ADDENDUM NO. 2 TO THE AUGUST 1, 1973
NEW YORK STATE STEEL CONSTRUCTION MANUAL
(EFFECTIVE FEBRUARY 2, 1976)

This Addendum consists of 2 sheets of INSTRUCTIONS and 20 sheets of REVISED PAGES.
Page 2
Under paragraph 102.3 in the first line, add, “project identification number” after the words, “contract number”.

Under paragraph 102.4.1 in the first line, change “A.A.S.H.O.” to read “A.A.S.H.T.O.” and in the third line, change “...State Highway Officials” to read “...State Highway and Transportation Officials”.

Under paragraph 102.4.3, delete the last line beginning with “definitions given...” and ending with “... (AWS A3.0)” and substitute the following: “definitions given in Appendix B of this Manual or in the current edition of ‘AWS Terms and Definitions’ (AWS A3.0)”.

Pages 3 thru 6
Remove and replace with revised pages.

Page 12
Under paragraph 202.6.5 in the second line, change the last word “and” to read “the”.

Pages 15 thru 18
Remove and replace with revised pages.

Page 22
Under paragraph 203.9.1.1 in the second line delete the word “welding”.

Pages 23 and 24
Remove and replace with revised pages.

Page 25
In Fig. 203.11.2a, delete the title, “Fig. 203.11.2a — Transition at Butt Joints in Parts of Unequal Thickness” and substitute the following: “Transition of Thickness.”

In Fig. 203.11.2b, delete the number in the title “Fig. 203.22.2b —”.

At the bottom of page 25, add the following title: “Fig. 203.11.2 — Transition of Butt Joints”.

Page 26
Delete the entire Fig. 203.11.2c

Page 31
In the title for Fig. 203.11.7, change the word “PREPARATION” to read “PENETRATION”.

Page 32
In the note with double asterisks (**), change the word “in” to read “is”.

Pages 33 and 34
Remove and replace with revised pages.

Pages 43 and 44
Remove and replace with revised pages.

Page 45
In Table 203.17 in the first line, change “3/4 to 1” to read “over 3/4 to 1”.

Pages 47 and 48
Remove and replace with revised pages numbered 47, 48, 48a and 48b.
Page 49
In Table 204.1a, change the nominal diameter of the hole for circular washers as follows:
For 3/8" bolts, change "21/32" to read "11/16"
For 1" bolts, change "1-1/16" to read "1-1/8"

Pages 51 and 52
Remove and replace with revised pages.

Page 54
Under paragraph 204.4.8, in the fourth line ending with "...pieces when assembled", add the following to the end of the sentence: "as described in paragraph 202.6.5."

Page 58
Under paragraph 204.7.2, the first line should read as follows: "Intermediate stiffeners and connection plates welded to the compression flange may be cut 1/8-inch short and then assembled..."

Page 56
In the title of Article 205.4, delete the words "or Straightness".

In the first line of paragraph 205.4.1, delete the words "or Straightness"

Page 59 and 60
Remove and replace with revised pages.

Page 61
Under Article 206.11, change the eighth and ninth lines to read: "Form B and GC 4b does not tabulate shipment weights for payment (see Section 616.4 and 616.5 of the Standard Specifications)."

Under Article 207.1 in the last line, change "Section 635" to read "Section 740".

Pages 63 and 64
Remove and replace with revised pages.

Page 65
In the title for Fig. 208.6.2, change "Fig. 208.6.2" to read "Fig. 208.6".

Page 66
Under Article 301 in the third line, change "(see Art. 206.9)" to read "(see Art. 206.8)".

Pages 71 and 72
Remove and replace with revised pages numbered 71, 71a, 71b and 72.

Page 73
In Fig. 401.4c, change Note 2 to read, "Specimen taken from center of the weld".

Page 74
In Fig. 401.4d, change Note 2 to read, "Minimum preheat shall be in accordance with Table 203.5."

Page 75
In Fig. 401.4e, change Note 2 to read, "Minimum preheat shall be in accordance with Table 203.5."

Page 77
Under Article 402.2, add the following to the first line, "and shall be preheated in accordance with Table 203.5."

Under paragraph 204.3.1, change the first line to read, "402.3.1. All manual shielded metal-arc welding qualification tests shall be performed using 5/32 inch..."
Page 79
Under Article 402.8, change paragraph (b) to read, "(b) One test weld may be made as a retest within 30 days provided there is evidence that the welder has had additional training or practice."

Under Article 402.8, add a paragraph as follows: "(c) One test weld may be made after 30 days."

Under paragraph 402.9.2, change the fifth line to read, "...least once every six (6) months by an Engineer-in-Charge or by a licensed Professional Engineer employed by the Owner and..."

Pages 80 thru 83
In Fig. 402a through d, change the longitudinal plate dimension "5" min." to read "5" (1/4, 0)."

Page 88
Under Article 403.8, change paragraph (b) to read, "(b) One test weld may be made as a retest within 30 days provided there is evidence that the operator has had additional training or practice."

Under Article 403.8, add a paragraph as follows: "(c) One test weld may be made after 30 days."

Under paragraph 404.1.3 in the second line, change "Fig. 404.1" to read "Fig. 404b."

Page 89
In Fig. 403, change the longitudinal plate dimension "15" min." to read "15" (1/4, 0)."

Page 90
Under Article 404.5 in the first line, change "Fig. 404.5" to read "Fig. 404e."

Page 97
Under Article 602.1 after the last line ending "...affects of live loads." Add the following: "If the Contract Plans do not show the limits of tension due to live load, it shall be assumed to extend for 10 feet beyond the dead load point of contraflexure."

Pages 101 thru 104
Remove and replace with revised pages.

Pages 117 and 118
Remove and replace with revised pages.

Page 122
After paragraph D7, add the following: "Differences between sensitivity measurements made on the DC or DCS blocks and the IIW block shall be accounted for when determining the Reference Level, "b"."

Page 123
In Fig. 700D, change the first note to read: "3 in. x 1 in. x 6 in. Finish all surfaces to ANSI 125 maximum."

Pages 125 thru 128
Remove and replace with revised pages.

Page 129
In table 700C, change the first line of Note 3 to read: "3. Discontinuities in the root-land area of complete joint penetration Double Vee, Double "J", Double "U" and Double Bevel Groove Welds. . . ."

Page 136
Add the following to the "Terms and Definitions": "D.C.E.S.: Deputy Chief Engineer (Structures) or his authorized representative. For projects not under the jurisdiction of the Department of Transportation, D.C.E.S. shall mean the Building Commissioner, Owner or Owner's Representative."
102.4.4.3. Fill plates will not be permitted. Web and flange shop butt welds may be moved to extend the thicker plate so that bolted connections are made in materials of the same thickness. All manufacturing dimensional tolerances shall be controlled so that bolted splices may be properly assembled without distortion and without requiring fills.

102.4.4.4. The D.C.E.S. reserves the right to order, at no extra cost, a welded splice at any location where a bolted splice design will require high strength bolts in excess of eight inches long.

102.4.4.5. Butt welded field splices in stringers and girders shall be made by complete penetration groove welds which shall be radiographed as required by the Contract Documents.

102.4.4.6. Bolted designs shall use ASTM A325 High Strength bolts only. The design shall be based upon the allowable shear for a friction-type connection. Bolt lengths shall be such that threads are excluded from shear planes in the connection.

102.4.4.7 When special corrosion resistant characteristics are required for the members to be spliced, ASTM A325 Type III, high strength bolts shall be used.

102.4.5. Location of Shop Welded Splices in Fabricated Members. Shop welded splices may be located at points in fabricated members that are consistent with lengths of plate available from the mills. Welded joints should be located at points of reduced tensile stress, if this will not create additional labor or material costs for the Contractor.

When flanges or webs of welded plate girders are detailed on the Contract Drawings as a series of plates of varying thickness joined by butt welds, the Contractor may, for the purpose of eliminating butt welds, extend the length of the thicker plate to the end of the next thinner plate or to the end of the member if approved by the D.C.E.S. The extra material required by this procedure must be furnished at no cost to the State. The maximum thickness transition at any joint shall not exceed a ratio of 1 to 2. Web thickness ratios may exceed this limit if shown on the Plans.

If the contractor increases the thickness of the bottom flange plate at a bearing location, he shall maintain the original girder elevation by making suitable compensating changes in the elevation or dimensions of the supports as approved by the D.C.E.S. In lieu of this, the Contractor may remove the increased thickness by machining the bottom flange plate at the bearing to maintain the original girder elevation. The transition between the machined surfaces and the adjacent plate surface shall have a slope not greater than 1 on 2½.

102.4.6. Standard Details for Fabrication. Unless otherwise provided in the Contract Documents, the following Standard Practices shall apply:

102.4.6.1. All bearing stiffeners on rolled beams and welded plate girders shall be fillet welded to the web and either welded to the bottom flange with a complete joint penetration groove weld or milled to bear against the bottom flange. On horizontally curved beams and girders, bearing stiffeners must be groove welded to the bottom flange. Bearing stiffeners may be either fillet welded or placed paint tight against the top flange except where the top flange is in tension, the bearing stiffener must be placed paint tight against the top flange and not welded to the flange.

102.4.6.2. Intermediate stiffeners and connection plates for simply supported plate girders shall consist of plates fillet welded to the web and to the flange which is in compression at that point under dead load. They shall be placed perpendicular to the flange or to a tangent to the flange at that location and shall be located as shown on the Contract Plans.

On fascia girders of continuous spans where stiffeners are installed on only one side of the web, the stiffeners shall be attached as described above. On interior girders of continuous spans, the stiffeners shall be attached as described above except in the stress reversal zones described on the Plans, they shall be placed paint tight against both flanges and not welded to either flange. If the reversal zone is not defined on the Contract Plans, it shall be assumed to extend 10 feet each side of the dead load point of contraflexure.

Revised Feb. 2, 1976
102.4.6.3. The ends of all beams and girders and all bearing stiffeners shall be vertical after dead load deflection.

102.4.6.4. Longitudinal stiffeners shall be continuous full length of the girder. They shall be assembled full length using complete penetration groove welds before attachment to the web with full length continuous fillet welds. Connection plates intersecting longitudinal stiffeners shall be notched and fillet welded or groove welded to the longitudinal stiffener at each intersection. Longitudinal stiffeners shall be groove welded to end bearing stiffeners and any other stiffener or connection plate where the longitudinal stiffener is terminated.

102.4.6.5. When the steel is to be erected to a grade of five percent or less, it will not be necessary to machine the top of the sole plate to a compensating bevel otherwise noted on the Contract Plans. No machining of the top sole plate will be required if the surface is plane and true as described in Article 202.5, “Machining of Contact Surfaces.”

102.4.6.6. When the Contract Plans specify welded plate girders with horizontal curvature, the girders shall be fabricated using heat-curving procedures in accordance with Section V or by flame cutting the flanges to the required radius prior to assembly to the web. The camber data for welded plate girders shall be provided by the Deputy Chief Engineer (Structures).

102.4.6.7. The horizontal curvature and camber if specified for rolled beams, shall be fabricated using only heat-curving procedures in accordance with Section V.

