and may be performed at his laboratory or an independent laboratory approved by the purchasing agency. Upon completion of the tests, all tested specimens shall be properly labeled as to test procedure, and be made available upon request to the purchasing agency.

8.2. The laboratory facilities and procedure must be open to observation by the purchaser while tests are underway. The purchasing agency reserves the right to check any or all parts of the required tests in the agency laboratory or a laboratory of his choice.

8.3. The coated dowel manufacturer and/or coating applicator shall provide certified copies of test reports to the purchasing agency showing all test data.

8.4. For the purpose of identification, the manufacturer or applicator shall provide certification showing the generic type of coating material along with the type and percentages of pigments, diluents, fillers, flexibilizers, and other additives used.

8.5. The coated dowel manufacturer is defined as a company that produces a complete product consisting of dowel bar and coating.

8.6. The coating applicator is defined as a company that applies coatings to dowel bars.
8.6. Rechecks of the coated dowels may be made at the discretion of the purchasing agency. The purchasing agency may delete any of the above specified test procedures during rechecks of any previously approved product.

9. STORAGE

9.1. Coated dowels stored outdoors for more than 30 days shall be covered with opaque polyethylene sheeting or other suitable protective material.

9.2. If a bond breaker is applied at the manufacturing location and stored outdoors for more than 30 days, the dowels shall be covered with an opaque polyethylene sheeting or other suitable protective material.

10. REPORT

10.1. The purchasing agency shall specify test report submittals required for each specified product.

10.2. For epoxy coated dowels, the following test reports shall be submitted for each project: coating thickness and 30-day moving average cathodic disbondment test.

8.7. For epoxy-coated dowels the following test reports shall be submitted for each project: coating thickness and 30-day moving average disbondment test.
Negative with comments:

1. It took me a little while to realize that the uploaded m 254 2016 Final Draft document included redlines and comments. It appears the document was uploaded to the ballot system in 'No Markup' mode and the redlines and comments were not visible upon initial download from the ballot system. In the future and especially when revising existing standards, it is recommended to upload the proposed revised standard in 'All Markup' mode so that the redlines and comments are visible upon initial download.

   Self explanatory

2. Once I switched the downloaded document from 'No Markup' mode to 'All Markup' mode, I realized that Steve Tritsch of JC Supply added comments providing the rational to explain some of the proposed revisions. Comments were not added for all the proposed significant revisions so some of my comments below include a number of "Why?" questions.

   Self explanatory

3. On page 1 and 2 of this standard, the ASTM designation should be revised to M 254-17 (assuming these proposed revisions will be balloted in the fall and adopted by the full SOM for publishing in 2017).

   Editorial

4. In Section 1.2, it appears that the "Type" now includes consideration of the "performance" (e.g., "higher performance" and "highest performance") in addition to the previous bond strength. As a result, revise Type A and Type B to include their intended performance (i.e., "standard performance" or "moderate performance").

   Not sure that we want to use/define standard or moderate for the performance. No change made.

5. In Section 1.2, it appears by Section 4.2 that the "Type" now includes consideration of the "number of coating layers" (single and dual), the 'flexibility' of the coating (flexible and non-flexible), and if it includes an "abrasion resistant overcoat (ARO)". As a result, consider including the proposed text "single layer flexible coating", "single layer non-flexible coating", "dual layer coating" and "Abrasion Resistant Overcoat (ARO)" that is proposed to be added to Section 4.2 and moving it or copying it to Section 1.2 for each appropriate Type.

   Editorial, done

6. In Section 1.2, revise from "The Type C" to "Type C".

   Editorial, done

7. In Section 2.1, add reference to "M 31/M 31M".

   M31 added

8. In Section 2.2, I do not like the addition of ASTM A1078 to the list of referenced documents in this standard. Addition and reference to ASTM A1078 is main reason for my negative vote. The ASTM A1078 is a relatively new standard first published by ASTM in 2012. In comparison, M 254 was first
published in 1977. Since we are AASHTO, I believe we should be revising M 254 to specify specifically what we want and not be referencing a relatively new ASTM A1078 standard for corrosion resistant dowel bars. M 254 should be appropriately revised and not reference ASTM A1078.

Reference to ASTM A1078 is easier to maintain than repeating text from that standard and needing to update it as changes are made through ASTM. Let’s save the TS some work.

9. In Section 2.2, delete reference to "A615" and go with comment #7 above.

M31 added

10. In Section 3, previous Section 3.3 regarding wear due to abrasion from pavement expansion and contraction is proposed to be deleted. Comment indicates ASTM A1078 has an abrasion requirement. Again, not sure why we are referencing ASTM A1078. Also, the abrasion resistance test in A1078 is different than the existing abrasion test specified in T 253 as pointed out in the comments from Bruce Ebersole for the T 253 ballot item (Ballot Item #3) below. There is no rational provided to support why the abrasion test referenced in ASTM A1078 (A775, Annex 1) is better than the current abrasion test in T 253. This is another reason for my negative vote.

Sections 3.3 and 6.5.3 - abrasion testing is removed because the testing conducted under ASTM A775 or ASTM A934 are more rigorous and must be met by the powder coating prior to use. The AASHTO test method and limit were set in 1977 and no current approved epoxy will ever fail the 70% threshold.

11. In Section 4.1, revise from "ASTM A615" to "M 31/M 31M". AASHTO Standards should always refer to the equivalent AASHTO standard, not an ASTM Standard.

M31 added

12. In Section 4.1, revise from "unless specified" to "unless otherwise specified".

Editorial, changed

13. In Section 4.2, I do not like that we are referencing ASTM A1078 here. We should be revising the requirements in M 254 to get what we want not referencing a similar and relatively new ASTM A1078. Another reason for my negative vote. Also, we should specifically indicate what the epoxy coating is to meet and not reference ASTM A1078 which then references other standards.

Reference to ASTM A1078 is easier to maintain than repeating text from that standard and needing to update it as changes are made through ASTM. Let’s save the TS some work.

13. In Section 5.2, Type A is separated from Types B, C, and D. However, only Types B, C, and D include a referenced test method for determining the coating thickness (SSPC-PA 2). What is the coating thickness test method for Type A? Why is the SSPC-PA 2 being referenced for coating thickness determination over the previous referenced coating thickness test method ASTM G12 (G12 was withdrawn and replaced with ASTM D7091)? Recommend referencing ASTM D7091 which references SSPC-PA 2 for frequency of tests due to more common accessibility to ASTMs vs SSPC specifications unless there is some specific reason to go with SSPC-PA 2 over ASTM D7091.
Add “and shall be determined by stripping the coating from the bar” after (25 ± 5 mills). The industry has developed over the past 40 years and ASTM A775, A934, and A1078 reference the SSPC-PA 2 method and we would prefer to keep this reference consistent.

14. In Section 5, it is recommended to keep the length dimension statement and not delete it due to redundancy with other contract documents. At least the statement refers a user of M 254 to where the length dimension requirements are located.

   I don’t think it is needed as previously stated. “The dowels shall be supplied to lengths and in support assemblies or baskets as specified by the purchasing agency.” Nothing about loose dowels. Also, detail sheets and/or standard specifications specify lengths.

15. In Section 6, it is recommended to keep the previous Sections 6.3 and 6.4 regarding damage from welding and strength of welding, respectively, and add "unless otherwise specified by the purchasing agency" to the end of Section 6.3

   Standard detail sheets specify wire sizes and welding or fabricator has to submit shop drawings. Statements are no longer needed – maybe in 1977, but not today.

16. In Section 6, it is recommended to keep the previous Section 6.5.1 regarding Load Deflection and add "unless otherwise specified by the purchasing agency" to the end. The load-deflection test is likely a required test in order to verify conformance with proposed Section 3.5 (previously Section 3.6).

   A redundant test. Steel strength is specified. Deflection testing may indicate poor concrete but not steel property. We have never heard of a failed test.

17. In Section 6, it is recommended to keep the previous Section 6.5.3 regarding Abrasion and perhaps revise the requirements if today's coatings typically perform better than the specified value (percentage). No reason has been given regarding difference in abrasion tests between that referenced in ASTM A1078 and T 253. Also, it appears an abrasion test is needed to determine acceptability of the Abrasion Resistant Overcoat (ARO) referenced in proposed Section 4.2.

   See response to comment 10 above.

18. In Section 6.3.1, the previous text "and subsequent freeze-thaw testing" has been deleted. It is not recommended to delete this text. The freeze-thaw testing represents actual field conditions of dowel bars in some states. Suggest adding, "unless otherwise specified by the purchasing agency" to allow option not to require.

   This was explained in the comments in the spec. Freezing and thawing is more concrete sensitive than steel/epoxy sensitive. May have been appropriate before modern epoxies, but not today.

19. In Section 6, it is recommended to keep the previous subsection requirements for "Corrosion", "Chemical Resistance", and "Coating Impact Resistance". The rationale that some of these are covered in ASTM A1078 is not acceptable. Another reason for my negative vote.

   These tests are covered by ASTM A775 and ASTM A934 which cover the powders (as well as ASTM A1078) and are therefore redundant herein.
20. In Section 6.3.2, although T 253 includes a reference to the test method for Coating Hardness, the Coating Hardness test method should be referenced here. Add the following to the end of the existing sentence "determined according to ASTM D1474/D1474M, using a 100-g (0.22-lb) mass". In addition, ASTM D1474/D1474M should be listed in Section 2.2.

   This would be redundant since reference is made to AASHTO T253 (Section 6.3) for the test and that information is contained therein.

21. In Section 6.3.3, the table should be given a number and a caption.

   Editorial, added

22. In Section 6.3.3, the table should include a column for "Test Method" and a column for "Units".

   Editorial, dual units will be added in final edits. Column for Test Method is redundant and would confuse the table.

23. In Section 6.3.3., revise the column 1, row 2, from "Thickness" to "Thickness, Min" and revise the column 1, row 3, from "Cathodic Disbondment" to "Cathodic Disbondment, radius". Then, revise columns 2, 3, 4, &amp; 5 and rows 2, 3, and 4 to remove the "min", "mils" (if adding a units column), and "radius".

   Editorial, change made

24. In Section 7.1, suggest adding back in the minimum number of individual dowel bars and the number of dowel bars configured in a basket to conduct the required testing of this specification and include the language "unless otherwise specified by the purchaser or specifying agency".

   Not necessary, 7.1 leaves it state specified.

25. In Section 9.1, revise from "1 month" to "30 days" as the length of months varies. In addition, revise to clarify the intent of the storage. Is it OK to store outside uncovered for &lt; 30 days and then at day 30 cover the material? What if dowel bars are stored outside by manufacturer for &lt; 30 days (uncovered) and then transported to a project site where it is stored outside for &lt; 30 days (uncovered)? Is the intent of this storage language to allow multiple storages each &lt; 30 days? This section needs clarified to account for multiple storage areas/times. Suggest requiring that the material be covered when stored as the simplest clarification.

   Text changed to 30 days. The industry is working this out now to clarify. Current the manufacturer has 1 month (according to ASTM) and then 2 months are allowed at the job site (again according to ASTM). Can you give us time to evaluate and keep the AASHTO reference at 30 days?

Additional comments from Bruce Ebersole (PennDOT Physical Test Lab Manager):

1. In § 4.2: What are the minimum requirements for the ARO overcoat?

   Good question. Only response we have now is industry integrity in meeting the Canadian spec.

