ADDENDUM NO. 1 TO THE AUGUST 1, 1973
NEW YORK STATE STEEL CONSTRUCTION MANUAL

Corrections on the first sheet should be made by writing over existing information as indicated. The remainder of the corrections should be made by removing existing pages and substituting the attached new sheets. This Addenda becomes effective August 1, 1974.
Foreword

Change lines 2 and 3 to read as follows:
"... Documents for Department of Transportation Construction projects. The Manual is a mandatory
supplement to Section 616-Structural Steel and..."

Table of Contents

Under Section II, Subsection 204, change "Shop Assembly" to read "Assembly".
Under Section II, Subsection 205, change "Member" to read "Members".
Under Section III, Subsection 314, change "Stain" to read "Stains".
Under Section IV, Subsection 402, change the page number from "79" to "77".

Page 6
Under Article 201.1 in the third line of the eighth paragraph, change "impracticable" to read "impractical".

Page 7
Under paragraph 202.2.1 in the first line of the second paragraph, change "steel" to read "plate".

Page 9
Under Paragraph 202.2.2.2, delete the last paragraph beginning with "The cost of all work..." and ending
with "... bid for this item."

Page 22
Under Paragraph 203.8.4.7 in the second line, delete the following: "chipped, or otherwise removed".

Page 25
Under Fig. 203.11.2a, delete the following from the two notes in the detail for Transition by Sloping Weld
Surface and Chamfering; "except as provided".

Page 42
Under Paragraph 203.14.2, delete the last sentence beginning with "The cost of such..." and ending with "... by the Contractor.".

Page 46
Under Paragraph 203.18.3 in the second line, change "or of the cross section" to read "or in the cross
section".

Page 49
Under Paragraph 204.1.3.3.2, delete the last sentence beginning with "When a button head..." and ending
with "... under the head"

Page 50
Under 204.1.3.3.4 in the fifth line, change the word "feet" to "foot".

Page 51
Under 204.1.3.4.2.4 in the second and third lines, delete the following: "and included in the price bid for
Structural Steel."

Page 69
Under Subsection 312 in the first line of the third paragraph, delete the phrase "or permit an offset between
plies."

Renumber the following pages and insert in the proper order:
from 75 through 78 to 73 through 76
from 83 through 86 to 81 through 84
Page 93
Under Article 501.6 in the first line of the third paragraph, delete the word “Preheating” and substitute “Prior to heating”.

Page 110
Under Article 704.6 in the fourth line, change “(1C)” to read “(1C)” see Fig. 700C for applications.

Page 116
In Fig. 700A, the dimensional units for the .060 hole should be inches.

Pages 121 and 122
At bottom of pages 121 and 122, add the following title: “Fig. 700C (continued) — Transducer Positions.

Page 123
Change the title of Fig. 700D from “Angle Transducer Resolution Block” to “Resolution Test Block.”
The units of all length dimensions should be inches.

Page 134
In Table for “No Intermediate Stiffeners,” add “Thick. of web” for title of first column.
In Table for “No Intermediate Stiffeners,” under depth of web, change “173” to read “178.”

Page 136
Under the definition of “Fusion” in the first line, change “or” to read “of”.

Page 137
Under the definition of “Overhead Positions” in the third line, change “401.3, 401.3.1 and 402.7” to read “402.7a, b and c”.

Page 138
Under the definition of “Pass” in the first line, change “of welding” to read “of a welding”.
Under the definition of “Positioned Weld” in the first line, change “make” to read “made”.

Page 139
Under the definition of “Slot Weld” in the fifth line, change “apartially” to read “partially”.
Under the definition of “Stringer Bead” in the first line, change “without” to read “without”.

Page 140
Under the definition of “Weld” in the fourth line, change “along” to read “alone”.


Section IX — Dye Penetrant Inspection

901. General ................................................................. 131
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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 2%. 

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

102.4.6.1 Intermediate stiffeners for plate girders shall consist of plates welded to the web and to the flange which is in compression at that point under deadload. They shall be placed perpendicular to the flange or to a tangent to the flange at each location. They shall be located as described on the Contract Plans.

On fascia girders of continuous spans, the stiffeners shall be attached as described above. On interior girders of continuous spans, the stiffeners shall be attached as described above except that in the stress reversal zones described on the Plans, they shall be placed paint tight against both flanges. If the reversal zone is not defined on the Contract Plans, it shall be assumed to extend 10 feet each side of the deadload point of contraflexure.

Also see Article 204.7, “Assembly of Stiffeners.”

102.4.6.2. When structural steel is to be placed at a grade greater than five percent, bearing stiffeners and connection plates at the points of support shall be placed vertical.
102.4.6.3 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.

102.4.6.4. The ends of all girders and beams shall be vertical after deadload deflection.

102.4.6.5. When the steel is to be erected to a grade of three percent or less, it will not be necessary to machine the top of the sole plate to a compensating bevel. No machining of the top of the 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 for welded plate girders shall be provided by the D.C.E.S.