102.4.6.8. The minimum distance between centers of fasteners shall not be less than the following:

- For 1-1/8 inch fasteners ........................................... 4 inches
- For 1 inch fasteners .................................................. 3-1/2 inches
- For 7/8 inch fasteners ................................................ 3 inches
- For 3/4 inch fasteners ................................................ 2-1/2 inches
- For 5/8 inch fasteners ................................................ 2-1/4 inches

For sealing, the maximum spacing of fasteners along the free edge of a plate shall be 4 inches plus four times the thickness of the thinner plate, but not more than 7 inches.

102.4.6.9. The minimum distance from the center of any fastener to the edge of a plate shall be:

- For 1-1/8 inch fasteners ........................................... 2 inches
- For 1 inch fasteners .................................................. 1-3/4 inches
- For 7/8 inch fasteners ................................................ 1-1/2 inches
- For 3/4 inch fasteners ................................................ 1-1/4 inches
- For 5/8 inch fasteners ................................................ 1-1/8 inches

In the flanges or legs of rolled sections this distance shall be:

- For 1-1/8 inch fasteners ........................................... 1-3/8 inches
- For 1 inch fasteners .................................................. 1-1/4 inches
- For 7/8 inch fasteners ................................................ 1-1/8 inches
- For 3/4 inch fasteners ................................................ 1 inch
- For 5/8 inch fasteners ................................................ 7/8 inch

The maximum distance from any edge shall be eight times the thickness of the thinnest outside plate, but shall not exceed 5 inches.
102.5. Approval of Shop Drawings. Shop drawings are required for all structural steel, except for rolled beam bridges not requiring fabrication or for miscellaneous steel, when specified in the Contract Documents. When the shop drawings prepared by the Contractor as specified are completed, triplicate reproductions shall be submitted to the D.C.E.S. who will review and indicate thereon corrections deemed necessary by the State.

The triplicate reproductions may be either three paper prints, or two paper prints and one sepia or other approved reproducible. If three paper prints are submitted, one set of paper prints, with corrections, indicated thereon will be returned to the Contractor. If two paper prints and one sepia are submitted, the set of sepia reproductions will be returned to the Contractor with the following stamp:

<table>
<thead>
<tr>
<th>Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved for Fabrication Without Weights</td>
</tr>
<tr>
<td>Approved - as - Noted</td>
</tr>
<tr>
<td>Disapproved</td>
</tr>
<tr>
<td>Submit Tracing for Approval Stamp</td>
</tr>
<tr>
<td>Correct Sepia and Resubmit</td>
</tr>
<tr>
<td>Make Indicated Changes to Tracing and Submit for Approval Stamp</td>
</tr>
</tbody>
</table>

Approval is limited to Materials and type of Details. No Steel shall be shipped from the Shop until the inspector is furnished a print made from the approved tracing.

*Does not apply when payment is not to be made on a pound-price basis.

As soon as the Contractor receives a reproducible marked "Approved," "Approved for Fabrication Without Weights," or "Approved-As-Noted," he is authorized to reproduce the drawing and furnish necessary copies to the shop and to the Inspector. If he agrees to the notations on the "Approved-As-Noted" drawings, he may begin the fabrication incorporating the required changes. If he feels that the notations on the drawing constitute "Extra Work" or "Disputed Work," the Contractor must notify the Department under the provisions of the Specifications For Disputed Work.

Any revisions made to shop drawings shall be clearly marked on the drawing by a revision symbol and date, unless the revision was the result of the comments marked on the shop drawings by the State during shop drawing review.

On Contracts involving one or more railroads, the Contractor shall furnish each Railroad Company with duplicate paper reproductions of the shop drawings at the same time triplicate reproductions are submitted to the D.C.E.S.

When the revisions marked on the shop drawings have been completed, the original reproducibles shall be submitted to the D.C.E.S. in a mailing tube for his approval stamp and signature. The Contractor shall carry out the construction in strict accordance with the approved drawings and shall make no further changes therein except with the written approval of the D.C.E.S. The D.C.E.S. approval shall not relieve the Contractor from his responsibility for errors that may exist in the shop drawings.

102.6. Detention of Shop Drawings. The D.C.E.S. shall be allowed two work days for the examination of each drawing in a set of shop drawings or ten work days minimum per set. A set of shop drawings shall be considered to be all drawings submitted by a given Contractor for a particular contract on any calendar day. If the shop drawings are detained for examination for a period longer than stated above, such detention will be taken into account when considering application by the Contractor for an extension of time for the completion of the contract. All shop drawings are time and date stamped as they are received and recorded in a log at the office of the D.C.E.S. This log shall be the basis for determining when drawings must be returned without adjustment of the completion date as described in this section.

The State will return corrected and/or approved drawings with the minimum possible delay. In order to expedite his work, the Contractor should indicate in his submittal his order of preference for the review and return of drawings and should submit all drawings in their order of importance to his construction program.
102.7. Disposal of Original Reproducibles. After the completion of the contract and before the final payment thereof, the Contractor shall deliver to the Deputy Chief Engineer (Structures) all approved original reproducibles which shall thereafter remain the property of the State.

102.8. Reproduction of Approved Shop Drawings. The Contractor (or Fabricator) shall distribute prints of the approved shop drawings, as follows:

1. Set to the Deputy Chief Engineer (Structures)
2. Sets to the General Contractor
3. Sets to the Regional Director of Transportation
4. Sets to the designated Inspection Agency.

In addition to the above drawings, the Contractor shall submit one set of reproducibles made of approved durable stock to the Regional Director of Transportation.

For every Railroad Company or Public Agency involved in the contract, the Contractor shall furnish three (3) additional sets of prints, on paper, and one (1) set of approved reproducible shop drawings made by an acceptable process.

102.9. Cost of Shop Drawing Prints and Reproducibles. The cost of all shop drawing prints and reproducibles required by the specification shall be included in the price bid for the payment item requiring the drawings. Any prints and reproducibles requested beyond the number specified shall be furnished by the Contractor at cost.
SECTION II

FABRICATION

201. GENERAL

201.1. Minimum Shop Facilities for Fabrication. The Contractor shall provide sufficient lifting capacity, physical plant and equipment for the fabrication and painting of structural steel. A minimum of two overhead cranes shall be provided. The cranes in each working area shall have a combined rated capacity equal to the lifting weight of the heaviest assembly fabricated for shipment unless alternate lifting and turning facilities are approved by the D.C.E.S.

Lifting chains shall be provided with adequate softeners to prevent damage to the corners of material during lifting and turning. If hooks are used for lifting, they must have sufficient width of jaw and throat to prevent damage to the flanges or to the web-to-flange welds.

Spreader beams, or multiple cranes, must be provided for lifting plates and long slender members to prevent distortions from handling.

Shops shall have sufficient enclosed floor space to allow all flame-cutting, air carbon-arc gouging, assembly, welding and painting to be performed inside except that the shop assembly of field connections for trusses, girders and arches may be performed outside the shop buildings.

The D.C.E.S. will approve limited fabrication, welding and painting outside the shop, provided the fabricator has made provisions to insure that the quality of work produced outside the shop buildings will not be adversely affected by weather or other conditions.

All welding and painting shall be done in an area that is kept dry. Further, areas for automatic and semiautomatic welding shall be kept at a temperature not lower than 40° F for at least one hour before work begins and at all times when work is being performed. In painting areas, the steel shall be at a temperature not lower than 40° F upon application of paint and shall remain at least 40° F until the paint is dry.

Unless modified by other provisions of the Contract Documents, fully automatic welding equipment shall be provided for making all flange-to-web welds and for attaching all stiffener and connection plates to webs of welded plate girders. Web to flange welds in box girders, arches, towers and truss web and chord members shall be made by fully automatic welding equipment unless otherwise approved by the D.C.E.S. Semiautomatic (hand-guided) or fully automatic welding equipment shall be used for all other principal welds.

The use of the Manual Shielded Metal-Arc process shall be limited to welding connection plates to rolled beams, welding bearing assemblies, minor detail attachments, and other limited welding applications where the use of automatic or semiautomatic welding equipment is impractical because of limited access, or the isolated location and short length of welds involved.

All welders using Gas Shielded Flux Cored-Arc Welding or Manual Shielded Metal-Arc Welding processes shall have access to a pneumatic chipping hammer or needle descaler and to an air carbon-arc gouger at all times.

201.2. Ordering of Materials. The Contractor shall bear all costs or damages which may result from the ordering of any materials prior to the approval of the shop drawings as described in sub-section 102 unless the State makes changes in the Principal Controlling Dimensions and Properties (Art. 101.5.) after the opening of bids.

201.3. Commencement of Shop Work. No shop work shall be started until the shop drawings have been approved. Any shop work started prior to the approval of shop drawings, shall be done at the Contractor's risk.
203.2.1.5. Specifications for High-Strength Low-Alloy Columbiun-Vanadium Steels of Structural Quality. (ASTM A572-Grade 50).

203.2.1.6. Specifications for High-Strength Low-Alloy Structural Steel with 50,000 psi Minimum Yield Point to 4 inches thick (ASTM A588).

203.2.2. When an ASTM A242 type of low-alloy structural steel is considered for use, it shall be made the subject of a special investigation as to weldability by the D.C.E.S., and the D.C.E.S. shall specify all pertinent information covering material, design and workmanship not covered by these Specifications.

203.2.3. When a structural steel other than those listed above is approved and such steel is proposed for welded construction, the weldability of the steel and the procedure for welding it shall be established by qualification tests in accordance with the requirements of Section IV and such other requirements as prescribed by the D.C.E.S.

203.2.4. Combinations of any of the steel base metals listed in par. 203.2.1 may be welded together. In joints involving combinations of base metals, welding preheat shall be in accordance with Table 203.5 for the higher strength steel being welded.

203.3. Approved Welding Processes.

203.3.1. The following welding processes shall be used for all welding unless other processes are approved by the D.C.E.S. on the basis of acceptable results of procedure qualification tests:

- Manual Shielded Metal-Arc Welding (SMAW)
- Submerged Arc Welding (SAW)
- Flux Cored-Arc Welding with External Carbon Dioxide Gas Shielding (FCAW)
- Electroslag Welding (EW)

All SMAW shall be performed using low-hydrogen electrodes as described in this specification. When FCAW is used, additional shielding shall be obtained from externally supplied carbon dioxide gas. EW will be permitted only in compression areas of bridge members and in buildings unless otherwise approved by the D.C.E.S.

203.4. Filler Metal Requirements.

203.4.1. The D.C.E.S. maintains a file of manufacturers' certified test results of filler metal qualification tests qualifying electrodes and flux for SAW, FCAW, EW and SMAW.

If the electrode or wire and flux combination to be used is not listed in this manufacturers' certification file or if the data contained therein is more than one year old because the manufacturer has failed to voluntarily submit the required certified test results, the Contractor will be required to furnish the Inspector with manufacturers' certified test results for each lot of electrode and flux used in the work.

This certification provides only for the acceptance of the electrode and flux. The welding procedure shall be qualified in accordance with the provisions of Section IV.

203.4.2. The electrode, electrode-flux combination, or grade of weld metal for complete joint penetration or partial joint penetration groove welds subject to shear stress and for fillet welds in shear may be of a lower strength than that required to match the base metal, provided the weld metal meets the stress requirements, as determined by the D.C.E.S. Under some conditions improved ductility is preferred to yield stress that matches the base metal.

Over matching of weld metal, i.e., when the weld metal is significantly stronger than the base metal is undesirable.
Over matching of weld metal can be one of the major contributors to lamellar tearing when the weld residual stresses stress the base metal in the short transverse "z" direction. The D.C.E.S. may disapprove welding processes, electrodes and fluxes, that will cause serious overmatching in his opinion.