2. In § 5.2: (2nd sentence) Should reference the Table of coating parameters (in Section 6.3.3).

   Editorial, change made
<table>
<thead>
<tr>
<th>Agency</th>
<th>Decision</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>No Vote</td>
<td>For corrosion effectiveness of epoxy coated dowel bars AASHTO M254 brings nothing new to the table not currently provided in Sect 52-2.02. If Caltrans is thinking to reference AASHTO M254, then Sect 40-1.02C(3) would benefit by replacing current references to Sect 52-2.02 with AASHTO M254.</td>
</tr>
<tr>
<td>International Zinc Assn</td>
<td>No Vote</td>
<td>Title should be more clear that specification relates to organic coatings only. For example 'Standard method of test for organic coated dowel bars'</td>
</tr>
<tr>
<td>Kansas</td>
<td>Affirmative</td>
<td>Misspelling of &quot;three&quot; in Section 6.2.</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Negative</td>
<td>Negative with comments: 1. It took me a little while to realize that the uploaded T 253 2016 Final Draft document included redlines and comments. It appears the document was uploaded to the ballot system in 'No Markup' mode and the redlines and comments are not visible upon initial download from the ballot system. In the future and especially when revising existing standards, it is recommended to upload the proposed revised standard in 'All Markup' mode so that the redlines and comments are visible upon initial download. 2. Once I switched the downloaded document from 'No Markup' mode to 'All Markup' mode, I realized that Steve Tritsch of JC Supply added comments providing the rational to explain some of the proposed revisions. Comments were not added for all the proposed significant revisions so some of my comments below include a number of &quot;Why?&quot; questions. 3. On page 1 and 2 of this standard, the ASTM designation should be revised to &quot;T 253-17&quot; (assuming these proposed revisions will be balloted in the fall and adopted by the full SOM for publishing in 2017). 4. In Section 1.1, the text indicates this standard test method is &quot;designed to test the qualifications...to withstand the effects of weathering&quot;. There are no weathering related tests in this proposed standard, so how will the qualifications in regard to &quot;weathering&quot; be determined? 5. In Section 1.1, the text indicates this standard test method is &quot;designed to test the qualifications...to withstand the effects of...the abrading and loading stresses&quot;. There are no &quot;abrading and loading stresses&quot; related tests in this proposed revised standard, so how will the qualifications in regard to &quot;abrading and loading&quot; be determined? The previous tests for abrading and loading (Section 7--Corrosion-Abrasion Test Procedure and Section 5--Load-Deflection Test Procedure) are proposed deletions. I do not recommend the existing Sections 5 and 7 be deleted and is part of the reason for my negative vote. 6. In Section 2.2, consider adding &quot;D7091&quot; here in lieu of adding proposed Section 2.3 and &quot;SSPC-PA 2&quot;. 7. In Section 2.2, recommend keeping &quot;G14&quot; and &quot;G20&quot; as M 254 should directly specify these and not specify them through a reference to ASTM A1078. ASTM A1078 should not be a reference. AASHTO should update/revise and specify what it wants in M 253 and not refer to a relatively new ASTM standard that has similar intent. This is main reason for the 6. In Section 3.2, the text references &quot;load, pullout, and corrosion tests&quot;, but the load test (previous Section 5--Load Deflection Test Procedure) and the corrosion test (previous Section 7--Corrosion-Abrasion Test Procedure) have been deleted in the proposed revised T 253. If the previous Section 5 and Section 7 test procedures are to remain deleted, this text here in Section 3.2 should be revised to delete references to &quot;load...and corrosion tests&quot;. I do not recommend these be deleted and is reason for my negative vote. 7. In Section 3.2, 2nd line, revise from &quot;condition&quot; to &quot;conditions&quot;. 8. In Section 3, I do not recommend deleting subsection 3.3 related to an &quot;abradermeter&quot;, subsection 3.5 related to &quot;hold-down devices&quot;, subsection 3.6 related to &quot;freeze-thaw equipment&quot;, and subsection 3.7 related to &quot;quantities of chemical&quot; as proposed. The rationale that hold down not necessary due to agency specification of basket dimensions and rationale that ASTM A1078 includes the abrasion and corrosion tests is not acceptable and is reason for my negative vote. 9. Previous Section 5--Load-Deflection Test Procedure is proposed to be deleted. I do not recommend it be deleted as is reason for my negative vote. This load-deflection test should be optional testing as specified by the purchasing agency. 10. In proposed revised Section 5--Pullout Test Procedure, previous subsections 6.5.1 and 6.7 do not apply.</td>
</tr>
</tbody>
</table>
Standard Method of Test for

Coated Dowel Bars

AASHTO Designation: T 253-02 (20112016)
Release: Group 2 (June 2016)
Standard Method of Test for
Coated Dowel Bars

AASHTO Designation: T 253-02 (20142016)
Release: Group 2 (June 2016)

1. SCOPE

1.1. These methods are designed to test the qualifications of the organic coating of corrosion-resistant dowel bars to withstand the effects of weathering, deicing chemicals, and the abrading and loading stresses experienced in field joints.

1.2. The units of measure to be used shall be either SI units or inch-pound units (shown in parentheses in this standard) depending on the units used in the applicable material specification.

1.3. The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:

- R 39, Making and Curing Concrete Test Specimens in the Laboratory
- T 106M/T 106, Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens)

2.2. ASTM Standards:

- G8, Standard Test Methods for Cathodic Disbonding of Pipeline Coatings
- G12, Standard Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel (withdrawn 2013)
- G14, Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)
- G20, Standard Test Method for Chemical Resistance of Pipeline Coatings

2.3. Other References:

- Society for Protective Coatings Specifications: SSPC-PA2 Measurement of Dry Coating Thickness with Magnetic Gauges

3. MATERIALS AND APPARATUS

3.1. The concrete design and constituents shall comply with the procedure and specification stated by the purchasing or specifying agency.

3.2. Suitable containers, molds, and miscellaneous concrete mixing equipment necessary for mixing and casting the simulated doweled joints for load, pullout, and corrosion tests to meet conditions stated in R 39.
3.3. An abradometer capable of operating at 60 to 70 double strokes per minute using 100-mm- (4-in.) long strokes. 

Comment [SLT5]: Modern epoxies already have abrasion requirements.
3.4.3.3 Universal test machine capable of operating accurately in the 0- to 45-kN (10,000 lbf) ranges and capable of controlled stress and strain rate loading.

3.5 Suitable hold-down devices for positioning and holding the casting in place without rotation during the flexure test.

3.6 Freeze–thaw equipment of sufficient capacity to handle the pullout and corrosion–abrasion test specimen.

3.7 Sufficient quantities of chemical to maintain solution for corrosion tests.

4. PREPARATION OF SAMPLES

4.1 The coated dowels for deflection tests may be in support baskets or loose. The coated dowels for the remainder of tests shall be loose.

4.2 Type A–coated dowels shall be cast without additional coating of any kind. Type B, C, and D–coated dowels shall be covered before casting with the debonding agent specified by the coating manufacturer.

4.3 The prepared dowels shall be cast in the appropriate molds specified for the various tests.

5. LOAD-DEFLECTION TEST PROCEDURE

5.1 Six dowels with basket assemblies, if any, will be utilized in three load-deflection tests. The test will be conducted in accordance with the following procedures:

5.2 Two dowels with basket assemblies, or without basket assemblies in case of loose dowels, shall be cast into each concrete test specimen in a manner to simulate two 305-mm (12 in.) long highway contraction joints. (See Figure 1.) The contraction joints are formed by dividing the mold into three sections with two-piece plates 9.5 mm (3/8 in.) thick. After the mold has been filled, the concrete shall be consolidated by vibration.

5.3 The concrete test specimens shall be made and cured in accordance with R 39. The specimens shall be removed from the molds after a 24-h curing period and shall be further moist-cured for a total of 14 days.

5.4 Upon completion of curing, the simulated joint shall be placed in a testing machine and loaded as illustrated in Figure 1. The end sections will be provided with suitable hold-down devices to prevent rotation. The load shall be applied at the rate of 8.9 kN/min (2000 lbf/min) until a load of 17.8 kN (4000 lbf) is obtained. The relative deflection between the loaded center section and the supported stationary ends will be measured under the 17.8-kN (4000-lbf) maximum load. Record maximum relative deflection under load.

Comment [SLT6]: Not applicable as agencies specify basket dimensions.

Comment [SLT7]: Not needed for pullout resistance; abrasion and corrosion tests are covered in ASTM 1078.

Comment [SLT8]: Deflection test irrelevant as detail sheets dictate dimensions.

Comment [SLT9]: No longer needed. Deleted from AASHTO 234 and agencies specify by detail sheets or submittal drawings.
6.5. PULLOUT TEST PROCEDURE

6.1.5.1. Three dowels shall be tested in accordance with the following procedures:

6.2.5.2. For one half of its length, each dowel shall be cast into a 152.4-mm (6-in.) diameter concrete cylinder. Care shall be taken to assure that the dowels are on the centerline axis of the concrete cylinder. The concrete shall be consolidated by vibration.

6.3.5.3. Cure the molded specimens in accordance with R 39. Remove the molds from the specimens after the first 24 h of a 48-h moist-curing period.

5.4. After 48-h curing ±2 h, place the concrete cylinder in the testing machine and apply a tensile load parallel to the axis of the dowel. Record the maximum pullout tensile load for the first 12.7 mm (0.5 in.) of movement for each of the three test specimens. The testing machine shall be adjusted to a free-running speed of 0.76 mm/min (0.030 in./min) prior to performing this test and this setting shall be maintained during the test.

6.4.5.5. All applicators shall perform the pullout test on an annual basis for each debonding agent used by the coater.

Comment [SLT10]: The annual test will demonstrate the coater's ability to properly apply the debonding agent.
6.5. After the first 12.7 mm (0.5 in.) of movement of the dowels, the test specimens will be further cured as before for an additional 12 days. Then the test specimens will be placed in a 10 mass percent sodium chloride solution in such a manner as to inundate half of the cross-sectional perimeter of the dowels. The sodium chloride solution will be maintained at this level and once a week it will be replaced by a fresh solution. The partially submerged specimens will be subjected to 50 cycles of freezing and thawing consisting of freezing in air for 16 h at a temperature of \(-28.9 \pm 1.7^\circ C\) (\(-20 \pm 3^\circ F\)) and thawing in air for 8 h at a temperature of \(22.8 \pm 1.7^\circ C\) (\(73 \pm 3^\circ F\)).

6.6. Upon completion of the freeze-thaw cycling, the test specimens will again be placed in the testing machine and the pullout load redetermined by pulling out the dowels an additional 12.7 mm (0.5 in.) at the rate specified in Section 6.4. Again record the maximum tensile load for each of the specimens.

6.7. After the total 25.4 mm (1 in.) movement of the dowel, remove the concrete by breaking it away from the dowel. The dowel and the concrete-dowel interface will be examined for corrosion, tearing, and perforation.

7.6. CORROSION-ABRASION-COATING THICKNESS TEST PROCEDURE

7.6.1. Three dowel bars shall be subjected to corrosion-abrasion-coating thickness testing in accordance with the following procedures: SSPC-PA 2.

7.6.2. Abrasion resistance of the dowels will be determined by the use of an abradometer. The abradometer is operated at 60 to 70 double strokes per minute using a 100-mm (4-in.) long stroke. The abrading block is a 4-in. long mortar block made of portland cement and Ottawa sand (T 106M/T 106) cast to fit over about one third of the perimeter of the test dowel. The test load is the 2500-g mass of the abrading assembly and block. Each dowel will be tested for a total of 10,000 double strokes (from the starting point to the far end and returning to the starting point is considered one double stroke). A single recorded thickness measurement is the average of three individual gage readings. A minimum of five recorded measurements shall be taken approximately evenly spaced along each side of the test specimen.

7.3. Upon completion of the abrading, the dowels will be examined for wear, perforation, and wrinkling.

7.4. After completion of testing in Section 7.3, determine loss of thickness due to abrasion by ASTM G12. A minimum of five readings shall be taken in both the abraded and unabraded portions of the dowel. The average of the five readings shall determine the respective thickness.

7.5. The abraded dowels will be placed in a 10 mass percent sodium chloride solution so as to inundate half of the cross section perimeter of the abraded area and expose the upper half to the atmosphere. The sodium chloride solution will be maintained at this level and once a week it will be replaced by a fresh solution. A sufficient length of the coated dowel will be subjected to the test so that not less than 50 mm (2 in.) of unabraded coating is tested at each end of the abraded area. The partially submerged specimens will be subjected to 50 cycles of freezing and thawing as specified in Section 6.5.

7.6. After the 50 cycles of freezing and thawing, the dowel will be removed and thoroughly examined for corrosion under five-power magnification.
8. **CHEMICAL RESISTANCE TEST PROCEDURE**

8.1. Three dowel bars will be subjected to chemical resistance testing in accordance with the following procedure:

8.2. Sample bars will be tested in the manner described in ASTM G20, by immersion for 45 days in each of the following: distilled water, an aqueous solution of 3 molar CaCl₂, an aqueous solution of 3 molar NaOH, and a solution saturated with Ca(OH)₂ at a temperature of 23.9 ± 1.7°C (75 ± 3°F).

9.7. **CATHODIC DISBONDING TEST PROCEDURE**

9.7.1. Two dowel bars shall be tested to determine their resistance to cathodic disbonding in the following manner:

9.7.2. The test procedure shall be Method A of ASTM G8, except: (1) the cathode and anode shall be dowel bars coated with the same material, (2) the electrolyte shall be an aqueous solution of 32 percent mass NaCl, (3) a potential of ±2.5 V shall be applied, and (4) no intentional holes shall be cut except for a single 6.43.2-mm (1/4 1/8-in.) diameter hole made in the middle of the immersed length in both the anode and the cathode. The test period duration shall be 30 days, 168 hours at a solution temperature of 75 ± 3.6°F.

10.8. **COATING HARDNESS TEST PROCEDURE**

10.8.1. Three dowel bars shall be tested in the following manner to determine the hardness of the plastic organic coating:

10.8.2. The hardness of the coating shall be determined using the method of ASTM D1474/D1474M, using a 100-g (0.22-lb) mass.