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.

102.5. 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>N. Y. S. D. O. T.</th>
<th>SEPIA REVIEW</th>
<th>CHECKED</th>
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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.

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Stiffeners and connection plates welded transverse to girder webs and flanges may be furnished with sheared edges provided their thickness does not exceed 3/8 inch. Universal mill plate may be used provided its thickness does not exceed 1.0 inch. All other stiffeners and connection plates shall be furnished with flame cut edges.

202.5. Machining of Contact Surfaces.

202.5.1. Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces which are to come in contact with each other or with concrete shall meet the American National Standard for Surface Roughness as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part I.

Steel slabs or plates in contact with a concrete surface:

ANSI 2000

Heavy plates in contact as part of bearing assemblies which are welded:

ANSI 1000

Ends of compression members, bearing stiffeners and fillers in compression:

ANSI 500

Rollers and Rockers:

ANSI 250

Pins, Pin Holes, Rotating Portion of Top of Rockers and Rocker Sockets in Sole Plates:

ANSI 125

Sliding Bearings:

ANSI 125

Sliding bearings shall be machined so that the lay of the cut is parallel to direction of movement.

Machine surfaces shall be plane and true conforming accurately to the dimensions shown on the plans.

Parts in bearing shall have uniform even contact with the adjacent bearing surface when assembled. The maximum gap between bearing surfaces shall be 0.040 inches unless a closer tolerance is specified.

Base and sole plates which are plane and true and which have a surface roughness not exceeding the above tabulated values need not be machined, however, sliding surfaces of base plates must be machined.

Surfaces of fabricated members shall not be machined until all fabrication on that particular assembly or sub-assembly is complete.

202.5.2. Abutting Joints. Abutting compression members shall be machined as specified above unless the Contract Documents indicate otherwise. Ends of abutting tension members shall be machined or machine burnished to an ANSI surface roughness value of 1,000 to secure close and neat but not contact fitting joints. When the design is based upon transmitting all stress through the fasteners, the Contract Document may detail all joints open 1/4 inch maximum in which case ends of members will be treated as abutting tension members regardless of direction of stress.

202.5.3. End Connection Angles. End connection angles of floor beams and stringers shall be flush with each other and accurately set as to position and length of member. In general, end connection angles shall not be finished unless required by the Contract Documents. However, faulty assembling and connecting may be cause for requiring them to be milled, in which case their thickness shall not be reduced by more than 1/16 inch, nor shall their fastener bearing value be reduced below design requirements.


202.6.1 Holes in Primary Stress Carrying Members. All holes in the following components of main members shall be subpunched and reamed, subdrilled and reamed, or drilled from the solid:

(a) Webs and flanges of girders, box girders, stringers, floor beams, arches, towers, bents and rigid frames.

(b) Lateral connection plates that are welded to tension flanges of the members listed above.

(c) Hangers and connection plates which support the members listed above.

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202.6.2. Holes in Trusses. Unless otherwise stated in the Contract Documents, all trusses regardless of type or size shall be subject to general reaming.

When general reaming is required, all rivet or bolt holes in main members shall be subpunched and reamed, subdrilled and reamed or drilled from the solid. This requirement shall not apply to holes in the top and bottom chord lateral members, truss sway bracing, and to the lateral plates, connection angles, etc., connecting these members to main members of the structure. Connection plates or other parts acting both as main member material and secondary (lateral, sway bracing, etc.) member material shall have subpunched or subdrilled and reamed or drilled holes in locations engaging similar holes in main members.

Reaming or drilling shall be done after mating pieces are assembled to the control lines approved on the Shop Drawings and firmly bolted together. No interchange of reamed or drilled parts will be permitted.

202.6.3. Drilled Holes. Drilled holes shall be 1/16 inch larger than the nominal diameter of the fastener. Burrs on the surfaces shall be removed by a method which leaves the hole free of burrs inside and out. The method shall not dish-out (reduce its thickness) the metal in the vicinity of the hole.

202.6.4 Subpunched and Reamed Holes. Holes for fasteners having diameters greater than 3/4 inch shall be punched 3/16 inch smaller than the nominal diameter of the fastener and for fasteners having diameters 3/4 inch or less shall be punched 1/16 inch less than the nominal diameter of the fastener. The punch and die shall have the same relative sizes as specified for full-size punched holes.

After punching, the holes shall be reamed to a diameter 1/16 inch larger than the nominal diameter of the fastener. Burrs resulting from reaming shall be removed as stated in Par. 202.6.3, Drilled Holes.

Reaming of fastener holes shall be done with twist drills or with tapered reamers. Reamers preferably shall not be guided by hand. No oil or grease shall be used as a lubricant unless all such material is removed by solvent cleaning before final assembly, painting and shipment.