203.4.3. When special corrosion resistant and color matching characteristics are required for welding ASTM A588 and A242 Steel using fillet welds larger than 1/4" or any multipass welds except as provided herein, electrodes conforming to the requirements of the latest edition of the “Specification for Low-Alloy Steel Covered Arc-Welding Electrodes” (AWS A5.5) shall be used for all manual welding. All other applications using automatic or semiautomatic processes shall be approved by the D.C.E.S. based upon the physical characteristics and chemical composition of the as-deposited weld metal.

In multiple-pass welds, the weld may be deposited using approved carbon steel filler metal provided that at least two layers on all exposed surfaces and edges are deposited with an approved filler metal meeting the corrosion resistant and color match requirements described above.

Where exposed, unpainted applications of ASTM A242 and A588 steel require weld metal with atmospheric corrosion resistance and color matching similar to that of the base metal, the following procedure may be used, providing the welding procedure is approved by the D.C.E.S.

**SHIELDED METAL-ARC** — Single pass fillet welds up to ¼ inch maximum and groove welds made with a single pass or with a single pass each side may be made using an approved E70XX low hydrogen electrode.

**SUBMERGED-ARC** — Single pass fillet welds up to 5/16 inch maximum and groove welds made with a single pass or a single pass each side may be made using an approved F71-XXXX electrode-flux combination.

**FLUX CORED-ARC** — Single pass fillet welds up to 5/16 inch maximum and groove welds made with a single pass or a single pass each side may be made using an approved E70T-1 electrode.

203.4.4. All electrodes, wire and flux shall be packaged, dried and stored in accordance with Articles 203.6 through 203.9.

203.5. Preheat & Interpass Temperature Requirements. With the exception of Electroslag welding, preheat and interpass temperatures shall conform to the requirements of Table 203.5 for the higher strength steel being welded.

203.6. Requirements for Manual Shielded Metal-Arc Welding.

203.6.1. Electrodes for Manual Shielded Metal Arc Welding (SMAW) shall conform to the requirements of the latest edition of “Specifications for Mild Steel Covered Arc Welding Electrodes” (AWS A5.1) or to the requirements of the latest edition of “Specifications for Low Alloy Steel Covered Arc Welding Electrodes” (AWS A5.5). Only classification E7018, E7028, E8016-C3 or E8018-C3 shall be used.

203.6.2. All SMAW electrodes shall be furnished in hermetically sealed containers and shall be dried for at least two hours, but not to exceed four hours between 500 and 550°F before they are used. After drying, electrodes may be placed in a storage oven held continuously at a temperature of at least 250°F until used in the work. E70XX electrodes not used within four hours and E80XX electrodes not used within two hours from the time they are removed from the drying or storage oven shall be redried for one hour minimum at a temperature between 700 and 800°F. or shall be discarded and not used in the work. If the relative humidity is greater than 70% the limits of 4 hours and 2 hours shall be reduced to 2 hours and 1 hour, respectively. Redrying of electrodes will only be permitted if the Contractor has the proper equipment for controlled drying at the temperatures specified above. Electrodes which have been wet shall not be redried or used under any condition.


203.6.3.1. The work shall be positioned for flat position welding whenever practicable. This process shall be operated using DC reverse polarity unless otherwise approved by the D.C.E.S.
### TABLE 203.5

**MINIMUM PREHEAT AND INTERPASS TEMPERATURE**

<table>
<thead>
<tr>
<th>Thickness of Thickest Part at Point of Welding – Inches</th>
<th>ASTM A36</th>
<th>A441, A500</th>
<th>ASTM A588</th>
<th>A242 (Weldable Grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 3/4, Incl.</td>
<td>50°F</td>
<td>100°F (note 5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 3/4 to 1 1/4 Incl.</td>
<td>70°F</td>
<td>200°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 1 1/4 to 2 1/2, Incl.</td>
<td>150°F</td>
<td>300°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 2 1/2</td>
<td>225°F</td>
<td>350°F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

1. When the base metal is below the temperature listed for the thickness and grade of material being welded, it shall be preheated (except as otherwise provided) in such manner that the surface of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded, but not less than 3 inches, both laterally and in advance of the welding. The preheat shall extend 3 inches minimum in the through thickness direction. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperature above the minimum shown may be required for highly restrained welds. PREHEAT & INTERPASS TEMPERATURES AND HEAT INPUT employed shall be such that the hardness of the heat affected zone shall not exceed Rockwell Hardness of C 27.

2. In joints involving combination of base metals, preheat shall be as specified for the higher strength steel being welded.

3. All field welding shall be done with a minimum preheat and interpass temperature of 150°F. No welding shall be done when the ambient temperature is lower than 0°F.

4. Crack repair procedures shall include higher preheat temperature, controlled interpass temperature, and post heating as approved by the D.C.E.S.

5. Preheat requirements for welding transverse stiffeners to A588 web plates up to 1/2 inch in thickness may be reduced to 50°F when welding by a fully automatic submerged arc process. The minimum welding heat input shall be 50 kilojoules per inch (when using submerged arc welders that weld both sides of a stiffener or connection plate simultaneously, the total heat input from both arcs shall be 100 kilojoules per inch minimum).

6. Lateral gusset plates shall be welded to girder flanges using a minimum preheat temperature of 250°F. unless higher temperatures are required by the Table.

7. Preheat requirements shall be waived for the welding of permanent metal forms to portions of girder flanges subject to compression stress and also for stud welding done in accordance with Subsection 208.

---

203.6.3.2. The classification and size of electrode, arc length, voltage and amperage shall be suited to the thickness of the material, type of groove, welding position and other circumstances attending the work.

203.6.3.3. The maximum size of electrode shall be as follows:

(a) 1/4 inch for all welds made in the flat position, except root passes.

(b) 1/4 inch for horizontal fillet welds.

(c) 5/32 inch for welds made in the vertical and overhead positions.

(d) 3/16 inch for root passes of groove welds and for all other welds not included under (a), (b), and (c) above.

203.6.3.4. The maximum thickness of layers subsequent to the root pass in fillet welds and of all layers in groove welds shall be:

(a) 1/4 inch for root passes of groove welds.

(b) 1/8 inch for subsequent layers of welds made in the flat position.

(c) 3/16 inch for subsequent layers of welds made in the vertical, overhead and horizontal positions.

The minimum size of a root pass shall be such as to prevent cracking.

203.6.3.5. The maximum size fillet weld which may be made in one pass shall be:

(a) 3/8 inch in the flat position.

(b) 5/16 inch in horizontal or overhead positions.

(c) 1/2 inch in the vertical position
203.6.3.6. When welding in the vertical position, the progression of all passes shall be upward. Vertical-down welding techniques shall not be permitted for any purpose.

203.6.3.7. Complete joint penetration groove welds made without the use of steel backing shall have the root arc-air gouged to sound weld metal before welding is started from the second side. Heat input, preheat and interpass temperatures must be maintained as provided in the Specifications.

203.6.3.8. Minimum preheat and interpass temperatures shall be maintained for all steels. As a further attempt to control minimum heat inputs for all steels being welded, the minimum size of electrode for Manual Shielded Metal Arc Welding shall be 5/32 inch.

203.7. Requirements for Submerged Arc Welding.

203.7.1. Definitions. (See Appendix B — Submerged Arc Welding).

203.7.2. General Requirements.

203.7.2.1. All Welding Procedures for submerged arc welding shall be qualified in accordance with the provisions of Section IV.

203.7.2.2. Submerged arc welding may be performed with one or more single electrodes, one or more parallel electrodes, or combinations of single and parallel electrodes. The spacing between arcs shall be such that the slag cover over the weld metal produced by a leading arc does not cool sufficiently to prevent the proper weld deposit of a following electrode. Submerged arc welding with multiple electrodes may be used for any pass of a groove or fillet weld.

203.7.2.3. The following articles governing the use of submerged arc welding are suitable for any steel included in Article 203.2. Considerations must include the additional heat input produced in simultaneous welding on the two sides of a common member. Electrode spacing orientation and weld travel speed shall be regulated to prevent bridging (undesirable base metal melting) and hot cracking.

203.7.2.4. The maximum size of electrodes shall not exceed ¾ inch diameter.

203.7.2.5. Surfaces on which submerged arc welds are to be deposited and adjacent faying surfaces shall be clean as specified in Article 202.4 and shall be free of moisture.

203.7.2.6. All bridge welds detailed as complete penetration groove welds and not required to be fused into steel backing shall have the root of the initial first side weld arc-air gouged to sound weld metal before welding is started from the second side. For any building weld that requires a specific root penetration, the contractor shall make a simple joint and provide a macroetched cross section to demonstrate that the proposed welding procedure will attain the required root penetration without back gouging. The D.C.E.S. at his discretion may accept a radiograph of a test joint or recorded evidence in lieu of the test specified in this paragraph. Nondestructive tests may be employed to assure penetration is achieved in the work.

203.7.2.7. Neither the depth nor the maximum width in the cross-section of weld metal deposited in each weld pass shall exceed the width at the surface of the weld pass (see Figure 203.7 a and b). This requirement may be waived if testing to the satisfaction of the D.C.E.S. has demonstrated that such welds exhibit freedom from cracking. Such testing shall be as directed by the D.C.E.S.

203.7.2.8. Tack welds in the way of fillet welds 3/8 inch or smaller in size, or in the root of joints requiring specific root penetration, shall be sufficiently small that they do not produce objectionable changes in appearance of the weld surface or result in decrease in penetration; otherwise they shall be removed or reduced in size by any suitable means prior to welding. Tack welds in the root of a joint with steel backing less than 5/16 inch thick shall be removed or made continuous for the full length of the joint using low-hydrogen electrodes.

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203.9.3. Condition of Flux. Flux used for electroslag welding shall be non-hygroscopic dry and free of contamination from dirt, mill scale or other foreign material. All flux shall be purchased in packages capable of being stored under normal conditions for at least six months without such storage affecting its welding characteristics or weld properties. Flux from packages damaged in transit or in handling shall be discarded or shall be dried before use at a minimum temperature of 250° F for one hour. Flux that has been wet shall not be used.

203.9.4. Procedures for Electroslag Welding.

203.9.4.1. The electrodes shall be dry, clean, and in suitable condition for use.

203.9.4.2. Flux and consumable guide coating (when the process requires a consumable guide tube) shall be dry and free of contamination from dirt, mill scale, or other foreign material which may affect the quality or strength of the weld.

203.9.4.3. The type and diameter of the electrodes used shall meet the requirements of the Procedure Specification.

203.9.4.4. Welds shall be started in such a manner to permit sufficient heat build-up for complete fusion of the weld metal to the groove face of the joint. Welds stopped at any point in the length of the joint and restarted after a delay of more than one minute shall be examined for full fusion by nondestructive methods and repaired if necessary in accordance with Par. 203.9.4.6.

203.9.4.5. With the high heat input characteristic of this process, preheating is not normally required. However, no welding shall be performed when the temperature of the base metal at the point of welding is below 40° F.