11. **COATING IMPACT RESISTANCE TEST PROCEDURE**

11.1. Three dowel bars shall be tested in the following manner to determine the resistance of the coating to impact:

11.2. The coating shall be subjected to an impact force of 9 J (80 in.-lb) with a 1.8-kg (4-lb) tup at 23.9 ± 1.7°C (75 ± 3°F) according to the procedure of ASTM G14.

12.9. **REPORT**

12.9.1. The report shall show all temperature, load, and miscellaneous data pertinent to the test conditions, including the following:

12.9.1.1. Maximum relative deflection under a 17.8-kN (4000-lbf) load for each specimen, procedure in Section 5, Load Deflection Test Procedure.

12.9.1.2. Maximum kilonewton (lbf) load for pullout of each specimen after 48-h curing period and after the subsequent 50-cycle freeze-thaw procedure in Section 65, Pullout Test Procedure.
12.1.3.9.1.2. **Original**: Record each thickness of coating and abraded thickness, procedure measurement and compute the average of all measurements in Section 6, Coating Thickness Test Procedure in Section 7, Corrosion–Abrasion Test Procedure.

12.1.4. Observation of the condition of each specimen after completion of the freeze–thaw cycling of procedure in Section 6, Pullout Test and procedure in Section 7, Corrosion–Abrasion Test Procedure.

12.1.5. Coating condition after completion of procedure in Section 8, Chemical Resistance Test Procedure.

12.1.6.9.1.3. Record each cathodic disbondment radius measurement and evidence, if any, of hydrogen evolution, corrosion products, undercutting or other film failure resulting from procedure in Section 9, Cathodic Disbonding Test Procedure.
12.1.7.9.1.4. Coating hardness as determined by procedure in Section 108, Coating Hardness Test Procedure.

12.1.8.9.1.5. Nature of the coating failure, if any, when subjected to procedure in Section 11, Coating Impact Resistance Test Procedure. [Comment [SLT17]: Deleted test requirement.]
PA Negative with comments:

1. It took me a little while to realize that the uploaded t 253 2016 Final Draft document included redlines and comments. It appears the document was uploaded to the ballot system in 'No Markup' mode and the redlines and comments were not visible upon initial download from the ballot system. In the future and especially when revising existing standards, it is recommended to upload the proposed revised standard in 'All Markup' mode so that the redlines and comments are visible upon initial download.

   Self explanatory

2. Once I switched the downloaded document from 'No Markup' mode to 'All Markup' mode, I realized that Steve Tritsch of JC Supply added comments providing the rational to explain some of the proposed revisions. Comments were not added for all the proposed significant revisions so some of my comments below include a number of "Why?" questions.

   Self explanatory

3. On page 1 and 2 of this standard, the ASTM designation should be revised to "T 253-17" (assuming these proposed revisions will be balloted in the fall and adopted by the full SOM for publishing in 2017.

   Editorial

4. In Section 1.1, the text indicates this standard test method is "designed to test the qualifications...to withstand the effects of weathering". There are no weathering related tests in this proposed standard, so how will the qualifications in regard to "weathering" be determined?

   Suggest the following then “These methods are designed to test the qualifications of the organic coating of corrosion-resistant dowel bars to withstand the effects of weathering, deicing chemicals, and the abrading and loading stresses experienced in field joints.”

5. In Section 1.1, the text indicates this standard test method is "designed to test the qualifications...to withstand the effects of...the abrading and loading stresses". There are no "abrading and loading stresses" related tests in this proposed revised standard, so how will the qualifications in regard to "abrading and loading" be determined? The previous tests for abrading and loading (Section 7--Corrosion-Abrasion Test Procedure and Section 5--Load-Deflection Test Procedure) are proposed deletions. I do not recommend the existing Sections 5 and 7 be deleted and is part of the reason for my negative vote.

   Solved by the deletion in 4.

6. In Section 2.2, consider adding "D7091" here in lieu of adding proposed Section 2.3 and "SSPC-PA 2". In Section 2.2, recommend keeping "G14" and "G20" as M 254 should directly specify these and not specify them through a reference to ASTM A1078. ASTM A1078 should not be a reference. AASHTO should update/revise and specify what it wants in M 253 and not refer to a relatively new ASTM standard that has similar intent. This is main reason for the 6. In Section 3.2, the text references "load, pullout, and corrosion tests", but the load test (previous Section 5--Load Deflection Test Procedure) and the corrosion test (previous Section 7--Corrosion-Abrasion Test Procedure) have been deleted in the proposed revised T 253. If the previous Section 5 and Section 7 test procedures are to remain deleted,
this text here in Section 3.2 should be revised to delete references to "load..and corrosion tests". I do not recommend these be deleted and is reason for my negative vote.

   Reference to load and corrosion tests should be deleted. See rationale provided in M254 responses.

7. In Section 3.2, 2nd line, revise from "condition" to "conditions".

   Editorial, change made

8. In Section 3, I do not recommend deleting subsection 3.3 related to an "abradometer", subsection 3.5 related to "hold-down devices", subsection 3.6 related to "freeze-thaw equipment", and subsection 3.7 related to "quantities of chemical" as proposed. The rationale that hold down not necessary due to agency specification of basket dimensions and rationale that ASTM A1078 includes the abrasion and corrosion tests is not acceptable and is reason for my negative vote.

   See rationale provided in M254 responses.

9. Previous Section 5--Load-Deflection Test Procedure is proposed to be deleted. I do not recommend it be deleted as is reason for my negative vote. This load-deflection test should be optional testing as specified by the purchasing agency.

   See rationale provided in M254 responses.

10. In proposed revised Section 5--Pullout Test Procedure, previous subsections 6.5, 6.6 and 6.7 related to immersion in a sodium chloride solution, freeze-thaw testing, additional pullout after freeze-thaw testing, and observance for corrosion after the freeze-thaw testing/additional pullout is proposed to be deleted. I do not recommend deleting these tests and is reason for my negative vote. The exposure to the sodium chloride solution and freeze-thaw testing is representative of actual field conditions and should be evaluated. The second pullout represents additional movement after some field exposure occurs. Expansion and contraction occurs over the life of the dowel bar, not just initially even with shorter pavement joint spacings. Possibly include text "unless otherwise specified by the purchasing agency" to allow agencies to not require these tests.

   See rationale provided in M254 responses.

11. In Section 6.1, revise from "in accordance with SSPC-PA 2" to "in accordance with ASTM D7091". ASTM D7091 refers to SSPC-PA 2 for frequency of tests. ASTMs are typically more accessible than the SSPC specifications. Is there a specific reason that SSPC-PA 2 is preferred over ASTM D7091?

   See rationale provided in M254 responses.

12. Previous Section 7--Corrosion-Abrasion Test Procedure is proposed to be deleted. I do not recommend it be deleted due to this testing being included in ASTM A1078. This T 253 should specify what AASHTO wants directly, not through a similar and relatively new ASTM A1078 standard. This is reason for my negative vote. In the proposed M 254, there is referenced "Abrasion Resistant Overcoat (ARO)", but with the deletion of the previous abrasion test procedure, there does not appear to be an abrasion test to determine acceptable abrasion resistance of the ARO.
These tests are covered by ASTM A775 and ASTM A934 which cover the powders (as well as ASTM A1078) and are therefore redundant herein.

13. Previous Section 8--Chemical Resistance Test Procedure is proposed to be deleted. I do not recommend this section be deleted due to proposed reference to ASTM A1078. This is reason for my negative vote.

These tests are covered by ASTM A775 and ASTM A934 which cover the powders (as well as ASTM A1078) and are therefore redundant herein.

14. In Section 7.2, the proposed revisions include revising the electrolyte aqueous solution from "7 percent mass NaCl" to "3 percent mass NaCl". It also proposes revising the applied potential from "2 V" to "1.5 V". It also proposes revising the hole size from "6.4-mm (1/4-in.)" to "3.2-mm (1/8-in.)". It also reduces the test period duration from "30 days" to "168 hours". Why? What is the expected affect on test results with the proposed revisions to the test procedure?

The cathodic disbondment test was updated to be consistent with ASTM A775 and A934.

15. In Section 7.2, next to last line, suggest revising from "anode and the cathode" to "anode and the cathode dowel bars".

16. In Section 7.2, revise from "75 ± 3.6 F" to "75 ± 3.6ºF".

Editorial, degree mark change made. Both the anode and cathode are dowel bars, so the first change is not made.

17. In Section 10.1, suggest revising from "plastic coating" to "organic coating" to coincide with text in Section 1.1 where it refers to "organic coating".

Editorial, change made

18. Previous Section 11--Coating Impact Resistance Test Procedure is proposed to be deleted. I do not recommend this section be deleted due to proposed reference to ASTM A1078. T 253 should directly specify the testing and not refer to a similar ASTM A1078 standard. This is reason for my negative vote.

These tests are covered by ASTM A775 and ASTM A934 which cover the powders (as well as ASTM A1078) and are therefore redundant herein.

19. In Section 12, the proposed revisions include deleting previous subsections 12.1.1 (load-deflection results), 12.1.4 (freeze-thaw and corrosion-abrasion results), 12.1.5 (coating condition results from chemical resistance test procedure), 12.1.8 (Coating failure results from impact test) due to deletion of tests and some the result of proposed reference to ASTM A1078. Again, I do not recommend these tests be deleted because they are included in ASTM A1078. ASTM A1078 should not be referenced in M 254 or T 253. This is reason for my negative vote.

See rationale provided in M254 responses.

20. In Section 9.1.3, 3rd line, revise from "Section7" to "Section 7".

Editorial, change made

21. In Section 9.1.4, revise from "Section8" to "Section 8".
-----Comments from Bruce Ebersole (PennDOT Physical Test Lab Manager):

1. Abrasion Resistance: Test is redundant only if the A1078 and T253 procedures are equivalent. They are not equivalent. A1078 references A775 Annex 1 which uses a 1000g weight on a flat plate for 1000 cycles and is based on weight loss. T253 uses a 2500g weight formed to a dowel for 10000 strokes and is based on thickness loss.

'Redundant' may be a poor choice of words. See rationale provided in M254 responses.

VA Negative with comments

SLT2, SLT3, STL7, SLT12, SLT13 and SLT14 – If this is ASTM A1078, does this ASTM need to be referenced in AASHTO T253? Comment SLT5 – If “Modern epoxies already have abrasion requirements”, are these requirements referenced in AASHTO T253? ASTM A1078 is referenced in the comments but not in the method. Section 3.3 was deleted because “Modern epoxies already have abrasion requirements.” But it doesn’t say what abrasion requirement is needed. Section 6.5 deleted the second part of the pullout procedure. Does this change the requirement for the pullout test? I think a task force of those who use this method needs to look into the changes to make sure M254 and T253 are on the same page.

See rationale provided in M254 responses.
<table>
<thead>
<tr>
<th>Agency</th>
<th>Decision</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>No Vote</td>
<td>No objections, it's a good idea. It's the same specification really.</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Negative</td>
<td>Negative with supporting comments: 1. According to the 2012 TS-4g Meeting Minutes showing status of standards, M 270 is an old Category B standard or jointly owned standard in today's nomenclature. Why would AASHTO want to give up its joint ownership of this standard? 2. Would giving up ownership of this standard make the standard solely owned by ASTM with the next ASTM revision to the standard? 3. I think the ownership issue of this standard needs more consideration/understanding so that we make an informed decision about discontinuing (i.e., the sunset of) M 270. 4. Our agency's construction specifications have many references to M 270 with most providing the equivalent ASTM A709, but the default is M 270. Discontinuing M 270 will require modification of many agency specifications and/or standard drawings and publications (e.g., design manuals).</td>
</tr>
</tbody>
</table>
Standard Specification for

Structural Steel for Bridges

AASHTO Designation: M 270M/M 270-15
ASTM Designation: A709/A709M-13a
Standard Specification for  

Structural Steel for Bridges  

AASHTO Designation: M 270M/M 270-15  
ASTM Designation: A709/A709M-13a

1. SCOPE

1.1. This specification covers carbon and high-strength low-alloy steel structural shapes, plates, and bars and quenched and tempered alloy steel for structural plates intended for use in bridges. Seven grades are available in four yield strength levels as follows:

<table>
<thead>
<tr>
<th>Grade SI [U.S.]</th>
<th>Yield Strength, MPa [ksi]</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 [36]</td>
<td>250 [36]</td>
</tr>
<tr>
<td>345 [50]</td>
<td>345 [50]</td>
</tr>
<tr>
<td>345S [50S]</td>
<td>345 [50]</td>
</tr>
<tr>
<td>345W [50W]</td>
<td>345 [50]</td>
</tr>
<tr>
<td>HPS 345W [HPS 50W]</td>
<td>345 [50]</td>
</tr>
<tr>
<td>HPS 485W [HPS 70W]</td>
<td>485 [70]</td>
</tr>
<tr>
<td>HPS 690W [HPS 100W]</td>
<td>690 [100]</td>
</tr>
</tbody>
</table>

1.1.1. Grades 250 [36], 345 [50], 345S [50S], or 345W [50W] are also included in ASTM A36/A36M, A572/A572M, A992/A992M, A588/A588M, and A514/A514M. When the supplementary requirements of this specification are specified, they exceed the requirements of A36/A36M, A572/A572M, A992/A992M, A588/A588M, and A514/A514M.

1.1.2. Grades 345W [50W], HPS 345W [HPS 50W], HPS 485W [HPS 70W], and HPS 690W [HPS 100W] have enhanced atmospheric corrosion resistance (Section 13.1.2). Product availability is shown in Table 2.

1.2. Grade HPS 485W [HPS 70W] or HPS 690W [HPS 100W] shall not be substituted for Grade 250 [36], 345 [50], 345S [50S], 345W [50W], or HPS 345W [HPS 50W]. Grade 345W [50W] or HPS 345W [HPS 50W] shall not be substituted for Grade 250 [36], 345 [50], or 345S [50S] without agreement between the purchaser and supplier.

1.3. When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized. See Appendix X3 of ASTM A6/A6M for information on weldability.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Plate Thickness, mm [in.]</th>
<th>Structural Shape Flange or Leg Thickness, mm [in.]</th>
<th>Yield Point or Yield Strength, ( \text{MPa} [\text{ksi}] )</th>
<th>Tensile Strength, ( \text{MPa} [\text{ksi}] )</th>
<th>Minimum Elongation, %</th>
<th>Reduction of Area, Min, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 [36]</td>
<td>To 100 [4], incl</td>
<td>to 75 [3], incl</td>
<td>250 [36] min</td>
<td>400–550 [58–80]</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>345 [50]</td>
<td>To 100 [4], incl</td>
<td>All</td>
<td>345 [50] min</td>
<td>450 [65] min</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>345W [50W] and HPS 345W [HPS 50W]</td>
<td>To 100 [4], incl</td>
<td>All</td>
<td>345 [50] min</td>
<td>485 [70] min</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HPS 485W [HPS 70W]</td>
<td>To 100 [4], incl</td>
<td>All</td>
<td>485 [70] min</td>
<td>585–760 [85–110]</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>HPS 690W [HPS 100W]</td>
<td>To 65 [2½], incl</td>
<td>over 65 to 100 [2½ to 4&quot;]</td>
<td>690 [100] min</td>
<td>760–895 [110–130]</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

See “Orientation” and “Preparation” under “Tension Tests” in ASTM A6/A6M.

Measure at 0.2 percent offset or 0.5 percent extension under load as described in Section 13 of T 244.

For plates wider than 600 mm [24 in.], the elongation requirement is reduced two percentage points. See elongation requirement adjustments under the Tension Tests section of ASTM A6/A6M.

For plates wider than 600 mm [24 in.], the reduction of area requirement, where applicable, is reduced five percentage points.

Where “—” appears in this table, there is no requirement.

Elongation in 50 mm [2 in.], 19 percent minimum for shapes with flange thickness over 75 mm [3 in.].

Not applicable.

The yield-to-tensile ratio shall be 0.87 or less for shapes that are tested from the web location; for all other shapes, the requirement is 0.85.

A maximum yield strength of 70 ksi [480 MPa] is permitted for structural shapes that are required to be tested from the web location.

For wide flange shapes with flange thickness greater than 75 mm [3 in.], elongation in 50 mm [2 in.] of 18 percent minimum applies.

If measured on the Figure 3 (T 244) 40-mm [1½-in.] wide specimen, the elongation is determined in a 50-mm [2-in.] gauge length that includes the fracture and shows the greatest elongation.

40 percent minimum applies if measured on the Figure 3 (T 244) 40-mm [1½-in.] wide specimen, 50 percent minimum applies if measured on the Figure 4 (T 244) 12.5-mm [½-in.] round specimen.

Not applicable to fracture critical Tension Components. (See Table 10.)
1.4. For structural products to be used as tension components requiring notch toughness testing, standardized requirements are provided in this standard. These requirements are based on American Association of State Highway and Transportation Officials (AASHTO) requirements for both fracture-critical and non-fracture-critical members.

1.5. Supplementary requirements are available but shall apply only if specified in the purchase order.

1.6. The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system is to be used independently of the other, without combining values in any way.

1.7. For structural products cut from coiled product and furnished without heat treatment or with stress relieving only, the additional requirements of ASTM A6/A6M, including additional testing requirements and the reporting of additional tests, apply.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
- T 243M/T 243, Sampling Procedure for Impact Testing of Structural Steel
- T 244, Mechanical Testing of Steel Products

2.2. ASTM Standards:
- A36/A36M, Standard Specification for Carbon Structural Steel
- A514/A514M, Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
- A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
- A992/A992M, Standard Specification for Structural Steel Shapes

3. TERMINOLOGY

3.1. Definitions of Terms Specific to This Standard:

3.1.1. fracture-critical member—a main load–carrying member or tension component of a bending member the failure of which would be expected to cause collapse of a structure or bridge without multiple, redundant load paths.

3.1.2. main load–carrying member—a steel member designed to carry primary design loads, including dead, live, impact, and other loads.

3.1.3. non-fracture-critical member—a main load–carrying member the failure of which would not be expected to cause collapse of a structure or bridge with multiple, redundant load paths.
3.1.4. **nontension component**—a steel member that is not in tension under any design loading.

3.1.5. **secondary member**—a steel member used for aligning and bracing of main load–carrying members or for attaching utilities, signs, or other items to them, but not to directly support primary design loads.

3.1.6. **tension component**—a part or element of a fracture-critical or non-fracture-critical member that is in tension under various design loadings.

### 4. ORDERING REQUIREMENTS

4.1. In addition to the items listed in the ordering information section of ASTM A6/A6M, the following items should be considered if applicable:

4.1.1. Type of component (tension or nontension, fracture-critical or non-fracture-critical) (see Section 10).

4.1.2. Impact testing temperature zone (see Table 3).

#### Table 3—Relationship between Impact Testing Temperature Zones and Minimum Service Temperatures

<table>
<thead>
<tr>
<th>Zone</th>
<th>Minimum Service Temperature, °C [°F]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–18 [0]</td>
</tr>
<tr>
<td>2</td>
<td>Below –18 to –34 [0 to –30]</td>
</tr>
<tr>
<td>3</td>
<td>Below –34 to –51 [–30 to –60]</td>
</tr>
</tbody>
</table>

### 5. GENERAL REQUIREMENTS FOR DELIVERY

5.1. Material furnished under this specification shall conform to the requirements of the current edition of ASTM A6/A6M for the specific structural product unless a conflict exists, in which case this specification shall prevail.

5.2. Coils are excluded from qualification to this specification until they are processed into a finished structural product. “Structural products produced from coil” means structural products that have been cut to individual lengths from a coil. The processor controls, or is responsible for, the operations involved in the processing of a coil into a finished structural product. Such operations include decoiling, leveling or straightening, hot forming or cold forming (if applicable), cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification. (See Note 1.)

**Note 1**—For structural products produced from coil and finished without heat treatment or with stress relieving only, two test results are to be reported for each qualifying coil. Additional requirements regarding structural products from coil are described in ASTM A6/A6M.

### 6. MATERIALS AND MANUFACTURE

6.1. For Grades 250 [36] and 345 [50], the steel shall be semikilled or killed.

6.2. For Grades 345W [50W], HPS 345W [HPS 50W], and HPS 485W [HPS 70W], the steel shall be made to fine grain practice.
6.3. For Grade 345S [50S], the steel shall be killed. Killed steel is confirmed on the test report by a statement of killed steel, a value of 0.10 percent or more for the silicon content, or a value of 0.015 percent or more for the total aluminum content.

6.4. For Grade 345S [50S], the steelmaking practice used shall be one that produces steel having a nitrogen content not greater than 0.015 percent and includes the addition of one or more nitrogen-binding elements, or one that produces steel having a nitrogen content of not greater than 0.012 percent (with or without the addition of nitrogen-binding elements). The nitrogen content need not be reported, regardless of which steelmaking practice was used.

6.5. For Grades HPS 345W [HPS 50W], HPS 485W [HPS 70W], and HPS 690W [HPS 100W], the steel shall be made using a low-hydrogen practice, such as vacuum degassing during steel making; controlled soaking of the ingots or slabs; controlled slow cooling of the ingots, slabs, or plates; or a combination thereof.

6.6. For Grade HPS 690W [HPS 100W] the requirements for fine austenitic grain size in ASTM A6/A6M shall be met.

6.7. Grades HPS 345W [HPS 50W] and HPS 485W [HPS 70W] shall be furnished in one of the following conditions: as-rolled, control-rolled, thermomechanical control processed (TMCP) with or without accelerated cooling, or quenched and tempered.

7. **HEAT TREATMENT**

7.1. For quenched and tempered Grades HPS 345W [HPS 50W] and HPS 485W [HPS 70W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to not less than 900°C [1650°F], quenching it in water or oil, and tempering it at not less than 590°C [1100°F]. The heat-treating temperatures shall be reported on the test certificates.

7.2. For Grade HPS 690W [HPS 100W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to a temperature in the range from 870 to 925°C [1600 to 1700°F], quenching it in water, and tempering it at not less than 565°C [1050°F] for a time to be determined by the manufacturer. The heat-treating temperatures shall be reported on the test certificates.

8. **CHEMICAL REQUIREMENTS**

8.1. The heat analysis shall conform to the requirements of the specified grade, as given in Tables 4 through 9.

8.2. For Grade 345S [50S], in addition to the elements listed in Table 6, test reports shall include, for information, the chemical analysis for tin. Where the amount of tin is less than 0.02 percent, it shall be permissible for the analysis to be reported as <0.02 percent.

8.3. The maximum permissible carbon equivalent value shall be 0.47 percent for structural shapes with flange thickness over 50 mm [2 in.], and 0.45 percent for other structural shapes. The carbon equivalent shall be based on heat analysis. The required chemical analysis as well as the carbon equivalent shall be reported. The carbon equivalent (CE) shall be calculated using the following formula:

\[
CE = \%C + \frac{\%Mn}{6} + \frac{\%(Cr + Mo + V)}{5} + \frac{\%(Ni + Cu)}{15}
\]  

\( (1) \)
<table>
<thead>
<tr>
<th>Product Thickness, mm [in.]</th>
<th>Shapes, all</th>
<th>Plates</th>
<th>Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To 20 [³/₄], incl.</td>
<td>20 to 40 [³/₄] to 1¹/₂], incl.</td>
<td>Over 40 to 65 [1¹/₂ to 2¹/₂], incl.</td>
</tr>
<tr>
<td>Carbon, max %</td>
<td>0.26</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Manganese, %</td>
<td>--</td>
<td>--</td>
<td>0.80–1.20</td>
</tr>
<tr>
<td>Phosphorus, max %</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Silicon, %</td>
<td>0.40 max</td>
<td>0.40 max</td>
<td>0.40 max</td>
</tr>
<tr>
<td>Copper, min % when</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

a For each reduction of 0.01 percentage points below the specified carbon maximum, an increase of 0.06 percentage points manganese above the specified maximum will be permitted up to the maximum of 1.35 percent.

b Manganese content of 0.85 to 1.35 percent and silicon content of 0.15 to 0.40 percent are required for shapes over 634 kg/m [426 lb/ft].

c Where “—” appears in this table, there is no requirement. The heat analysis for manganese shall be determined and reported as described in the Heat Analysis section of ASTM A6/A6M.
Table 5—Grade 345 [50] Chemical Requirements (Heat Analysis)\(^a\)

<table>
<thead>
<tr>
<th>Max Diameter, Thickness, or Distance Between Parallel Faces, mm [in.]</th>
<th>Carbon, Max %</th>
<th>Manganese, Max %</th>
<th>Phosphorus, Max %</th>
<th>Sulfur, Max %</th>
<th>Silicon(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plates to 40-mm [1 1/2-in.] Thick, Shapes to 634 kg/m [426 lb/(\text{ft})], Bars, Zees, and Rolled Tees,</td>
<td>0.23</td>
<td>1.35</td>
<td>0.04</td>
<td>0.05</td>
<td>0.40</td>
</tr>
<tr>
<td>Plates over 40-mm [1 1/2-in.] Thick and Shapes over 634 kg/m [426 lb/(\text{ft})],</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15–0.40</td>
</tr>
<tr>
<td>Columbium, Vanadium, and Nitrogen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>See Footnote.(^d)</td>
</tr>
</tbody>
</table>

\(^a\) Copper, when specified, shall have a minimum content of 0.20 percent by heat analysis (0.18 percent product analysis).

\(^b\) Silicon content in excess of 0.40 percent by heat analysis must be negotiated.