203.9.4.6. Welds having defects prohibited by Art. 203.18 or 203.19 shall be repaired as permitted by Art. 203.20 utilizing a qualified welding process or the entire weld shall be removed and replaced. Since this process melts the base metal up to 1\(\frac{1}{4}\) inches back from the original joint boundary on each side of the joint under some welding conditions in thick plate, these melt-back areas shall also be examined by nondestructive tests and repaired when necessary. When a defective joint is cut out and rewelded, it may be necessary to repair the new joint boundaries by procedures approved by the D.C.E.S. prior to rewelding unless by the rearrangement of plates, the defective melt-back areas are relocated to areas where there is no calculated stress.

203.9.4.7. All electroslag welds will be subject to nondestructive testing. The type of testing may be shown on the plans or directed by the D.C.E.S. at the time the welding procedure specification is approved if E.W. was not called for on the plans.

203.10. Special requirements for A588 Steel. The following notes shall apply whenever ASTM A588 Steel is used for primary stress carrying members.

203.10.1. Flame Cut Edges. The Contractor shall take steps to insure that the flame cut edges of main material subject to tensile stresses are not hardened by the cutting process. This may be achieved by preheating, post heating or control of the burning process. Flame cut edges found to have a Rockwell Hardness Value of C 30 or greater will be considered unacceptable. A portable Rockwell Hardness Tester will be employed by the Inspector to determine conformance with these requirements. Unacceptably hard surfaces shall be removed by grinding or machining.

203.10.2. Tack Welds. There shall be no tack welding on steel that is not preheated to the minimum specified preheat and interpass temperature required for this steel unless the tack weld and adjacent heat affected zone is completely remelted and incorporated in the subsequent semi-automatic or automatic weld. All temporary tack welds that are not remelted and incorporated into a permanent weld shall be removed by grinding. The areas where the tack welds are removed shall be magnetic particle inspected by the Contractor in accordance with Section VIII. Hardness tests of these areas may also be performed by the Inspector.
203.10.3. Minimum Heat Input. The welding procedure used shall produce the following minimum heat input values:

For material from 3/8 inch to 3/4 inch in thickness incl. . . . 35 kilojoules per in.  
Material over 3/4 inch in thickness . . . 50 kilojoules per in.

Heat input values shall be calculated by the Contractor for all proposed welding procedures and submitted to the D.C.F.S. for approval. (Also see provisions for minimum preheat and interpass temperatures, Article 203.5).

203.11. Joint Details.

203.11.1. Residual Stresses. Joints shall be welded so as to minimize, in so far as practical, stresses due to the contraction of the weld metal and adjacent base metal upon cooling. When weldments are subject to unusual restraint or when plate thickness becomes excessive, the Contractor may submit revised joint details to limit the size of the weld nugget and thereby reduce residual stresses and distortion caused by welding. The State will approve these weld details provided it is adequately demonstrated that there is access for welding and that the details, welding procedure and inspection methods used will insure satisfactory results in the work. Peening may be approved by the D.C.F.S. to control shrinkage stresses. All peening shall be performed in accordance with Par. 203.13.8.

203.11.2 Butt Joints.

203.11.2.1 When butt joints are used to join material of different thickness or widths, there shall be a smooth transitional slope between the offset surfaces or edges. This slope shall not exceed that shown in Figure 203.11.2.

203.11.2.1.1 The transition of thickness may be accomplished by, sloping weld faces, chamfering the thicker part, or a combination of the two methods.

203.11.2.1.2 The transition of width shall be accomplished by sloping the edges of the wider part.

203.11.2.2 If it becomes necessary to have butt joints at locations other than shown on the Contract Plans, it must be so detailed on the shop drawings. These joints shall be welded by a prequalified procedure and tested in accordance with the provisions of Section VI.

203.11.3. Prohibited Types of Joints and Welds. The following types of joints and welds are prohibited in bridges:

(a) Butt joints not fully welded throughout their cross section.
(b) Groove welds made from one side only unless completely fused to a steel backing as specified in Art. 203.15.
(c) Intermittent groove welds.
(d) Intermittent fillet welds, unless otherwise specified.
(e) Bevel and J grooves for other than horizontal position welding.

NOTE: This does not prohibit the use of partial penetration tee and corner welds for bridges and building when detailed on the plans.

203.11.4. Qualification of Joints.

203.11.4.1. Joints that conform to the details specified in Par. 203.11.5 through 203.11.9 and which are welded with manual shielded metal-arc, submerged arc or flux cored arc welding in accordance with the requirements of Arts. 203.6, 203.7 and 203.8 of this manual, may be used without performing joint welding procedure qualification tests.
203.11.8. Complete Joint-Penetration Groove Welds Made by Submerged Arc Welding.

203.11.8.1. A complete-penetration groove weld is defined as one welded from both sides or from one side and fused into steel backing of a chemistry suitable for welding, generally A36 Steel, having complete penetration and fusion of weld and base metal throughout the depth of the joint.

203.11.8.2. Complete joint penetration groove welds made by submerged arc processes in butt, tee and corner joints which may be used without performing the joint welding procedure tests prescribed by Par. 203.11.4.1 are detailed in Fig. 203.11.8 and are subject to the limitations specified in Par. 203.11.8.3 and 203.11.8.4.

203.11.8.3. All submerged arc welding of groove welds is to be done in the flat position.

203.11.8.4. Dimensions of groove welds specified on design or shop drawings may deviate from the dimensions shown in Fig. 203.11.8 only within the following limits:

(a) The specified thickness of material is the maximum nominal thickness that may be used.
(b) The root face of the joint is minimum. It may be detailed to exceed the dimension shown by not more than 1/16 inch.
(c) The root opening of closed joints shall be detailed as zero (no deviation). The root opening of open joints with backings is minimum. It may be detailed to exceed the dimension shown by not more than 1/16 inch.
(d) The groove angle is minimum. It may be detailed to exceed the dimensions shown by not more than 10 degrees.
(e) The radius of U-grooves is minimum. It may be detailed to exceed the dimensions shown by not more than 1/8 inch. U-grooves may be prepared prior to or after fitting.
### VEE-GROOVE WELD

<table>
<thead>
<tr>
<th>BUTT JOINT (B)</th>
<th>SINGLE-VEE - GROOVE (2)</th>
<th>DOUBLE-VEE - GROOVE (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B-L1-S</strong></td>
<td><strong>B-L2a-S</strong></td>
<td><strong>B-L2b-S</strong></td>
</tr>
<tr>
<td><strong>B-L2a-S</strong></td>
<td><strong>B-L2b-S</strong></td>
<td><strong>B-L3c-S</strong></td>
</tr>
</tbody>
</table>

**Welds must be centered on joint.**

**T**

<table>
<thead>
<tr>
<th>T</th>
<th>T&lt;sub&gt;1&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over ¾” to 1”</td>
<td>¾”</td>
</tr>
<tr>
<td>Over 1” to 1½”</td>
<td>½”</td>
</tr>
<tr>
<td>Over 1½” to 2”</td>
<td>⅛”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T</th>
<th>T&lt;sub&gt;1&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over ¾” to 1”</td>
<td>¾”</td>
</tr>
<tr>
<td>Over 1” to 1½”</td>
<td>½”</td>
</tr>
<tr>
<td>Over 1½” to 2”</td>
<td>⅛”</td>
</tr>
</tbody>
</table>

**For T ≥ 5½”:**

\[ T_1 = 2/(3T - ¾) \]

---

**LIMITATIONS FOR JOINTS**

<table>
<thead>
<tr>
<th>C</th>
<th>R</th>
<th>Max. Thickness (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-L2a-S</td>
<td>30°</td>
<td>⅛”</td>
</tr>
<tr>
<td>C-L2a-S</td>
<td>45°</td>
<td>⅛”</td>
</tr>
<tr>
<td>C-L2b-S</td>
<td>60°</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Gouge roots of joints without backing as follows:
   - Air carbon-arc gouge to sound weld metal before welding the second side. The minimum radius of the gouge shall be ⅛ inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.
   - AWS joint detail modified.

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**Fig. 203.11.8** - COMPLETE JOINT PENETRATION prequalified submerged arc welded joints - base metal of LIMITED (L) and UNLIMITED (U) thickness.
Steel backing shall be made continuous for the full length of the weld. All necessary joints in the steel backing shall be complete joint penetration butt welds meeting all workmanship requirements of Section II.

203.15.2. All run-off tabs and backings shall be removed after welding and the joint ground smooth. Backing may be left in place on tee and corner welds unless otherwise specified.

203.16. Temporary and Tack Welds.

203.16.1. Temporary and tack welds shall be subject to the same quality requirements as final welds except that:

(a) Preheat is not mandatory for single pass welds which are completely remelted with their attendant heat affected zones and incorporated into continuous semi-automatic or automatic welds.

(b) Defects such as undercut, unfilled craters and porosity need not be removed before the final semi-automatic or automatic welding if such welds are to be remelted.

(c) The minimum length of each tack weld shall be 1½ inches.

203.16.2. Temporary or tack welds which are not incorporated into the final weld shall be removed and the surface shall be made flush with the original surface. The areas where the welds are removed shall be magnetic particle inspected by the Contractor in accordance with Section VIII. Hardness tests of these areas may be performed by the Inspector.

Temporary or tack welds which are incorporated into final welds shall be made with electrodes meeting the physical requirements of the final weld and shall be cleaned thoroughly. Multiple pass tack welds shall have cascaded ends.

203.16.3. There shall be no temporary attachments by welding to tension areas of any structural steel unless specifically approved by the D.C.E.S. All temporary welds in tension areas, when approved, shall meet all the quality requirements of the specifications for permanent welds including preheat, interpass temperatures and minimum heat input controls. Temporary welds shall be removed as described in Par. 203.16.2.

203.16.4. For temporary and tack welding on ASTM A588 Steel the provisions of Par. 203.10.2 shall also apply.

203.16.5 Tack welds used to attach permanent metal forms to girder flanges shall be subject to the above requirements except that preheat is not mandatory. Tack welds are not permitted on girder flanges in tension or reversal zones. See paragraph 102.4.6.2 for definition of reversal zone.

203.17. Weld Profiles and Fillet Weld Sizes (Bridges and Buildings)

203.17.1. All fillet welds shall be of acceptable types as depicted by Fig. 203.17 A, B and C with no defects such as those shown in Fig. 203.17 D. In no case, except at the outside of a corner joint, shall the convexity exceed the value 0.1S + 0.03 in., where S is the actual size of the fillet weld in inches. (See Fig. 203.17 C.)

Fillet welds in any single continuous weld shall be permitted to underrun the nominal fillet size required by 1/16 inch without correction provided that the undersize weld does not exceed 10% of the length of the weld. On web-to-flange welds on girders, no underrun is permitted at the ends for a length equal to twice the width of the flange.

Oversize fillet welds are not considered unacceptable unless they produce excessive distortion. Corrections when necessary will be limited to correcting distortion and testing the soundness of the weld and adjacent base metal.

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Fig. 203.17 — Illustrations of acceptable and defective weld profiles.
203.20.3. The removal of weld metal may be done by machining, grinding, chipping or air carbon-arc gouging unless otherwise provided. The removal shall be conducted in such a manner that the remaining weld metal or base metal is not nicked or undercut. Defective portions of the weld shall be removed without substantial removal of the base metal. All air-carbon arc gouging shall be followed by grinding to remove carbon pick-up.

203.20.4. Additional weld metal to compensate for deficiency in size shall be deposited using an electrode preferably smaller than that used for making the original weld, but not less than 5/32 in. in diameter. The surfaces shall be cleaned thoroughly before welding. Minimum preheat and interpass temperatures shall be observed. Minimum welding heat input requirements shall be observed.

203.20.5. Where work performed subsequent to the making of a deficient weld has rendered the weld inaccessible or has caused new conditions which would make the correction of the deficiency dangerous or ineffectual, the original conditions shall be restored by removing welds or members or both before making the corrections, or else the deficiency shall be compensated for by additional work done according to a design revision approved by the D.C.E.S.

203.20.6. Caulking of welds shall not be permitted.

203.20.7. Written repair procedures including sketches or full-size drawings as necessary to fully describe the deficiencies and the proposed repair shall be prepared by the Contractor (Fabricator) and submitted to the Deputy Chief Engineer (Structures) for approval, when any of the following conditions exist:

(a) Defective base metal including lamellar tears
(b) Large number of weld defects, Par. 203.20.2 in any one member
(c) Any cold crack in weld or base metal
(d) Heat-shrink procedures used to increase the camber of welded plate girders (see paragraph 502.3).
(e) Members repair welded or modified to correct fabrication errors in cutting, punching, drilling, fitting, etc.

203.20.8. When written repair procedures are required for the repair of defects, they shall include an accurate description of the location of the defect. Generally, the location shall be shown on the approved shop drawings and shall become part of the permanent job record. Separate repair procedure sheets shall be prepared to show the defect in plan view, elevation and section as necessary to adequately describe the defect. A space shall be provided on this sheet for the inspector's signature to show that he has inspected the defect and has found that the drawings accurately describe the defect. The detailed repair procedure shall include at least the following steps in the sequence that they are to be performed:

1. The area of the steel adjacent to the defect shall be cleaned by grinding to expose the surface boundaries of the defect.
2. Plan views and sections of the excavations of defects shall be shown. All arc-air gouging shall be followed by grinding to remove carbon pick-up and to remove surface irregularities.
3. Magnetic particle testing shall be performed in accordance with Section VIII to insure that the limits of the defects have been completely removed prior to welding the excavation.
4. All preheat and interpass temperatures shall be shown. When required, post heat, peening and stress-relief heat treatment procedures shall also be described.
5. Run-off tabs and back-up bars shall be shown in detail. They shall be removed after welding and all surfaces shall be finished flush by machining or grinding.
6. Nondestructive testing procedures shall be performed at the completion of the repair. The methods and procedures shall be described on the repair sheet.
7. A space should be provided for the Inspector to sign indicating the work has been acceptably completed.
203.20.9 The D.C.E.S. shall be advised prior to cutting apart improperly fitted and welded members.

203.21. Stress-Relief Heat Treatment.

203.21.1. Where required by the Contract Documents, welded assemblies shall be stress relieved by heat treating. Finish machining shall be done subsequent to stress relieving. The welded assembly shall be adequately supported during stress relieving. The temperature shall be maintained uniformly during heating and cooling so that the temperature throughout the assembly will differ by not more than 100°F at any time. After a mean temperature range between 1100°F and 1200°F is reached, the temperature of the assembly shall be held within the above specified limits for one hour per inch of thickness. When the assembly has cooled to 600°F it may be removed from the furnace unless cooling to a lower temperature is required to prevent distortion.

203.21.2. Alternately, when it is impractical to post-weld heat treat to the temperature limitations stated above, welded assemblies may be stress relieved at lower temperatures for longer periods of time as follows:

<table>
<thead>
<tr>
<th>Decrease in Temperature below Minimum Specified Temperature (Degree F)</th>
<th>Minimum Holding Time at Decreased Temperature (Hours per Inch of Thickness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td>200</td>
<td>10</td>
</tr>
</tbody>
</table>
204. ASSEMBLY

204.1. Bolts and Bolted Connections.

204.1.1. General. Where the use of bolts is indicated in the Contract Documents, the bolts furnished shall be unfinished bolts (ordinary rough or machine bolts), turned bolts, or high strength bolts, as specified.

204.1.2. Unfinished and Turned Bolts. Unfinished bolts shall be standard bolts with hexagonal heads and nuts. The use of "button" head bolts will not be permitted. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of lengths which will extend entirely through their nuts but not more than 3⁄8 inch beyond them. The diameter of the bolt holes shall be 1/16 inch greater than the diameter of the bolts used.

Holes for turned bolts shall be carefully reamed or drilled and the bolts turned to a driving fit by being given a finishing cut. The threads shall be entirely outside of the holes and the heads and nuts shall be hexagonal. One-quarter inch thick washers shall be used with all turned bolts. Approved nut-locks shall be used on all turned bolts unless otherwise approved by the D.C.E.S. Washers shall be provided for all bolts passing through slotted holes. Unless otherwise noted, these washers shall completely cover the slotted holes.

204.1.3. Connections using high strength bolts. This specification covers the assembly of structural joints using ASTM Designation A325 High Strength Steel Bolts or other approved fasteners, tightened to a specified tension. The bolts shall be used in holes having a nominal diameter slightly larger than the nominal bolt size. The hole size shall not exceed the nominal bolt size by more than 1/16 inch, except as provided for by the Specifications.

204.1.3.1. Bolts, Nuts and Washers.

204.1.3.1.1. The bolts, nuts and washers used shall conform to the provisions of ASTM Designation A325 unless otherwise provided in the Contract Documents. When the Contract Plans specify unpainted corrosion resistant steel for members which are to be bolted together, ASTM A325 Type III, high-strength bolts shall be used.

204.1.3.1.2. Bolt dimensions shall conform to the current requirements of the American National Standard for Heavy Hexagon Structural Bolts (ANSI B18.2.1). Bolt lengths shall provide for two flat washers on each bolt, or beveled washers as required, with the end of the bolt flush with the outer face of the nut. Bolt lengths shall also be such that the nut in the fully tightened position does not encounter the thread runout.

204.1.3.1.3. Nut dimensions shall conform to current requirements of the American National Standard for Heavy Semifinished Hexagon Nuts (ANSI B18.2.2).

204.1.3.1.4. Circular washers shall be flat and smooth and their nominal dimensions shall conform to the dimensions given in Table 204.1a.

Beveled washers for American Standard beams and channels shall be square or rectangular, shall taper in thickness, and shall conform to the dimensions given in Table 204.1a. Where necessary, washers may be clipped on one side to a point not closer than 7⁄8 of the bolt diameter from the center of the washer.

204.1.3.2. Bolted Parts

204.1.3.2.1. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Holes may be punched, subpunched, or reamed, or drilled as required by the Contract Documents, and shall have a nominal diameter not more than 1/16 inch in excess of the nominal bolt diameter except as provided by the Specifications.

Revised Feb. 2, 1976
TABLE 204.1c

Nut Rotation\(^9\) from Snug Tight Condition

<table>
<thead>
<tr>
<th>Bolt Length (as measured from underside of head to extreme end of point)</th>
<th>Disposition of Outer Faces of Bolted Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Both faces normal to bolt axis</td>
</tr>
<tr>
<td>Up to and including 4 diameters</td>
<td>1/3 turn</td>
</tr>
<tr>
<td>Over 4 diameters but not exceeding 8 diameters</td>
<td>1/2 turn</td>
</tr>
<tr>
<td>Over 8 diameters but not exceeding 12 diameters</td>
<td>2/3 turn</td>
</tr>
</tbody>
</table>

\(^9\)Applicable to coarse thread heavy hex structural bolts of all sizes and lengths up to 12-inch diameter, and heavy hex semi-finished nuts. Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned.

Tolerance on rotation:
- 30° (one-twelth full turn) over or under for bolts installed by 1/2 turn or less.
- 45° (one-eighth full turn) over or under for bolts installed by 2/3 turn or more.

204.1.3.4.2. Inspection of bolt tightness shall be performed by the following procedure.

204.1.3.4.2.1. Inspection shall be performed by the use of an inspection torque wrench provided by the Contractor.

204.1.3.4.2.2. Three bolts of the length and diameter being installed shall be placed and individually tested in a calibration device capable of indicating bolt tension. A washer shall be placed under the part being turned.

204.1.3.4.2.3. Each bolt specified in par. 204.1.3.4.2.2. shall be tightened in the calibration device to the minimum tension specified for its size as listed in Table 204.1b. The inspecting wrench shall then be applied to the tightened bolt and the torque necessary to turn the nut or head 5 degrees (approximately 1 inch at 12-inch radius) in the tightening direction shall be determined. The nut or head shall be in motion when the torque is measured. The average torque measured in the tests of each three bolts shall be taken as the “minimum job inspecting torque” to be used in the manner specified in par. 204.1.3.4.2.5. The “maximum job inspecting torque” shall be determined by multiplying the “minimum job inspecting torque” by 1.5.

204.1.3.4.2.4. All labor and equipment necessary for the inspection of the bolt tightness shall be provided by the Contractor. The State shall witness the bolt testing, but will not provide equipment or labor.
204.1.3.4.2.5. Bolts represented by each inspection lot described in par. 204.1.3.4.2.2 shall be inspected after installation by applying the inspecting wrench to a minimum of 10 percent of the bolts, but not less than two bolts, selected at random in each connection. The actual torque value of each inspected bolt shall be determined as the head or nut is in motion as the inspecting wrench is applied in the tightening direction. This value shall fall within the minimum and maximum values determined by par. 204.1.3.4.2.3. If any bolt is found to have a torque value below the minimum, or above the maximum job inspecting torque, all bolts in the connection shall be checked. All undertightened bolts shall be tightened, and reinspected. All overtightened bolts shall be loosened and the bolt and nut removed for visual inspection of the bolt and nut threads. Where there is visible thread damage or where the nut does not spin freely on the bolt stem when tightened by hand without the aid of a wrench, the bolt shall be rejected and replaced. Other A325 bolts may be retightened. Replaced and retightened bolts shall then be inspected as described above.

204.1.3.4.2.6. When approved by the D.C.E.S., devices that measure bolt tension in each installed fastener will be accepted in lieu of the inspection torque tests described herein.

204.1.3.5. Bolt Testing by Department Laboratory.

204.1.3.5.1. Field Connections.

204.1.3.5.1.1. Tests will be performed by the laboratory to insure that the bolts meet the physical and chemical requirements of the specifications. Only bolts from the following critical connections shall be submitted for testing:

- Stringer and girder splices;
- Stringer and girder direct support connections; i.e., attachment of stringers to cross girders, beams, etc.;
- All main member connections in trusses, arches, towers, bents and rigid frames.

204.1.3.5.1.2. For testing purposes, two bolts from each manufacturer’s control lot to be used in the above described critical joints shall be sampled by the Engineer and submitted to the Department Laboratory for testing. A manufacturer’s control lot is defined as all bolts of the same nominal length and diameter which are produced at the same time under the same production controls. The manufacturer’s lot numbers shall be clearly marked on all containers. Lots received at the job site which contain less than 20 bolts shall not be sampled for testing.

204.1.3.5.2. Shop connections. Bolts for main connections as listed in Par. 204.1.3.5.1 that are to be installed at the fabrication plant shall be submitted to the Department Laboratory by the shop inspector. All provisions of Par. 204.1.3.5.1 shall apply.

204.2. Riveting. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. The heating of the points of rivets more than the remainder will not be permitted. When ready for driving they shall be free from slag, scale and other adhering matter and when driven they shall completely fill the holes. Burned, burred or otherwise defective rivets, or rivets which throw off sparks when taken from the furnace, forge, or electric heater shall not be driven.