\(^c\) Manganese, minimum by heat analysis of 0.80 percent (0.75 percent product analysis) shall be required for all plates more than 10 mm [\(\frac{3}{8}\) in.] in thickness; a minimum of 0.50 percent (0.45 percent product analysis) shall be required for plates 10 mm [\(\frac{3}{8}\) in.] and less in thickness and for all other products. The manganese-to-carbon ratio shall not be less than 2-to-1. For each reduction of 0.01 percentage points below the specified carbon maximum, an increase of 0.06 percentage points manganese above the specified maximum is permitted, up to a maximum of 1.60 percent.

\(^d\) Alloy content shall be in accordance with one of the following types, and the contents of the applicable elements shall be reported:

<table>
<thead>
<tr>
<th>Type</th>
<th>Elements</th>
<th>Heat Analysis, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Columbium(^e)</td>
<td>0.005–0.05(^f)</td>
</tr>
<tr>
<td>2</td>
<td>Vanadium</td>
<td>0.01–0.15</td>
</tr>
<tr>
<td>3</td>
<td>Columbium(^e)</td>
<td>0.005–0.05(^g)</td>
</tr>
<tr>
<td></td>
<td>Vanadium</td>
<td>0.01–0.15</td>
</tr>
<tr>
<td></td>
<td>Columbium plus vanadium</td>
<td>0.02–0.15(^g)</td>
</tr>
<tr>
<td>5</td>
<td>Titanium</td>
<td>0.006–0.04</td>
</tr>
<tr>
<td></td>
<td>Nitrogen</td>
<td>0.003–0.015</td>
</tr>
<tr>
<td></td>
<td>Vanadium</td>
<td>0.06 max</td>
</tr>
</tbody>
</table>

\(^e\) Product analysis limits = 0.004 to 0.06 percent.

\(^f\) Product analysis limits = 0.005 to 0.17 percent.

\(^g\) Product analysis limits = 0.01 to 0.16 percent.
### Table 6—Grade 345S [50S] Chemical Requirements (Heat Analysis)

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon, max</td>
<td>0.23</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50 to 1.60&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Silicon, max</td>
<td>0.40</td>
</tr>
<tr>
<td>Vanadium, max</td>
<td>0.15&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Columbium, max</td>
<td>0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phosphorus, max</td>
<td>0.035</td>
</tr>
<tr>
<td>Sulfur, max</td>
<td>0.045</td>
</tr>
<tr>
<td>Copper, max</td>
<td>0.60</td>
</tr>
<tr>
<td>Nickel, max</td>
<td>0.45</td>
</tr>
<tr>
<td>Chromium, max</td>
<td>0.35</td>
</tr>
<tr>
<td>Molybdenum, max</td>
<td>0.15</td>
</tr>
</tbody>
</table>

<sup>a</sup> Provided that the ratio of manganese to sulfur is not less than 20 to 1, the minimum limit for manganese for shapes with flange or leg thickness not exceeding 25 mm [1 in.] shall be 0.30 percent.

<sup>b</sup> The sum of columbium and vanadium shall not exceed 0.15 percent.

### Table 7—Grade 345W [50W] Chemical Requirements (Heat Analysis)

<table>
<thead>
<tr>
<th>Element</th>
<th>Type A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Type B&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.19 max</td>
<td>0.20 max</td>
</tr>
<tr>
<td>Manganese&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.80–1.25</td>
<td>0.75–1.35</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.04 max</td>
<td>0.04 max</td>
</tr>
<tr>
<td>SulfurS</td>
<td>0.05 max</td>
<td>0.05 max</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.30–0.65</td>
<td>0.15–0.50</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.40 max</td>
<td>0.50 max</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.40–0.65</td>
<td>0.40–0.70</td>
</tr>
<tr>
<td>Copper</td>
<td>0.25–0.40</td>
<td>0.20–0.40</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.02–0.10</td>
<td>0.01–0.10</td>
</tr>
</tbody>
</table>

<sup>a</sup> Weldability data for these types have been qualified by FHWA for use in bridge construction.

<sup>b</sup> Types A and B are equivalent to ASTM A588/A588M Grades A and B, respectively.

<sup>c</sup> For each reduction of 0.01 percentage points below the specified maximum for carbon, an increase of 0.06 percentage points above the specified maximum for manganese is permitted, up to a maximum of 1.50 percent.
Table 8—Grades HPS 345W [HPS 50W], HPS 485W [HPS 70W], and HPS 690W [HPS 100W] Chemical Requirements (Heat Analysis)

<table>
<thead>
<tr>
<th>Element</th>
<th>Grades HPS 345W [HPS 50W] and HPS 485W [HPS 70W]</th>
<th>Grade HPS 690W [HPS 100W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.11 max</td>
<td>0.08 max</td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65 mm [2.5 in.] and under</td>
<td>1.10–1.35</td>
<td>0.95–1.50</td>
</tr>
<tr>
<td>Over 65 mm [2.5 in.]</td>
<td>1.10–1.50</td>
<td>0.95–1.50</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.020 max</td>
<td>0.015 max</td>
</tr>
<tr>
<td>Sulfur&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.006 max</td>
<td>0.006 max</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.30–0.50</td>
<td>0.15–0.35</td>
</tr>
<tr>
<td>Copper</td>
<td>0.25–0.40</td>
<td>0.90–1.20</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.25–0.40</td>
<td>0.65–0.90</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.45–0.70</td>
<td>0.40–0.65</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.02–0.08</td>
<td>0.40–0.65</td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.04–0.08</td>
<td>0.04–0.08</td>
</tr>
<tr>
<td>Columbium (Niobium)</td>
<td>0.01–0.03</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.010–0.040</td>
<td>0.020–0.050</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.015 max</td>
<td>0.015 max</td>
</tr>
</tbody>
</table>

<sup>a</sup> The steel shall be calcium treated for sulfate shape control.
<sup>b</sup> Where “—” appears in this table, there is no requirement.

9. **TENSILE REQUIREMENTS**

9.1. The material as represented by test specimens, except as specified in Section 7.2, shall conform to the requirements for tensile properties prescribed in Table 2.

9.2. For Grade 250 [36], shapes less than 645 mm<sup>2</sup> [1 in.<sup>2</sup>] in cross section and bars, other than flats, less than 12.5 mm [1/2 in.] in thickness or diameter need not be subjected to tension tests by the manufacturer.

10. **IMPACT TESTING REQUIREMENTS**

10.1. *Non-Fracture-Critical, T, Tension Components*—Structural products ordered for use as tension components of non-fracture-critical members shall be impact tested in accordance with T 243M/T 243 and as given in Table 10. The test results shall meet the requirements given in Table 10.

10.2. *Fracture-Critical, F, Tension Components*—Structural products ordered for use as tension components of fracture-critical members shall be impact tested in accordance with T 243M/T 243 and as given in Table 10. The test results shall meet the requirements given in Table 10.

10.3. Steel grades ordered for use without suffix “T” or “F” as listed in Sections 10.1 and 10.2 do not require impact testing and shall be used as nontension components or secondary members only.
11. TEST SPECIMENS AND NUMBER OF TENSION TESTS

11.1. For Grades 250 [36], 345 [50], and 345W [50W], and nonquenched and tempered Grades HPS 345W [HPS 50W] and HPS 485W [HPS 70W], location and condition, number of tests, and preparation of test specimens shall meet the requirements of ASTM A6/A6M.

11.2. The following requirements, which are in addition to those of ASTM A6/A6M, shall apply only to HPS 690W [HSP 100W] and quenched and tempered Grades HPS 345W [HPS 50W] and HPS 485W [HPS 70W].
11.2.1. When possible, all test specimens shall be cut from the plate in its heat-treated condition. If it is necessary to prepare test specimens from separate pieces, all of these pieces shall be full thickness and shall be similarly and simultaneously heat treated with the material. All such separate pieces shall be of such size that the prepared test specimens are free of any variation in properties due to edge effects.

11.2.2. After final heat treatment of the plates, one tension test specimen shall be taken from a corner of each plate as heat treated (except as specified in Section 11.1).

Note 2—The term “plate” identifies the “plate as heat treated.”

12. RETESTS

12.1. Grades 250 [36], 345 [50], 345S [50S], and 345W [50W] and nonquenched and tempered Grades HPS 345W [HPS 50W] and HPS 485W [HPS 70W] shall be retested in accordance with ASTM A6/A6M.

12.2. The manufacturer may reheat treat quenched and tempered plates that fail to meet the mechanical property requirements of this specification. All mechanical property tests shall be repeated when the material is resubmitted for inspection.

13. ATMOSTHERMAL CORROSION RESISTANCE

13.1. Steels meeting this specification provide two levels of atmospheric corrosion resistance:

13.1.1. Steel grades without suffix provide a level of atmospheric corrosion resistance typical of carbon steel without copper.

13.1.2. The steel for Grades 345W [50W], HPS 345W [HPS 50W], and HPS 485W [HPS 70W] shall have an atmospheric corrosion resistance index of 6.0 or higher, calculated from the heat analysis in accordance with ASTM G101. (See Note 3.) When properly exposed to the atmosphere, these steels can be used bare (unpainted) for many applications. The steel for HPS 690W [HPS 100W] provides an improved level of atmospheric corrosion resistance over alloy steel without copper.

Note 3—For methods of estimating the atmospheric corrosion resistance of low-alloy steels, see ASTM G101. The user is cautioned that the ASTM G101 predictive equation (Predictive Method Based on the Data of Larabee and Coburn) for calculation of an atmospheric corrosion resistance index has only been verified for the composition limits stated in that guide.

14. MARKING

14.1. In addition to the marking requirements of ASTM A6/A6M, the structural product shall be marked as follows:

14.1.1. For Grades 50W [345W] the composition type shall be included.

14.1.2. For structural products that conform to the requirements of Section 10.1, the letter T and the applicable zone number (1, 2, or 3) shall follow the grade designation.

14.1.3. For structural products that conform to the requirements of Section 10.2, the letter F and the applicable zone number (1, 2, or 3) shall follow the grade designation.
15. KEYWORDS

15.1. Alloy; atmospheric corrosion resistance; bars; bridges; carbon; fracture-critical; high-strength; low-alloy; non-fracture-critical; plates; quenched; shapes; steel; structural steel; tempered.

SUPPLEMENTARY REQUIREMENTS

Requirements other than those shown in this section may be specified subject to agreement between the supplier and the purchaser. In addition, the following supplementary requirements are also suitable for use with this specification.

S1. FREQUENCY OF TENSION TESTS

S1.1. Tension testing that is additional to the tension testing required by ASTM A6/A6M shall be made as follows:

S1.1.1. Plate—One tension test shall be made using a test specimen taken from each as rolled or as heat-treated plate.

S1.1.2. Structural Shapes—One tension test shall be made using a test specimen taken from each 5 Mg [5 tons] of material produced on the same mill of the same nominal size, excluding length, from each heat of steel. Each single piece exceeding 5 Mg [5 tons] in mass [weight] shall be tested. If shapes are heat treated, one test shall be made on specimens taken from each heat of the same nominal size, excluding length, in each furnace lot.

S1.1.3. Bars—One tension test shall be made using a test specimen taken from each 5 Mg [5 tons] of the same heat and same diameter or thickness if the material is furnished as rolled or is heat treated in a continuous-type furnace. For material heat treated in a noncontinuous furnace, one test shall be taken from each heat of the same bar diameter or thickness for each furnace charge.

S2. ULTRASONIC EXAMINATION

S2.1. Refer to S8 of ASTM A6/A6M.

S3. MAXIMUM TENSILE STRENGTH (GRADES 345 [50], 345W [50W], AND 345S [50S])

S3.1. Refer to S18 of ASTM A6/A6M.

S4. FINE AUSTENITIC GRAIN SIZE

S4.1. The steel shall be killed and have a fine austenitic grain size.

S5. ATMOSPHERIC CORROSION RESISTANCE

S5.1. When specified, the material manufacturer shall supply to the purchaser evidence of atmospheric corrosion resistance satisfactory to the purchaser.

S5.2. Refer to S23 of ASTM A6/A6M (applicable to Grades 250 [36] and 345 [50]).
S6. LIMITATION ON WELD REPAIR (FRACTURE-CRITICAL MATERIAL ONLY)

S6.1. Weld repair of the base metal by the material manufacturer or supplier is not permitted. Standardized supplementary requirements for use at the option of the purchaser are listed in ASTM A6/A6M.