Loose, burned, badly formed or otherwise defective rivets shall be cut out. Caulking and re-cupping of rivet heads will not be allowed. In cutting out defective rivets, care shall be taken not to damage the adjacent metal. If necessary, the rivet shanks shall be removed by drilling. Countersinking shall be neatly done and countersunk rivets shall completely fill the holes.

Shop rivets shall be driven by direct-acting riveters where practicable. The riveting machine shall retain the pressure for a short time after the upsetting is complete.
205.12. Deviation from Flatness and Fit of Intermediate Stiffeners. The out-of-flatness of intermediate stiffeners shall not exceed 1/2 inch in the depth of the stiffener. The edge of the stiffener that is welded to the web of the girder shall be straight and when fit to the web, shall have no gaps in excess of 3/32-inch between the web and the stiffener.

205.13. Deviation from Straightness of Bearing Stiffeners. The out-of-straightness of bearing stiffeners shall not exceed 3/4 inch up to 6 feet or 1/2 inch over 6 feet and the actual centerline of the stiffener shall lie within the thickness of the stiffener as measured from theoretical centerline location.

205.14. Heat-Shrink Correction. Any camber or sweep modifications made to shapes or plates assembled and welded or prior to assembly, shall conform to the requirements of Section V, Heat Curving and Cambering Rolled Beams and Welded Plate Girders.

If heat-shrink procedures are used to correct distortion in butt welded joints, nondestructive tests, if required, shall be performed after such heat straightening.

206. MILL AND SHOP INSPECTION.

206.1. General. All steel to be furnished under this item shall be subject to shop inspection unless otherwise specified. Steel not furnished as stock steel under the conditions set forth herein shall be subject to mill inspection.

206.2. Stock Steel. No mill inspection will be required for stock steel. Stock steel will be accepted for miscellaneous parts not subject to stress. Stock steel will be accepted on the basis of the results of chemical and physical tests performed by the manufacturer. Certified copies of the results of chemical analysis and physical tests shall be furnished to the Inspector as required under the heading, "Basis of Acceptance" of Material Specification 715-01.

206.3. Notice of Rolling and Fabrication. The Contractor shall furnish the Inspector with two copies of the mill order and give ample notice to the Inspector of the beginning of the work at the mill and shop so that inspection may be provided. No material shall be rolled or fabricated before the Inspector has been notified where the orders have been placed.

206.4. Facilities for Inspection. The Contractor shall provide all facilities for the inspection of material and workmanship in both the mill and shop. The Inspector shall be allowed free access to all parts of the premises concerned with the work. Work done while the Inspector has been refused access shall be automatically rejected.

206.5. Inspector's Authority. The Inspector shall have the authority to reject materials and workmanship which do not conform to the requirements of the Contract Documents. Inspections shall be made of materials and workmanship before, during and after fabrication. Materials and workmanship which are inspected in process (while being fabricated) and which are found to contain defects or to have been subjected to damaging fabrication procedures shall be rejected while still in process.

The Inspector shall have the right to perform, at the expense of the State, nondestructive tests of the materials and workmanship.

Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors. It is expressly understood that it will not relieve the Contractor from any responsibility in regard to unacceptable material or workmanship and the necessity for replacing the same.

It is the Contractor's responsibility to establish and maintain an effective Quality Control Program. Inspection by State Representatives is not a substitute for Quality Control by the Contractor.

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206.6. Visual Inspection and Nondestructive Tests. Welds shall be subject to nondestructive testing as required by Articles 203.18 and 203.19 of this Manual and as stated in the Contract Documents and testing procedures shall conform to the requirements of Sections VI, VII, VIII and IX of this Manual. Welds, base metal (including castings and forgings), fasteners and other structural components shall be subjected to a thorough visual examination. Structural materials incorporating cracks, seams, inclusions, laminations or other defects discovered during visual examination shall be acceptably repaired or replaced. In general, defects in the base metal shall be repaired if and as required by ASTM Designation A6 and Art. 202.2.

The limits of all defects in welds and base metal shall be determined before a repair procedure is approved. To determine the limits of defects, the Inspector may require such nondestructive tests as radiographic inspection, ultrasonic inspection, magnetic particle, or dye penetrant inspection to be performed upon the defective piece.

206.7. Photographs and Drawings. When defects are discovered under the provisions of Art. 206.6 and material is rejected, the Engineer may require photographs and dimensioned drawings to accompany the repair procedure submitted by the Contractor to aid in the evaluation of the repair procedure. The same provision shall apply to any structural steel rejected for workmanship deficiencies, failure to meet dimensional tolerances, or damage due to rough handling or accident. In addition, the State may require photographs of specific work or assembly conditions during shop fabrication that are a proper part of the permanent job record.

When the D.C.E.S. requests photographs of any portion of the shop fabrication, the Contractor may furnish the photographs at no additional cost to the State or allow the State to take the photographs. The Contractor shall have the right to direct the taking of photographs so that only the work is recorded and so that no procedure or equipment that is the private development (industrial secret) of the fabricator is revealed.

206.8 Inspector’s Mark of Acceptance for Shipment. When the structural steel is ready for shipment from the shop and is properly loaded on the rail cars, trucks, or barges, the Inspector representing the State shall affix the acceptance stamp of his company. This acceptance mark shall be made by paint or ink stamp. The mark shall be placed near the erection mark on the piece and the inspector’s steel die stamp shall be applied over the paint or ink impression.

Each shipment piece, bundle, keg, box or bound pallet shall be acceptance-marked by the Inspector by direct marking on the piece as described above or by acceptance-marking on durable tags when the material is boxed or bundled.

Application of the Inspector’s acceptance stamp implies that at the time of shipment from the shop it was the opinion of the Inspector that the structural steel was fabricated from accepted materials by approved processes, painted and loaded for shipment in accordance with the requirements of the Contract Documents.

Application of the Inspector’s stamp of approval for shipment does not imply that the structural steel will not be rejected by the State if subsequently found to be defective as described in Article 206.5 and 206.9.

206.9. Rejection. The Inspector shall reject all material and workmanship that does not conform to the requirements of the Contract Documents.

Acceptance of structural steel by State representatives at the mill, shop or in the field shall in no way preclude further testing, and inspection if there is reason to believe the material or workmanship does not conform to the requirements of the Contract Documents.

Defective materials and workmanship wherever discovered shall be rejected and then repaired or replaced at no cost to the State. All repair procedures are subject to the approval of the D.C.E.S.

206.10. Marking and Shipping. Erection pieces with computed weights exceeding three tons shall have the lifting weight to the nearest one-half ton marked thereon. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packaged separately. Pins, small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

The weight of all tools and erection material shall be kept separate.
208.4.3. While in operation, the welding gun shall be held in position without movement until the weld metal has solidified.

208.4.4. At the time of welding, the studs shall be free from rust, rust pits, scale, oil or other deleterious matter that would adversely affect the welding operation.

208.4.5. The stud base shall not be painted, galvanized, or cadmium plated prior to welding.

208.4.6. The areas on the member to which the studs are to be welded shall be free of scale, rust, dirt, paint, grease, or other injurious material to the extent necessary to obtain satisfactory welds. These areas may be cleaned by wire brushing, peening, prick-punching, or grinding.

If the Contractor elects to use a rust preventive lacquer coating on the steel surfaces, this coating will be allowed to remain during the welding of studs provided acceptable stud welds are uniformly produced.

208.4.7. Welding shall not be done when the base metal temperature is below zero degrees F., or when the surface is wet or exposed to falling rain or snow.

208.4.8. Longitudinal and lateral spacings of stud shear connectors with respect to each other and to edges of beam or girder flanges may vary a maximum of 1 inch from the location shown on the drawings, provided the adjacent studs are not closer than 2 1/2 inches center to center. The minimum distance from the edge of a stud base to the edge of a flange shall be the diameter of the stud plus 1/8 inch, but preferably not less than 1 1/2 inches. The accuracy of location of other types of studs shall be such as to permit a workmanlike assembly of attachments without alterations or reaming.

208.4.9. After welding, arc shields shall be broken free from shear connectors and anchor studs and, where practicable, from all other studs.

208.4.10. The studs, after welding, shall be free from any defect or substance that would interfere with their intended function.

208.5. Welding Procedure Tests for Unthreaded Studs

208.5.1. The first two studs welded on each member, after being allowed to cool, shall be tested by bending to an angle of 30 degrees from its original axis by striking the stud with a hammer. If failure occurs in the weld zone of either stud, the procedure shall be corrected and two more studs shall be welded to the member and tested. If either of the second two studs fail, additional welding shall be continued on test material of the same thickness as the member and in the same general position until two consecutive studs are tested and found to be satisfactory. Two consecutive studs shall then be welded to the member, tested and found to be satisfactory before any more production studs are welded to the member.

208.5.2. For members having less than 20 studs, the stud welding procedure may be tested at the start of each day's production welding period in lieu of testing in accordance with 208.5.1. Each welding unit before use in production shall be used to weld two studs to separate test material in the same general position (flat, vertical, overhead, sloping) and of similar thickness. After being allowed to cool, they shall be bent as described above. If failure occurs, the procedure shall be corrected and two consecutive studs shall be welded to the test material, tested and found to be satisfactory before any production studs are welded to the member.

208.5.3. The foregoing testing shall be performed after any change in the welding procedure.

208.5.4. If failure occurs in the stud shank, an investigation shall be made to ascertain and correct the cause before more studs are welded.
208.5.5. Studs on which a full 360 degree weld fillet is not obtained shall be replaced or at the option of the studwelding contractor, be repaired by adding a 5/16 inch fillet weld in place of the missing weld fillet. All welding shall be performed using 5/32 inch diameter E7018 electrodes. All welding procedures and preheat requirements shall be as described in this Manual. The minimum length of repair weld shall be 3/8 inch beyond the defective area on each end of the defect being repaired. The repair weld shall be fused at all boundaries, have full throat throughout its length and all craters shall be filled.

208.5.6. If the reduction in the length of studs as they are welded becomes less than normal, i.e., the length of stud is more than 1/16 inch greater than specified, welding shall be stopped immediately and not resumed until the cause has been corrected.

208.5.7. The areas of all components subjected to tensile stresses where a defective stud has been removed shall be made smooth and flush. Where in such areas base metal has been pulled out in the course of stud removal, a shielded metal-arc welding process with low-hydrogen electrodes in accordance with the requirements of this Manual, shall be used to fill the pockets and the weld surface ground flush. In compression areas of members, the repair provisions shall be the same as for tensile areas except that, when the depth of defect is not more than the lesser of 1/8 inch or 7% of the base metal thickness, the defect may be faired by grinding in lieu of filling the defective area with weld metal. Where a replacement stud is to be placed in the defective area, the above repair shall be made prior to welding the replacement stud. Replacement studs shall be tested by bending to an angle of 15 degrees from their original axis. The areas of components exposed to view in completed structures shall be made smooth and flush where a stud has been removed.

208.6. Welding Procedure Test for Threaded Studs  Welding procedures for threaded studs shall be tested with a calibrated torque wrench as described in Figure 208.6. Testing frequency and retests shall be as described in paragraph 208.5.1. All provisions of paragraphs 208.5.2 through 208.5.7 shall apply for threaded studs.