S7. SINGLE-HEAT BUNDLES

S7.1. Bundles containing shapes or bars shall be from a single heat of steel.
SOM_TS4f-16-02 Item No. 5 - Illinois did an extensive review of M31 and made proposed revisions to bring it up to date. Additionally, since several states use ASTM A706 and there is no AASHTO equivalent for it the equivalent portions of A706 were added to this M31 revision.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Decision</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kansas</td>
<td>Affirmative</td>
<td>No maximum yield strength to be specified for the W marked bars? No minimum tensile strength as a ratio of yield strength for the W marked bars? The above was one of the benefits of A706 in that it guaranteed ample reserve strength once yield was attained. (CN)</td>
</tr>
<tr>
<td>Missouri</td>
<td>Affirmative</td>
<td>Affirmative vote with the following comments: 1) In Section 18.1, the first sentence references Section 6.2. Section 6.2 has been struck out indicating it is being removed from the specification. 2) The two sections identified as 19.1.319.1.3 Bend test; and a19.1.3 Materials test report. The second section should be labeled 19.1.43) The two sections identified as 19.2.419.2.4 Bend test results; and a19.2.4 Materials test report. The second section should be labeled 19.2.5</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Affirmative</td>
<td>Affirmative with comments: 1. In Section 6.1.3.1, suggest adding a Table # and Table caption to the proposed new chemical requirements table. 2. In the proposed new chemical requirements table, column 3, row 4, the proposed phosphorus verification analysis, % max value of &quot;0.43&quot; is not quite the previous limit of &quot;by more than 25%&quot;. Multiplying 0.25 * 0.035 = 0.00875 which rounds to 0.009 and then, 0.0035 + 0.009 = 0.044. 3. In Table 2, the footnote a, should only appear in the header for 2nd column &quot;Type S Grade 280 [40]&quot; and for &quot;Type W Grade 280 [40]&quot; and should not appear in any other column headings. 4. In Section 19.1.3 (2nd one), revise from subsection &quot;19.1.3&quot; to &quot;19.1.3.1&quot;. In Section 19.2.4 (2nd one), revise from subsection &quot;19.2.4&quot; to &quot;19.2.4.1&quot;. Comments from Bruce Ebersole (PennDOT Physical Test Lab Manager): 1. There are no Grades 40 and 75 in A706. Therefore there should be no Grade 40 or 75 listed for Type W in Table 2.2. Type W (A706) requires a Maximum Yield Strength which is absent from Table 2.</td>
</tr>
</tbody>
</table>
AASHTO Designation: M 31M/M 31-XX

Standard Specification for

Deformed and Plain Carbon and Low-Alloy Steel Bars for
Concrete Reinforcement

1. SCOPE

1.1. This specification covers deformed and plain carbon and low alloy steel concrete reinforcement bars in cut lengths or coils. Steel bars containing alloy additions, such as with the AISI and SAE series of alloy steels, are permitted if the resulting product meets all the other requirements of this specification. The standard sizes and dimensions of deformed bars and their number designations shall be those listed in Table 1. The text of this specification references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this specification.

1.2. Bars are of four minimum yield strength levels: namely, 280 MPa [40,000 psi], 420 MPa [60,000 psi], 520 MPa [75,000 psi], and 550 MPa [80,000 psi], designated as Grade 280 [40], Grade 420 [60], Grade 520 [75], and Grade 550 [80], respectively. Bars which have carbon contents limited to 0.30% or less, and meet the carbon requirements of this specification, shall be designated as Type W. Bars that have carbon contents greater than 0.30% shall be designated as Type S.

1.3. Hot-rolled plain rounds, in sizes up to and including 63.5 mm [2⅛ in.] in diameter in coils or cut lengths, when specified for dowels, spirals, and structural ties or supports, shall be furnished under this specification in Grade 280 [40], Grade 420 [60], Grade 520 [75], and Grade 550 [80]. For ductility properties (elongation and bending), test provisions of the nearest smaller nominal diameter deformed bar size shall apply. Requirements providing for deformations and marking shall not be applicable.

1.4. Welding of the material in this specification should be approached with caution since no specific provisions have been included to enhance its weldability. When the steel is to be welded, a welding procedure suitable for the chemical composition and intended use or service should be used (Note 1).

Note 1—The use of the latest edition of ANSI/AWS D1.4 is recommended for welding reinforcing bars. This document describes the proper selection of the filler metals and preheat/interpass temperatures, as well as performance and procedure qualification requirements.

1.5. This specification is applicable for orders in either SI units (M 31M) or in inch-pound units (M 31). SI units and inch-pound units are not necessarily equivalent; therefore, each system must
be used independently of the other. Combining values from the two systems may result in non-conformance with the specification. Inch-pound units are shown in brackets in the text for clarity, but they are the applicable values when the material is ordered to M 31.

1.6. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Table 1—Deformed Bar Designation Numbers, Nominal Masses, Nominal Dimensions, and Deformation Requirements

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Nominal Mass, kg/m [lb/ft]</th>
<th>Diameter, mm [in.]</th>
<th>Cross-Sectional Area, mm² [in.²]</th>
<th>Perimeter, in. [mm]</th>
<th>Deformation Requirements, mm [in.]</th>
<th>Maximum Average Spacing</th>
<th>Minimum Average Height</th>
<th>Maximum Gap (Chord of 12.5% of Nominal Perimeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 [3]</td>
<td>0.560 [0.376]</td>
<td>9.5 [0.375]</td>
<td>71 [0.11]</td>
<td>29.9 [1.178]</td>
<td>6.7 [0.262]</td>
<td>0.38 [0.015]</td>
<td>3.6 [0.143]</td>
<td></td>
</tr>
<tr>
<td>13 [4]</td>
<td>0.994 [0.668]</td>
<td>12.7 [0.500]</td>
<td>129 [0.20]</td>
<td>39.9 [1.571]</td>
<td>8.9 [0.350]</td>
<td>0.51 [0.020]</td>
<td>4.9 [0.191]</td>
<td></td>
</tr>
<tr>
<td>16 [5]</td>
<td>1.552 [1.043]</td>
<td>15.9 [0.625]</td>
<td>199 [0.31]</td>
<td>49.9 [1.963]</td>
<td>11.1 [0.437]</td>
<td>0.71 [0.028]</td>
<td>6.1 [0.239]</td>
<td></td>
</tr>
<tr>
<td>19 [6]</td>
<td>2.235 [1.502]</td>
<td>19.1 [0.750]</td>
<td>284 [0.44]</td>
<td>59.8 [2.356]</td>
<td>13.3 [0.525]</td>
<td>0.97 [0.038]</td>
<td>7.3 [0.286]</td>
<td></td>
</tr>
<tr>
<td>22 [7]</td>
<td>3.042 [2.044]</td>
<td>22.2 [0.875]</td>
<td>387 [0.60]</td>
<td>69.8 [2.749]</td>
<td>15.5 [0.612]</td>
<td>1.12 [0.044]</td>
<td>8.5 [0.334]</td>
<td></td>
</tr>
<tr>
<td>25 [8]</td>
<td>3.973 [2.670]</td>
<td>25.4 [1.000]</td>
<td>510 [0.79]</td>
<td>79.8 [3.142]</td>
<td>17.8 [0.700]</td>
<td>1.27 [0.050]</td>
<td>9.7 [0.383]</td>
<td></td>
</tr>
<tr>
<td>64 [20]</td>
<td>24.84 [16.69]</td>
<td>63.5 [2.500]</td>
<td>3167 [4.91]</td>
<td>199.5 [7.85]</td>
<td>44.5 [1.75]</td>
<td>2.86 [0.113]</td>
<td>24.3 [0.957]</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same mass per meter as the deformed bar. [The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight per foot as the deformed bar.]

\(^b\) Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars. [Bar designation numbers approximate the number of millimeters of the nominal diameter of the bar.]

2. REFERENCED DOCUMENTS

![s00149_annot]

2.1. AASHTO Standards:

- **T 244**, Mechanical Testing of Steel Products
- **T 285**, Bend Test for Bars for Concrete Reinforcement

2.2. ASTM Standards:

- **A370**, Standard Test Methods and Definitions for Mechanical Testing of Steel Products
- **A510/A510M**, Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel, and Alloy Steel
- **A706/A706M**, Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
- **A751**, Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- **E29**, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
2.3. Military Standards:

- MIL-STD-129, Marking for Shipment and Storage
- MIL-STD-163, Steel Mill Products Preparation for Shipment and Storage

2.4. Federal Standard:

- Fed. Std. No. 123, Marking for Shipment (Civil Agencies)

2.5. AWS Standard:

- ANSI/AWS D1.4, Structural Welding Code—Reinforcing Steel

3. TERMINOLOGY

3.1. Description of Terms Specific to This Standard:

3.1.1. deformations—transverse protrusions on a deformed bar.

3.1.2. deformed bar—steel bar with protrusions; a bar that is intended for use as reinforcement in reinforced concrete construction.

3.1.2.1. Discussion—The surface of the bar is provided with lugs or protrusions that inhibit longitudinal movement of the bar relative to the concrete surrounding the bar in such construction. The lugs or protrusions conform to the provisions of this specification.

3.1.3. plain bar—steel bar without protrusions.

3.1.4. rib—longitudinal protrusion on a deformed bar.

4. ORDERING INFORMATION

4.1. It shall be the responsibility of the purchaser to specify all requirements that are necessary for material ordered to this specification. Orders for carbon or low alloy steel bars for concrete reinforcement material under this specification shall contain the following information:

4.1.1. Quantity (mass) [weight],

4.1.2. Deformed or plain Name of the material (deformed and plain carbon steel bars for concrete reinforcement),

4.1.3. Bar designation number (size) of deformed bars, or diameter of plain bars,

4.1.4. Cut length or coils,
4.1.5. Grade Deformed or plain,

4.1.6. Type S or Type W - Grade,

4.1.7. Packaging (see Section 21),

4.1.8. AASHTO designation and year of issue, and

4.2 The purchaser shall have the option to specify additional requirements, including but not limited to, the following:

4.2.1.9. Certified mill test reports for Type S bars, if desired. (See Section 19.),

4.2.2 Require bars in each bundle to be supplied from a single heat (19.1),

4.2.3 Special packaging or marking requirements (See Section 21),

4.2.4 Domestic origin,

4.2.5 Other special requirements, if any.

5. MATERIAL AND MANUFACTURE

5.1. The bars shall be rolled from properly identified heats of mold cast or strand cast steel using any commercially accepted steelmaking process, including electric furnace, basic oxygen, or open hearth. The producer shall have the option to manufacture the bars either by hot rolling, or thermal mechanical processing, or quench & tempering, whereby the selected process enables the requirements of this specification to be satisfied.

6. CHEMICAL REQUIREMENTS

6.1. The chemical analysis of each heat of steel shall be determined in accordance with ASTM A751. The manufacturer shall perform the analysis on test samples taken preferably during the pouring of the heat.

6.1.2 For Type S bars, the percentages of carbon, manganese, phosphorus, and sulfur shall be determined. The phosphorus content thus determined shall not exceed 0.06 percent.

6.1.2.1 A chemical verification analysis may be made by the purchaser from finished Type S bars. The phosphorus content determined shall not exceed 0.075 %.

6.1.3 For Type W bars, the percentages of carbon, manganese, phosphorus, sulfur and silicon shall be determined and reported. If any other alloying elements are intentionally added to the heat to produce the required properties for Type W bars, such as copper, nickel, chromium, molybdenum, vanadium, niobium, titanium or boron, they shall also be determined.
6.1.3.1 The maximum heat and verification (check) analysis allowable percentages for carbon, manganese, phosphorus, sulfur and silicon are as follows:

Table 2—Chemical Requirements, SI Units

<table>
<thead>
<tr>
<th>Element</th>
<th>Heat Analysis, % max</th>
<th>Verification Analysis, % max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.50</td>
<td>1.56</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.035</td>
<td>0.040</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.045</td>
<td>0.053</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.50</td>
<td>0.55</td>
</tr>
</tbody>
</table>

6.1.4. For Type W bars, the heat analysis shall be such that the carbon equivalent (C. E.) does not exceed 0.55%, as calculated by the following formula:

\[
\text{C.E.} = \%C + \frac{\%\text{Mn} + 6}{6} + \frac{\%\text{Cu} + 40}{40} + \frac{\%\text{Ni} + 20}{20} + \frac{\%\text{Cr} + 10}{10} - \frac{\%\text{Mo} + 50}{50} - \frac{\%\text{V} + 10}{10}
\]

6.2. An analysis may be made by the purchaser from finished bars. The phosphorus content thus determined shall not exceed that specified in Section 6.1 by more than 25 percent.

7. REQUIREMENTS FOR DEFORMATIONS

7.1. Deformations shall be spaced along the bar at substantially uniform distances. The deformations on opposite sides of the bar shall be similar in size, shape, and pattern.

7.2. The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45 degrees. Where the line of deformations forms an included angle with the axis of the bar from 45 to 70 degrees inclusive, the deformations shall alternately reverse in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the line of deformation is over 70 degrees, a reversal in direction is not required.

7.3. The average spacing or distance between deformations on each side of the bar shall not exceed seven tenths of the nominal diameter of the bar.

7.4. The overall length of deformations shall be such that the gap (measured as a cord) between the ends of the deformations shall not exceed 12.5 percent of the nominal perimeter of the bar. Where the ends terminate in a rib, the width of the rib shall be considered as the gap between these ends. The summation of the gaps shall not exceed 25 percent of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.1416 times the nominal diameter.