208.7 Inspection Requirements

208.7.1. Unthreaded studs shall be tested by striking at least one stud in every 100 with a two pound hammer to bend the stud to an angle of 15° from its original axis; or, if threaded, the stud shall be torque-tested in accordance with paragraph 208.6. If failure occurs, two more of the studs shall be bent or torque-tested. If either of these two studs fail, all of the studs represented by the tests shall be bend-tested, torque-tested or replaced.

208.7.2. All studs subject to weld repairs in accordance with paragraph 208.5.5 and all studs in which the reduction in length due to welding is less than normal shall be struck with a 2-pound hammer and bent to an angle of 15° from its original axis, or if threaded, the stud shall be torque-tested. Unthreaded studs which have been repaired shall be tested by bending in a direction that places the repair fillet weld in tension. If during inspection or subsequent straightening as described in paragraph 208.7.4, cracks occur in the stud shank, the weld or the base metal, the studs shall be replaced.

208.7.3. The Engineer or the Inspector, where conditions warrant, may select a reasonable number of additional studs to be subjected to the tests specified in 208.7.1 and 208.7.2.

208.7.4. Bent unthreaded studs that show no sign of failure shall be acceptable for use and left in the bent position if no portion of the stud is less than one inch from a proposed concrete surface. All required bending and straightening shall be done without heating before completion of the stud welding operation on the job, except as otherwise provided in the Contract.

208.7.5. If, during the progress of the work, inspection and testing indicate, in the judgment of the Engineer, that the stud welds being produced are not in accordance with this Manual, the contractor will be required at his expense to make changes (such as welding procedure, welding equipment, and stud base) necessary to secure satisfactory results on studs to be subsequently welded.

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401.6. Limitation of Variables.

401.6.1. When submitting reports for approval of procedure qualification, the Contractor shall include specific values for all applicable variables included on the Weld Procedure Qualification Record, Fig. 401.6. and in par. 401.6.2.

401.6.2. The changes set forth in paragraphs 401.6.2.1 and 401.6.2.2 shall be considered essential changes in a welding procedure and shall require establishing a new procedure by qualification. When a combination of welding processes is used, the variables applicable to each process shall apply.

401.6.2.1. Submerged Arc Welding.

(a) A change in electrode and flux combination.
(b) A change in the filler metal strength level.
(c) A change in electrode diameter when using an alloy flux.
(d) A change in the number of electrodes used; i.e., single electrode to multiple electrode or vice versa.
(e) A change in the type of current (AC or DC) or polarity.
(f) A change of more than 10% above or below the specified mean amperage for each size electrode used.
(g) A change of more than 7% above or below the specified mean arc voltage for each size electrode used.
(h) A change of more than 15% above or below the specified mean travel speed.
(i) A change of more than ±10% or 1/8 inch, whichever is greater, in the longitudinal spacing of the arcs.
(j) A change of more than ±10° in the angular rotation of any parallel electrode.
(k) A change in the angle of electrodes in machine or automatic welding of more than:
   (1) ±3° in the direction of travel
   (2) ±5° normal to the direction of travel
(l) For a specified welding groove, a change of more than ±25% in the specified number of passes. If the area of the groove is increased, it is also permissible to increase the number of passes in proportion to the increased area.
(m) An increase in the diameter of the electrode used, over that called for in the approved welding procedure.

401.6.2.2. Flux Cored Arc Welding With External Shielding Gas.

(a) A change in electrode and method of shielding.
(b) A change in the filler metal strength level.
(c) An increase in the diameter of electrode used over that called for in the approved welding procedure.
(d) A change in the number of electrodes used; i.e., single electrode to multiple electrode or vice versa.
(e) A change from a single gas to any other single gas or to a mixture of gases or a change in specified percentage composition of gas mixture.
(f) A change of more than 10% above or below the specified mean amperage for each size electrode used.
(g) A change of more than 7% above or below the specified mean arc voltage for each size electrode used.
(h) A change of more than 10% above or below the specified mean travel speed.
(i) An increase of 25% or more or a decrease of 10% or more in the rate of flow of shielding gas or mixture.
(j) For a specified welding groove, a change of more than ±25% in the specified number of passes. If the area of the groove is increased, it is also permissible to increase the number of passes, in proportion to the increased area.
(k) A change in type of welding current (AC or DC), polarity or mode of metal transfer across arc.
401.7. Test Results

401.7.1. Reduced-Section Tension Test. The tensile strength shall be not less than the minimum of the specified tensile range of the base metal used in the test. All specimens must meet these minimum requirements.

401.7.2. Side, Face and Root Bend Tests. The convex surface of the specimen shall be examined. The presence of a crack or other open defect exceeding 1/8-inch measured in any direction shall be cause for failure. All specimens must meet these minimum requirements.

401.7.3. All Weld Metal Tension Test. The mechanical properties shall be not less than those specified in Table 401.7.

401.7.4. Charpy V-Notch Impact Test. Five specimens shall be machined in accordance with ASTM A370. After testing, the highest and the lowest values shall be disregarded. The three remaining values shall be averaged, and this average shall meet the requirements of Table 401.7.

401.7.5. Chemical Requirements for Filler Metal Used to Join ASTM A242 and A588 Steels Used in Exposed Untreated Applications.

Deposited weld metal shall have a chemical composition that conforms to any of the following classifications as shown in AWS A5.5:


In lieu of meeting any of the above criteria, the deposited weld metal shall meet the following requirements:

C = 0.12 max
S = 0.04 max
Ni = 0.40 to 0.80
Mn = 0.50 to 1.30
Si = 0.35 to 0.80
Cr = 0.45 to 0.70
P = 0.03 max
Cu = 0.03 to 0.75

401.7.6. Retests. If any one test specimen listed in 401.7.1 through 401.7.4 fails to meet the test requirements, two retests of that particular specimen may be performed with specimens machined from the original procedure qualification test plate. Both retest specimens must produce results that meet the test requirements. If sufficient material is not available from the original test plate, a new test plate may be made provided welding parameters are the same as those used to weld the original test plate. Any deviation from the original parameters, other than those allowed under 401.6, “Limitation of Variables,” will be cause to consider the new test plate as a separate qualification test.

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<table>
<thead>
<tr>
<th>Mech. Properties</th>
<th>Process</th>
<th>SAW</th>
<th>FCAW with CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, psi</td>
<td>72,000 to 95,000</td>
<td>72,000 Min.</td>
<td></td>
</tr>
<tr>
<td>Yield Strength, psi–Min.</td>
<td>60,000</td>
<td>60,000</td>
<td></td>
</tr>
<tr>
<td>*Elong. in 2” – Min.</td>
<td>22%</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Avg. Charpy V-Notch Impact Strength – Min</td>
<td>20 ft.lbs @ 0°F</td>
<td>20 ft.lbs @ 0°F</td>
<td></td>
</tr>
</tbody>
</table>

*For each percentage point increase in elongation over the minimum, the tensile strength or yield strength, or both, may decrease 1000 psi to a minimum value of 70,000 psi for tensile strength and 58,000 psi for yield strength.
Fig. 401.4 a – Reduced section tension specimen

Fig. 401.4 b – Face, Root and Side Bend Specimens.
Table 607.

<table>
<thead>
<tr>
<th>Steel Thickness Range</th>
<th>Thickness of Penetrameter</th>
<th>Designation on Penetrameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1/4 in. incl.</td>
<td>0.005 in.</td>
<td>5</td>
</tr>
<tr>
<td>Over 1/4 in. thru 3/8 in.</td>
<td>0.0075 in.</td>
<td>7</td>
</tr>
<tr>
<td>Over 3/8 in. thru 1/2 in.</td>
<td>0.010 in.</td>
<td>10</td>
</tr>
<tr>
<td>Over 1/2 in. thru 5/8 in.</td>
<td>0.0125 in.</td>
<td>12</td>
</tr>
<tr>
<td>Over 5/8 in. thru 3/4 in.</td>
<td>0.015 in.</td>
<td>15</td>
</tr>
<tr>
<td>Over 3/4 in. thru 7/8 in.</td>
<td>0.0175 in.</td>
<td>17</td>
</tr>
<tr>
<td>Over 7/8 in. thru 1 in.</td>
<td>0.020 in.</td>
<td>20</td>
</tr>
<tr>
<td>Over 1 in. thru 1 1/4 in.</td>
<td>0.025 in.</td>
<td>25</td>
</tr>
<tr>
<td>Over 1 1/4 in. thru 1 1/2 in.</td>
<td>0.030 in.</td>
<td>30</td>
</tr>
<tr>
<td>Over 1 1/2 in. thru 2 in.</td>
<td>0.035 in.</td>
<td>35</td>
</tr>
<tr>
<td>Over 2 in. thru 2 1/2 in.</td>
<td>0.040 in.</td>
<td>40</td>
</tr>
<tr>
<td>Over 2 1/2 in. thru 3 in.</td>
<td>0.045 in.</td>
<td>45</td>
</tr>
<tr>
<td>Over 3 in. thru 4 in.</td>
<td>0.050 in.</td>
<td>50</td>
</tr>
<tr>
<td>Over 4 in. thru 6 in.</td>
<td>0.060 in.</td>
<td>60</td>
</tr>
<tr>
<td>Over 6 in. thru 8 in.</td>
<td>0.080 in.</td>
<td>80</td>
</tr>
</tbody>
</table>

608. CONTINUITY OF INSPECTION. Welded joints shall be radiographed and the film indexed in a manner that will provide complete and continuous inspection of the joint within the limits specified. Joint limits must be shown clearly on the radiograph. Short film, short screens, excessive undercut by scatter radiation, or any other process that obscures joint edges will render the radiograph unacceptable. Films should have sufficient length to produce ½ inch of “black” (film exposed to direct radiation from the source) beyond each plate edge.

In general, webs and flanges shall be radiographed before the member is assembled. When, because of some unusual situation, it is necessary to radiograph a member which has already been assembled (a tee conformation), the source shall be placed between the flanges and the film shall be placed against the outside flange surface such that both the flange edge and the web-to-flange welds are clearly delineated on the film. A similar technique shall be used for radiographing webs of members already assembled.

609. FILM SIZE. When the joint thickness is less than 3 inches, radiographs may be 4½ in. x 17 in. in size. When the length of the joint is such that more than one radiograph is required, one of the films may be shortened to 4½ inches x 10 inches if the Contractor elects to do so. When joint thicknesses are 3 inches or greater, the minimum film size shall be 7 inches x 17 inches. Larger radiographs may be required in areas where there have been excessive repairs, to radiograph cope hole closure welds or joints with unusual dimensions.

610. FILM DENSITY AND QUALITY. All radiographs shall be clean and free of film processing defects. Film stains, excessive water marks, pressure marks, or artifacts caused by screen scratches, light leaks in cassettes, etc., or other deficiencies in the radiograph that interfere with interpretation shall cause rejection of the film. In general, the quality of the radiograph will be determined by the quality of the penetrameter images and freedom from film defects. The use of film side penetrameters shall be cause for rejection of the radiographs.

Radiographs shall have an H&D density of 1.5 minimum to 4.0 maximum. Densities within the range of 2.5 to 3.5 are preferred. When transitions in thickness are radiographed where the ratio of the thicker plate to the thinner plate is in the order of 3 to 1 or greater, radiographs should be exposed to produce a density of greater than 3.0 minimum in the thinner plate area. When this is done, densities of less than 1.5 will be accepted in the thicker plate area. Except for this condition, densities outside the maximum and minimum limits listed above will be cause for rejection of the film.

Radiographic density shall not vary by more than 0.50 in any section of equal thickness depicted in the radiograph.

All radiographs shall be reviewed on a variable intensity illuminator (viewer) of the spot-review type. The viewer shall incorporate a means of adjusting the size of the spot under examination. The viewer shall have sufficient capacity to illuminate radiographs with a density of 4.0 without difficulty. Film review shall be done in an area of subdued light.
A suitable variable intensity viewer shall be furnished by the Contractor for the use of the Inspector when reviewing radiographs. The viewer shall be available whenever radiography is being performed and shall remain available for two weeks after radiographic inspection has been completed.

611. FILM IDENTIFICATION. In order that films shall be properly identified for examination, filing and actual physical matching with the steel when required, the following information should appear on each film:

(a) New York State Contract Number.
(b) Initials of Radiographic Inspection Company.
(c) Initials of Fabricator and the Fabricator’s Shop Order Number.
(d) Date.
(e) Erection Mark.
(f) Weld Number and an individual Piece Mark in the event that there is a duplication of erection marks on the Contract.
(g) Location Letters.
(h) Penetrameters.

See Figure 611 for details of film identification.

All the information described in this subsection shall appear on each film. The images appearing on the film shall be obtained by placing lead numbers and letters on the steel on the source side prior to exposure. The minimum height of numbers and letters shall be 5/16 inch. The Contractor will be permitted to preprint the New York State Contract Number, the name of the radiographic company, and the fabricator’s name on the radiographs by a direct light process provided that this information is not placed within 1 inch of the edge of the weld. When this preprinting technique is used, the remaining items of film identification listed above shall be produced on the radiograph by the use of lead numbers as described. The fabricator’s shop order number shall be placed on the radiograph by the use of lead numbers.

NOTE: Grease pencils and similar materials shall not be used to mark on radiographs. No identifying mark or notation shall be placed on a radiograph by any procedure that might interfere with the interpretation of the radiograph.

612. WELD IDENTIFICATION. Radiographs are identified as above described. Individual welds are identified on the film and in the radiographic inspection report based upon weld numbers assigned prior to radiography by numbering the web and flange welds from left to right beginning from the marked end as shown on the shop drawing.

613. PERMANENT STEEL IDENTIFICATION AND FILM IDENTIFICATION. Each weld joint shall be permanently die-stamped with the identifying erection mark, weld number, piece mark when required, and location letters required by this specification as shown in Figure 613.

The die-stamped numbers and letters shall be 3/8 inch to ½ inch high. Dies shall be lightly struck to produce the minimum impression that can be clearly seen in the absence of paint and mill scale. Low stress dies, i.e., dies manufactured to produce impressions that are rounded at the bottom of the impression rather than sharp edged, shall be used.

Lead location letters and weld numbers used to permanently identify the radiographs shall be placed directly over the impressions die-stamped in the steel prior to radiography. Location letters shall be placed as shown in Figure 613. Spacing shall be somewhat random. Templates shall not be used. In general, when radiographs are viewed in register, only those films representing the same joint should have the location letters perfectly superimposed.

Care should be taken to be sure that the die-stamped impressions are not lost during any repair welding or surface preparation that follows radiography. To help insure that the exact center of weld is not lost during the work, at least two center punch marks should be placed 1.00 foot from the center of the weld. These marks may be placed on one or both sides of the weld with one impression 2 inches to 3 inches from each end of the joint.
614. RADIOGRAPHIC REPORTS AND SUBMISSION OF RADIOGRAPHS. A separate radiographic report will be required for each erection piece. The radiographic report shall be prepared by the company providing radiographic inspection services and will be subject to the review and approval of the inspector. Radiographic reports shall conform in general to the example shown in Figure 614.

NOTE: The Radiographic Inspection Report described in Figure 614 has been completed to show the testing and repair of a fairly complex piece.

NOTE: Lead characters placed directly over characters die-stamped on the steel for the purpose of re-matching the film to the weld zone after processing.

Fig. 611 — Film and Weld Identification
PERMANENT STEEL IDENTIFICATION
Fig. 613
TYPE "DC"
Distance Calibration Block

TYPE "SC"
Sensitivity Calibration Block

Sound entry point lines and degree of angle indications to be indented into surfaces where indicated.

Material: ASTM A36 or equivalent
Minimum Surface Finish: ANSI 125

Fig. 700B—Other Calibration Blocks.
### Weld Identification

### Material Thickness

### Weld Joint

### Weld Process

### Remarks

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Defect Number</th>
<th>Transducer Angle</th>
<th>Node</th>
<th>DECIBELS</th>
<th>DEFECT</th>
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<td>Reference Level</td>
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### NOTES:

1. "Use Node I, II or III – See Glossary of Terms

2. In order to attain "Rating d":
   (a) with instruments with Gain Control, use the formula: a-b-c=d
   (b) with instruments with Attenuation Control, use the formula: b-a-c=d
   (c) A + or - sign must accompany the "d" figure unless "d" is equal to zero

3. Distance from X is used in describing the location of a weld discontinuity in a direction perpendicular to the weld reference line. Unless this figure is zero, a + or - sign must accompany it. See Table 700A for the location of the X-X axis for butt, tee and corner welds.

4. Distance from Y is used in describing the location of a weld discontinuity in a direction parallel to the weld reference line. This figure is attained by measuring the distance from the "Y" end of the weld to the beginning of said discontinuity.

5. Make separate report following repairs. (Suffix report No. with R1, R2, etc.)

Inspected by ____________________________  Date ____________________________
Contract No. ____________________________  REPORT NO. ____________________________
Sheet No. ____________________________ of ____________________________

---

Fig. 700F – Ultrasonic Test Report

Revised Feb. 2, 1976
### TABLE 700A

**PROCEDURE CHART**

<table>
<thead>
<tr>
<th>Weld Type</th>
<th>5/16 to 1</th>
<th>&gt; 1/2 to 1</th>
<th>&gt; 1 to 1½</th>
<th>&gt; 1½ to 1¾</th>
<th>&gt; 1¾ to 2½</th>
<th>&gt; 2½ to 3½</th>
<th>&gt; 3½ to 4½</th>
<th>&gt; 4½ to 5½</th>
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<th>&gt; 7 to 8</th>
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<td>0</td>
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<td>or 3**</td>
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<td>F</td>
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<td></td>
<td>5** or 4**</td>
<td>F</td>
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<td>Electroslag &amp; Electroslag</td>
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### PROCEDURE LEGEND

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<th>Area of Weld Thickness</th>
<th>NO.</th>
<th>TOP QUARTER</th>
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<td>70° I and II</td>
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<td>70° + 60° II</td>
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<td>70° A</td>
<td>60° A+70° GB</td>
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</tbody>
</table>

*Revised Feb. 2, 1976*
TABLE 700A (continued)

LEGEND
X —— Check from Face "C"
G —— Grind Weld Face Flush
O —— Not Required
RT —— Radiographic Inspection
I —— Examine weld in Node I
II —— Examine weld in Node II
III —— Examine weld in Node III
F —— Further evaluate fusion boundary indications with either 70°, 60° or 45° transducer whichever sound path is nearest to being perpendicular to the suspected fusion surface.
* —— Required only where reference level indication of defect is noted in fusion zone while searching or scanning level with primary procedure selected from first column.
** —— Use 15 or 20 inch screen distance calibration (the smaller value) as necessary to permit testing of the complete weld and adjacent heat-affected zones using the search unit required by the Procedure Legend.
† —— Applies to AC, GAF, single vee, double vee, single "U", double "U" and square groove welds.
†† —— Applies to single bevel, double bevel, single "J" and double "J" groove welds.

"A" Face The face of the material from which the initial scanning is done (on Tees and Corners follow above sketches.)
"B" Face Opposite the "A" Face (same plate).
"C" Face The face opposite the weld on the connecting member on Tee or Corner joints.

NOTES:

1. All examinations are to be made from Face "A" except as noted in the Procedure Chart (Table 700A) and scanned from both sides of the weld on Face "A" or Face "A" and Face "B" as indicated, where mechanically possible.

2. Unless otherwise indicated by the Procedure Legend, all tests are to be performed in Node I. Node II is specified in some cases to avoid testing in the first inch of the sound path. Node III may only be used when approved by the D.C.E.S.

3. Face "A" on both connecting members at a butt weld must lie in a single plane. Should neither Face "A" nor Face "B" of a Butt Weld lie in a single plane, the testing procedure will be subject to the approval of the D.C.E.S.

EXAMPLE: BUTT WELD IN 4" MATERIAL
NO. 4 PROCEDURE

FACE "A"
TOP QUARTER — 60° B
MIDDLE HALF — 70° A
BOTTOM QUARTER — 60° A

FACE "B"

Revised Feb. 2, 1976
TABLE 700B – HIGHWAY AND RAILWAY BRIDGES

MINIMUM ACCEPTANCE LEVELS (DECIBELS)

<table>
<thead>
<tr>
<th>REFLECTOR SEVERITY</th>
<th>Weld Thickness and Transducer Angle</th>
<th>5/16 to 3/4&quot;</th>
<th>&gt;3/8 to 11/8</th>
<th>&gt;1% to 2%</th>
<th>&gt;2% to 6%</th>
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<td>70°</td>
<td>70°</td>
<td>60°+5°</td>
<td>45°+5°</td>
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<td>+13</td>
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<td>+11</td>
<td>+10</td>
<td>+13</td>
<td>+15</td>
</tr>
</tbody>
</table>

LARGE REFLECTORS:

Any discontinuity, regardless of length having a more serious rating (smaller number) than this level shall be rejected.

SMALL REFLECTORS:

Any discontinuity longer than 3/16" having a more serious rating (smaller number) than this level shall be rejected.

MINOR REFLECTORS:

Only those discontinuities exceeding 2" in length and having a more serious rating (smaller number) than this level shall be rejected.

NOTES:

1. Discontinuities which have a more serious rating than those of “Minor Reflectors,” shall be separated by at least 2L, L being the length of the larger discontinuity. Discontinuities not separated by at least 2L are considered to be one continuous discontinuity whose length is determined by the combined length of the discontinuities plus their separation distance.

2. Discontinuities which have a more serious rating that those of “Minor Reflectors” shall not begin at a distance smaller than 2L from the end of the weld or from any intersecting weld, L being the discontinuity length.

3. Discontinuities in the root-land area of complete joint penetration Double Vee, Double "J", Double "U" and Double Bevel Groove Welds detected at “Scanning Level” shall be evaluated at an acceptance level 4 db. more sensitive than prescribed by this table; i.e., add plus four units to the number in the table.

4. Discontinuities which have a more serious rating than those of “Minor Reflectors” and which exceed 3/16" in length are permitted only in the middle half of the weld thickness.

*Flaws evaluated with 60° or 45° search units and rejected at the acceptance levels listed in the table, but which are acceptable at the minimum acceptance level listed for a 70° transducer shall also be evaluated with a 70°, 70° & 45° or 70° & 60° search units, as necessary to evaluate the flaw with all three angles transducers. If this detailed testing reveals that the sound beam of the 60° or 45° search unit is striking the flaw at 90° ± 15°, the acceptance level listed for a 70° transducer shall be used as the basis for acceptance, regardless of the angle of the search unit used to evaluate the flaw.

Revised Feb. 2, 1976