7.5. The spacing, height, and gap of deformations shall conform to the requirements prescribed in Table 1.

8. MEASUREMENTS OF DEFORMATIONS
8.1. The average spacing of deformations shall be determined by measuring the length of a minimum of ten spaces and dividing that length by the number of spaces included in the measurement. The measurement shall begin from a point on a deformation at the beginning of the first space to a corresponding point on a deformation after the last included space. Spacing measurements shall not be made over a bar area containing bar marking symbols involving letters or numbers.

8.2. The average height of deformations shall be determined from measurements made on not less than two typical deformations. Determinations shall be based on three measurements per deformation, one at the center of the overall length and the other two at the quarter points of the overall length.

8.3. Insufficient height, insufficient circumferential coverage, or excessive spacing of deformations shall not constitute cause for rejection unless it has been clearly established by determinations on each lot (Note 2) tested that typical deformation height, gap, or spacing do not conform to the minimum requirements prescribed in Section 7. No rejection may be made on the basis of measurements if fewer than ten adjacent deformations on each side of the bar are measured.

Note 2—A lot is defined as all the bars of one bar number and pattern of deformation contained in an individual shipping release or shipping order.

9. TENSILE REQUIREMENTS

9.1. Type S and Type Whe materials, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 2.

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Type S Grade 280 [40]</th>
<th>Type S Grade 420 [60]</th>
<th>Type S Grade 520 [75]</th>
<th>Type S Grade 550 [80]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, min MPa [psi]</td>
<td>420 [60,000]</td>
<td>620 [90,000]</td>
<td>690 [100,000]</td>
<td>725 [105,000]</td>
</tr>
<tr>
<td>Yield strength, min, MPa [psi]</td>
<td>280 [40,000]</td>
<td>420 [60,000]</td>
<td>520 [75,000]</td>
<td>550 [80,000]</td>
</tr>
</tbody>
</table>

Comment [LR3]: Renumbered Table Caption to reflect adding Table 2 caption for Chemical Requirements.

Comment [LR4]: Deleted footnote from Grades 420, 520, and 550 for Type S since the footnote is not applicable to any of those grades — per comment from Pennsylvania.
<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Type W Grade 280 [40]</th>
<th>Type W Grade 420 [60]</th>
<th>Type W Grade 520 [75]</th>
<th>Type W Grade 550 [80]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 [3]</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>13, 16 [4, 5]</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>19 [6]</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>22, 25 [7, 8]</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>29, 32, 36 [9, 10, 11]</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>43, 57 [14, 18]</td>
<td>—</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

*a Grade 280 bars are furnished only in sizes 10 through 19. [Grade 40 bars are furnished only in sizes 3 through 6.]*

*b Tensile strength shall not be less than 1.25 times the actual yield strength.*

9.2. The yield point or yield strength shall be determined by one of the following methods:

9.2.1. The yield point shall be determined by drop or halt of the gauge of the tensile testing machine of the beam or halt of the pointer method as described in Section 14.1.1 of T 244.

9.2.2. Where the steel tested does not have a well-defined yield point, the yield point shall be determined at extension under load using an autographic diagram method or and extensometer as described in Sections 14.1.2 and 14.1.3 of T 244.
The extension under load shall be 0.005 mm/mm [0.005 in./in.] of gauge length (0.5 percent) for Grade 280 [40] and Grade 420 [60] and shall be 0.0035 mm/mm [0.0035 in./in.] of gauge length (0.35 percent) for Grade 520 [75].

9.3. When material is furnished in coils, the test sample must be straightened prior to placing it in the jaws of the tensile testing machine. Straightening shall be done carefully to avoid formation of local sharp bends and to minimize cold work.

Note 3—Insufficient straightening prior to attaching the extensometer can result in lower-than-actual yield strength readings.

9.4. The percentage of elongation shall be as prescribed in Table 2 when tested in accordance with Section 14.4 of T 244.

10. BENDING REQUIREMENTS

10.1. The bend-test specimen shall withstand being bent around a pin without cracking on the outside radius of the bent portion when tested in accordance with T 285. The requirements for angle of bending and sizes of pins are prescribed in Table 3. When material is furnished in coils, the test sample must be straightened prior to placing it in the bend tester.

10.2. The bend test shall be made on specimens of sufficient length to ensure free bending and with apparatus that provides:

10.2.1. Continuous and uniform application of force throughout the duration of the bending operation.

10.2.2. Unrestricted movement of the specimen at points of contact with the apparatus and bending around a pin free to rotate.

10.2.3. Close wrapping of the specimen around the pin during the bending operation.

10.3. It is permissible to use other more severe methods of bend testing, such as placing a specimen across two pins free to rotate and applying the bending force with a fixed pin. When failures occur under other more severe methods, retests shall be permitted under the bend test method prescribed in Section 10.2.

Table 3—Bend Test Requirements

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Pin Diameter for Bend Testing of Type S Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 280 [40]</td>
</tr>
<tr>
<td>10, 13, 16 [3, 4, 5]</td>
<td>$3^{1/2} d^0$</td>
</tr>
<tr>
<td>19 [6]</td>
<td>$5 d$</td>
</tr>
</tbody>
</table>

Comment [LR10]: Renumbered Table Caption to reflect adding Table 2 caption for Chemical Requirements.
<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Pin Diameter for Bend Testing of Type W Bars&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 280 [40]&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>10, 13, 16 [3, 4, 5]</td>
<td>3 d&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>19 [6]</td>
<td>4 d</td>
</tr>
<tr>
<td>22, 25 [7, 8]</td>
<td>4 d</td>
</tr>
<tr>
<td>29, 32 [9, 10]</td>
<td>6 d</td>
</tr>
<tr>
<td>36 [11]</td>
<td>6 d</td>
</tr>
<tr>
<td>43, 57 [14, 18], (90°)</td>
<td>8 d</td>
</tr>
</tbody>
</table>

<sup>a</sup> Test bends 180 degrees unless noted otherwise.

<sup>b</sup> d = nominal diameter of specimen.

### 11. PERMISSIBLE VARIATION IN WEIGHT [MASS]

11.1. The permissible variation shall not exceed 6 percent under nominal mass [weight], except for bars smaller than 9.5 mm [3/8 in.] plain round, the permissible variation in mass [weight] shall be computed upon the basis of the permissible variation in diameter in ASTM A510M [ASTM A510]. For larger bars up to and including 63.5 mm [2 1/2 in.], use ASTM A6/A6M. Reinforcing bars are evaluated on the basis of nominal mass [weights]. In no case shall the overmass [overweight] of any bar be the cause for rejection.

11.2. The specified limit of variation shall be evaluated in accordance with ASTM E29 (rounding method).

### 12. FINISH

12.1. The bar shall be free of detrimental surface imperfections.

12.2. Rust, seams, surface irregularities, or mill scale shall not be cause for rejection, provided the weight, dimensions, cross-sectional area, and tensile properties of a hand wire-brushed test specimen are not less than the requirements of this specification.
12.3. Surface imperfections other than those specified in Section 12.2 shall be considered detrimental when specimens containing such imperfections fail to conform to either tensile or bending requirements. Examples include, but are not limited to, laps, seams, scabs, slivers, cooling or casting cracks, and mill or guide marks (Notes 4 and 5).

Note 4—Reinforcing bar intended for epoxy coating application should have surfaces with a minimum of sharp edges to achieve proper cover. Particular attention should be given to bar marks and deformations, where coating difficulties are prone to occur.

Note 5—Deformed bars destined to be mechanically spliced or butt-welded may require a certain degree of roundness in order for the splices to adequately achieve strength requirements.

13. TEST SPECIMENS

13.1. All mechanical tests shall be conducted in accordance with T 244, including Annex A9.

13.2. Tension test specimens shall be the full section of the bar as rolled. The unit stress determinations on full-sized specimens shall be based on the nominal bar area.

13.3. The bend-test specimens shall be the full section of the bar as rolled.

14. NUMBER OF TESTS

14.1. For bar sizes No. 10 to 36 [3 to 11], inclusive, one tension test and one bend test shall be made of the largest size rolled from each heat. If, however, material from one heat differs by three or more designation numbers, one tension and one bend test shall be made from both the highest and lowest designation numbers of the deformed bars rolled.

14.2. For bar sizes Nos. 43 and 57 [14 and 18] bars, one tension test and one bend test shall be made of each size from each heat.

14.3. For all bar sizes, one set of dimensional property tests, including bar mass [weight] and spacing, height, and gap of deformations, shall be made of each bar size rolled from each heat.

15. RETESTS

15.1. If results of an original tension specimen fail to meet the specified minimum requirements and are within 14 MPa [2000 psi] of the required tensile strength, within 7 MPa [1000 psi] of the required yield strength, or within 2 percentage units of the required elongation, a retest shall be permitted on two random specimens for each original tension specimen failure from the lot. Both retest specimens shall meet the requirements of this specification.

15.2. If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in Sections 15.4.2 and 15.4.3, a retest shall be permitted on two random specimens from the same lot. If the results of both test specimens meet the specified requirements, the lot
shall be accepted. The retest shall be performed on test specimens that are at air temperature but not less than 16°C [60°F].

15.3. If a mass [weight] test fails for reasons other than flaws in the specimen as described in Section 15.4.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

15.4. If the original test or any of the random retests fail because of reasons listed in Sections 15.4.1, 15.4.2, or 15.4.3, the test shall be considered an invalid test:

15.4.1. The elongation property of any tension test specimen is less than that specified and any part of the fracture is outside the middle half of the gauge length, indicated by scribe marks on the specimen before testing;

   **Note 6**—Marking specimens with multiple scribes or punch marks can reduce the occurrence of fracture outside or near these marks and the need for declaring the test invalid.

15.4.2. Mechanical reasons, such as failure of testing equipment or improper specimen preparation;

15.4.3. Flaws are detected in a test specimen, either before or during the performance of the test.

15.5. The original results from Sections 15.4.1, 15.4.2, or 15.4.3 shall be discarded and the test shall be repeated on a new specimen from the same lot.

16. INSPECTION AND PERIODIC TESTING

16.1. **Inspection and periodic testing** are important methods for owners and contractors to assure that quality bar products are provided to each project job site.

   **16.1.1 Initial Purchase**—For first-time orders, the purchaser shall have the option to determine if the manufacturer has procedures in place to assure that quality products are provided and are in conformance with the requirements of this specification. Quality indicators include, but are not limited to, controls on processing, sampling and testing, heat identification, marking, bar and scrap segregation, and storage conditions.

   **16.1.2 Plant Visitation**—By agreement with the manufacturer, the purchaser can visit the manufacturer’s plant to observe and sample production of the reinforcing bars that were ordered. The manufacturer shall receive proper notice prior to visitation, which will be conducted at reasonable hours and will not unnecessarily interfere with plant operations.

   **16.1.3 Periodic Re-assessment**—Purchasers that maintain lists of qualified manufacturers of steel reinforcing products can establish periodic quality re-assessments in time intervals of one year or more in agreement with the manufacturers. Time intervals for re-assessment shall be based on
plant conditions, number of organizational realignments or new ownership, and history of production quality and conformance.

16.1.4 Representatives of Purchasers—The purchaser or ultimate owner of the reinforcing bars covered by this specification shall have the option to authorize qualified representatives to sample, monitor or test bars for specification conformance. The requirements of 16.1.1, 16.1.2 and 16.1.3 shall also apply to the representatives of purchasers. All significant issues or agreements regarding compliance or conformance with this specification shall be promptly reported to the purchaser and ultimate owner of the reinforcing bars before any final decision is made.

16.2 Product Non-Conformance—If the testing or processing of the reinforcing bars conclusively demonstrate non-conformance with this specification, the purchaser shall have the cooperation of the manufacturer to determine the root cause of the problem. The purchaser shall have the right to observe production and evaluate proposed solutions to correct the deficiencies within a rehearing period not to exceed five working days or other mutually agreeable time table. If the deficiencies of the production lot cannot be remedied, the lot shall be considered as rejectable.

16.3 Purchase Order Cancellation—The manufacturer shall be afforded a reasonable time to correct the root cause of non-conformance. The purchaser and the manufacturer shall mutually agree on a time period for correction of the problem that is reasonable for both parties. If the manufacturer cannot subsequently provide written assurance of conformance, the purchase order shall be considered as voidable.

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 that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him or her that the material is being furnished in accordance with this specification. All tests (except product analysis) 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.

16.2 For Government Procurement Only—Except as otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements specified herein and may use his or her own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification, where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

17. REJECTION

17.1. Unless otherwise specified, any rejection based on tests made in accordance with Section 6.12 shall be reported to the manufacturer within five working days from the receipt of samples by the purchaser.
17.2. Material that shows injurious defects subsequent to its acceptance at the manufacturer’s works will be rejected, and the manufacturer shall be notified.

18. REHEARING

18.1. Samples tested in accordance with Section 6.12 that represent rejected material shall be preserved for two weeks from the date rejection is reported to the manufacturer. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

19. TEST REPORTS

19.1. For Type S bars, when specified in the purchase order, report the following information, on a per-heat basis. Additional items may be reported as requested or desired.

19.1.1. Chemical analysis, including carbon, manganese, phosphorus, and sulfur;
19.1.2. Tensile properties;
19.1.3. Bend test; and

19.2. For Type W bars, the following information must be reported on a per-heat basis. Report additional items as requested or desired in the purchase order.

19.2.1. Chemical analysis, including elements carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, chromium, molybdenum and vanadium;
19.2.2. Carbon equivalent in accordance with 6.1.4;
19.2.3. Tensile properties;
19.2.4. Bend test results; and
19.2.5. Material test report.

19.3. Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier’s facility. The content of the EDI transmitted document must meet the requirements of the invoked AASHTO standard(s) and conform to any EDI agreement between the purchaser and the supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

20. MARKING

Comment [LR11]: Corrected reference since Section 6.2 was deleted – per comment from Missouri.

Comment [LR12]: Deleted because not needed since it is a list – per L. Rowden review.

Comment [LR13]: Renumbered to remove duplicate numbering – per comment from Missouri and Pennsylvania.

Comment [LR14]: Deleted because not needed since it is a list – per L. Rowden review.

Comment [LR15]: Renumbered to remove duplicate numbering – per comment from Missouri and Pennsylvania.
20.1. When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer’s heat or test identification number.

20.2. Each producer shall identify the symbols of his marking system.

20.3. All bars produced to this specification, except plain round bars that shall be tagged for grade, shall be identified by a distinguishing set of marks legibly rolled into the surface of one side of the bar to denote, in the following order:

20.3.1. **Point of Origin**—Letter or symbol established as the producer’s mill designation.

20.3.2. **Size Designation**—Arabic number corresponding to bar designation number of Table 1.

20.3.3. **Type of Steel**—The letter *S* or *W* indicates that the bar was produced to this specification or for Grade 420 [60] bars only; the letters *S* and *W* indicates that the bar was produced to meet both Specifications M 31M/M 31 Type S and ASTM A615; the letter *W* indicates that the bar was produced to meet Specification M31M/M31 Type W and ASTM A706/A706M. A Type W bar will also meet the requirements for Type S bars of the same Grade. Grade 40 Type W bars shall be marked with a W. Grade 40 Type S bars have no markings.

20.3.4. **Minimum Yield Designation**—For Grade 420 [60] bars, either the number 4 [60] or a single continuous longitudinal line through at least five spaces offset from the center of the bar side. For Grade 520 [75] bars, either the number 5 [75] or two continuous longitudinal lines through at least five spaces offset each direction from the center of the bar. For Grade 550 [80] bars, either the number 80 [6] or three continuous longitudinal lines through at least five spaces offset each direction from the center of the bar. (No yield strength marking designation for Grade 280 [40] bars is required.)

20.3.5. It shall be permissible to substitute: a metric size bar of Grade 280 for the corresponding inch-pound size bar of Grade 40, a metric size bar of Grade 420 for the corresponding inch-pound size bar of Grade 60, a metric size bar of Grade 520 for the corresponding inch-pound size bar of Grade 75, and a metric size bar of Grade 550 for the corresponding inch-pound size bar of Grade 80.

21. **PACKAGING AND PACKAGE MARKING**

21.1. When specified in the purchase order, packaging shall be in accordance with the procedures in ASTM A700-05.

21.2. **For Government Procurement Only**—When specified in the contract or order, and for direct procurement by or direct shipment to the U.S. Government, material shall be preserved, packaged, and marked packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.
22. KEYWORDS

22.1. Concrete reinforcement; deformations (protrusions); steel bars; carbon equivalent.

1 Agrees with ASTM A615/A615M-12 except for the bend testing procedure, which is referenced to T 285 and Section 9.1.2.
# TS 4f Group 2 Ballot Items

<table>
<thead>
<tr>
<th>Item #</th>
<th>Ballot Item</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Adopt MP 18M/MP 18-15 Provisional Standard Specification for Uncoated, Corrosion-Resistant, Deformed and Plain Chromium Alloyed, Billet-Steel Bars for Concrete Reinforcement and Dowels to a full AASHTO Specification standard.</strong>&lt;br&gt;&lt;br&gt;This provisional standard has reached its 8 year time limit as a provisional standard. A task force has reviewed this provisional standard and separated the provisional specification portion of MP 18 from the provisional test methods that were included in the standard as annexes. The major adjustments were to Section 11 and 17 which referenced the annexes A1, A2, A3 and B1. The grade 75 steel was increased to grade 80 to correspond with ASTM changes and Section 23, Storage and Handling, was added. The task force is recommending to the Subcommittee on Materials that the specification portion of MP 18 is ready to be elevated to a full specification standard.&lt;br&gt;&lt;br&gt;See pages 2-3, 9-25 and 26-40 of the minutes.</td>
<td>SOM</td>
</tr>
<tr>
<td>2</td>
<td><strong>Adopt Annex A1 of MP 18M/MP 18-15 described as T MP18a.1 Standard Method of Test for Sensitivity of Stainless Steel to Intergranular Attack to a full AASHTO Test standard.</strong>&lt;br&gt;&lt;br&gt;This Annex was included in MP18 as a short term corrosion test that can be requested by purchaser to assure quality of stainless steels when the provisional standard specification was expanded to include stainless steels. Adjustments were made to Section 1 to match AASHTO style and formatting for a full test standard. The task force is recommending that this test portion of MP 18 is ready to be elevated to a full standard method of test.&lt;br&gt;&lt;br&gt;See pages 2-3, 9-25 and 41-44 of the minutes.</td>
<td>SOM</td>
</tr>
<tr>
<td>3</td>
<td><strong>Adopt Annex A2 of MP 18M/MP 18-15 described as T MP18a.2 Standard Method of Test for Comparative Qualitative Corrosion Characterization of Steel Bars Used for Concrete Reinforcement (Linear Polarization Resistance and Potentiodynamic Polarization Tests) to a full AASHTO Test standard.</strong>&lt;br&gt;&lt;br&gt;This Annex has been included in MP18 as a qualitative corrosion test to check resistance of steel to chloride attack for steels in the provisional standard specification. Originally this test was used to demonstrate A1035 steel’s improved resistance to chloride attack. This Annex has been in the provisional standard for 8 years. Adjustments were made to Section 1 to match AASHTO style and formatting. The task force is recommending that this test portion of MP 18 is ready to be elevated to a full standard method of test.&lt;br&gt;&lt;br&gt;See pages 2-3, 9-25 and 45-52 of the minutes.</td>
<td>SOM</td>
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<td>Ballot Item</td>
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<td>4</td>
<td>Adopt Annex A3 of MP 18M/MP 18-15 described as T MP18a.3 Standard Method of Test for Comparative Qualitative Corrosion Characterization of Uncoated Chromium-Alloyed Steel Bars Used for Concrete Reinforcement (Florida Tombstone Test) to a full AASHTO Test standard.</td>
<td>This Annex was included in MP18 as a qualitative long term corrosion test that provides an agency the means of evaluating and comparing the relative corrosion resistance of different types of steel reinforcement when the provisional standard specification was expanded to include stainless steels. Adjustments were made to Section 1 to match AASHTO style and formatting. A Significance and Use section plus a Summary of the Method section were developed from the note in this annex (A3) to MP 18. A reference mix design and an example mix design were added in Section 7. The task force is recommending that this test portion of MP 18 is ready to be elevated to a full standard method of test.</td>
</tr>
<tr>
<td>5</td>
<td>Adopt Annex B1 of MP 18M/MP 18-15 described as T MP18b.1 Standard Method of Test for Identification of Iron-Based Alloy Steel Bars for Concrete Reinforcement or Dowels by Handheld X-Ray Fluorescence (XRF) Spectrometer to a full AASHTO Test standard.</td>
<td>This Annex was included in MP18 as a test method to quickly identify the composition of iron-based alloys using a field-ready, hand-held XRF. This method is intended to be used to verify the type of stainless steel alloy reinforcing bars on a project. Adjustments were made to Section 1 to match AASHTO style and formatting. A Significance and Use, Calibration and Standardization, Procedure and Report and Interpretation of Results sections were developed in greater detail than what originally appeared as Annex B1 in MP 18. The task force is recommending that this test portion of MP 18 is ready to be elevated to a full standard method of test.</td>
</tr>
<tr>
<td>6</td>
<td>Adopt the proposed Macrocell Slab - Chloride Threshold Test designated AASHTO T MP18a4 by task force 2015-01 to a full AASHTO Test Standard.</td>
<td>This test method describes a procedure to measure the chloride threshold concentration to initiate active corrosion of reinforcing bars in concrete using a macrocell slab type specimen. The Test measurement of chloride threshold concentration can be used to project service life of various reinforced concrete structural members when placed in corrosive environments. The method was developed to evaluate corrosion resistance of chromium alloyed bars for concrete reinforcement and dowels. This test is a long-term quantitative test performed by exposing steel samples embedded in concrete and it provides the purchaser with a test that can be used for prequalification of chromium alloyed steel bars in MP 18.</td>
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<tr>
<td></td>
<td>Fall 2016 ballot items and justifications</td>
<td></td>
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</tbody>
</table>
| 7 | **Adopt MP XYZ, Steel Wire and Welded Wire, Plain and Deformed, for Concrete Reinforcement.**  
ASTM combined A82, A185, A497, and A496 into one standard, A1064. AASHTO had equivalency with those four standards in M32, M55, M221, and M225 and has now combined those four standards into this single standard. The intent is to have this single standard take the place of the four older standards and then discontinue them once adopted.  
This new specification is similar to ASTM A1064 with the following exceptions:  
• Units are stated in either SI units or inch-pound units and within the text, the inch-pound units are shown in brackets.  
• Section 4.1.7 references “the exclusion of oversteeling.” The current ASTM A1064 specification allows this practice, where the manufacturer is permitted to use oversized wire in place of the size originally. In the AASHTO method in cases in which such oversteeling is practiced and the overall weight of the order is increased by more than ten percent, the producer shall identify the welded wire reinforcement with the style being furnished.  
• Tables for the Dimensional Requirements for Plain & Deformed Wire are shown at the end of the specification  
See pages 3-4 and 79-95 of the minutes. | SOM |
| 8 | **Sunset M 270M /M 270, Structural Steel for Bridges.**  
This standard is obsolete and ASTM A 709 is the industry standard for structural steel for bridges.  
See pages 4 and 121-135 of the minutes. | SOM |
| 9 | **Revise M 31M/M31-15, Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement, to be equivalent with ASTM A 615/A 615M with noted additions and exceptions.**  
An extensive review was done of M31 to bring it up to date and also to include an allowance for weldable steel similar to ASTM A706.  
See pages 4-5 and 136-152 of the minutes. | SOM |
# TS 4f  2016 Annual Meeting Summary

**Meeting Date:** 8/1/2016

## Items approved by the TS for TS/Subcommittee/Concurrent Ballot

<table>
<thead>
<tr>
<th>Standard Designation</th>
<th>Summary of Proposed Changes</th>
<th>TS Only, Subcommittee Only or Concurrent? (TS / S / C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP 18</td>
<td>Editorial and technical in nature</td>
<td>S</td>
</tr>
<tr>
<td>T MP 18a.1</td>
<td>Test procedure removed from MP18</td>
<td>S</td>
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<tr>
<td>T MP 18a.2</td>
<td>Test procedure removed from MP18</td>
<td>S</td>
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<tr>
<td>T MP 18a.3</td>
<td>Test procedure removed from MP18</td>
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<tr>
<td>T MP 18b.1</td>
<td>Test procedure removed from MP18</td>
<td>S</td>
</tr>
<tr>
<td>T MP 18a.4</td>
<td>Editorial and technical revisions</td>
<td>C</td>
</tr>
<tr>
<td>T MP XYZ</td>
<td>New standard based on four old ones</td>
<td>S</td>
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<tr>
<td>M 270</td>
<td>Sunset the standard</td>
<td>S</td>
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<tr>
<td>M 31</td>
<td>Revise per Illinois changes</td>
<td>S</td>
</tr>
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</table>

## New Task Forces Formed:

<table>
<thead>
<tr>
<th>Task Force Name</th>
<th>Summary of Task</th>
<th>Names of TF Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOM_TS 4f-1-2016</td>
<td>Work with NTPEP members to put a “Buy America” requirements document together for steel and iron products</td>
<td>FL, OK, PA, SC, AL, FHWA, AASHTO (Sarc)</td>
</tr>
</tbody>
</table>

## Research Liaison:

**Other Action Items:**

Sunset AASHTO M270