202.6.5. Accuracy and Quality of Reamed and Drilled Holes. Holes drilled from the solid shall be accurately placed, perpendicular to the faying surface, cylindrical, and shall show no offset between and adjacent piles.

Holes which are to be reamed shall have been accurately subpunched or subdrilled and the assembled parts, before reaming, shall conform to the requirements specified for Par. 202.6.8, Accuracy of Punched Holes. After reaming, holes shall be perpendicular to the faying surface and 75 of any group of 100 contiguous holes in the same surface or a like proportion of any group of holes shall show no elongation of the hole greater than 1/32 inch. The remainder of the holes shall not be elongated greater than 1/16 inch.

202.6.6. Punched Holes. When reaming is not required, holes may be punched full size under the following conditions:

(a) When the metal has a specified minimum yield point less than 40,000 psi and a thickness of 3/4 inch or less.

(b) When the metal has a specified minimum yield point of 40,000 psi or more and a thickness of 5/8 inch or less.

202.6.7. Size of Punched Holes. Full-size punched holes shall be 1/16 inch larger than the nominal diameter of the fastener. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. Holes must be clean cut, without torn or ragged edges. If any holes must be enlarged to admit fasteners, they shall be reamed in accordance with the provisions of the Contract Documents.

202.6.8. Accuracy of Subpunched Holes. The punching of holes shall be so accurately done that, after assembling the component parts of a member or an assembly of connecting members and before reaming, a cylindrical pin 1/8 inch smaller than the nominal diameter of the punched hole may be passed through at least 75 of any group of 100 contiguous holes in the same surface or a like portion for any group of holes. If this requirement is not fulfilled, the badly punched pieces shall be rejected. If any such
hole will not pass a pin 3/16 inch smaller than the nominal diameter of the punched hole, this shall be cause for rejection. The requirement for the fitting of subsize pins during assembly is to provide the minimum offset of holes between assembled plies and to insure that when reaming is performed as required by the Specifications, all cold worked material will be removed from surfaces of the hole. Reaming shall remove all cold worked (punch sheared) material from the boundaries of subpunched and reamed holes. The depth of removal shall be 1/16 inch minimum. If the accuracy of subpunch work will not guarantee this hole quality when reamed, the amount of metal to be removed by reaming shall be increased from the minimum amount stated in Par. 202.6.4. Subpunched and Reamed Holes, by a sufficient extra amount to insure compliance with this specification. No interchange of reamed or drilled parts will be permitted.

202.6.9. Drifting of Holes. Any drift pinning done during assembly shall be only the minimum necessary to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.


202.7.1. General. The material furnished for pins and rollers shall conform to the following requirements:

When pins and rollers are designed for a minimum yield stress of 36 ksi, the material furnished shall conform to the requirements of ASTM Designation A235 Class E.

When pins and rollers are designed for a minimum yield stress of 50 ksi, the material furnished shall conform to the requirements of ASTM Designation A235, Class G.

Any pin or roller greater than twelve (12) inches in diameter shall be furnished in conformance with the requirements of ASTM Designation A237, Class A.

Pins and rollers shall be accurately manufactured to the dimensions shown on the plans. The surface finish shall be as required by the Specifications. Pins larger than 9 inches in diameter shall have a hole not less than 2 inches in diameter bored longitudinally through their centers. The hole shall be bored before the pin is subjected to heat treatment. Boring shall be conducted in a manner that will prevent injury to the pin. Pins which contain interior defects shall be rejected. The minimum radius on any reentrant cut machined in a pin or roller shall be 1/4 inch.

202.7.2. Boring Pin Holes. Holes for pins shall be bored true to detail dimensions, smooth and straight, normal to the axis of the member and parallel with any other interconnected pin hole unless otherwise required. A finishing cut shall always be made. The length outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from detailed dimensions more than 1/32 inch. Boring of holes in fabricated members shall be done after the riveting, bolting or welding is completed.

202.7.3. Pin Clearances. The diameter of the pin hole shall not exceed that of the pin by more than .020 inch for pins 5 inches or less in diameter, or .035 inch for larger pins.

202.7.4. Pin Threads. Pin threads shall make close fits in the nuts and shall meet the American National Standards Institute requirements for unified screw threads (ANSI B1.1) except that for diameters greater than 1 1/4 inches, pins shall be made with 6 threads to the inch.

202.7.5. Pilot and Driving Nuts. Two pilot nuts and two driving nuts shall be furnished for each size of pin, unless otherwise specified.

202.8. Bronzed Surfaced Expansion Bearings. Bronzed surfaced bearings shall be fabricated as follows:

The bronze surfacing shall be deposited on the steel base plate by the Oxy-Acetylene or the Manual Shielded Metal-Arc-Welding process.

The bronze electrodes and/or filler metal shall be of a size and type approved by the D.C.E.S. Electrodes conforming to AWS A5.6 Classification E CuAl-A2 and E CuAl-B are acceptable for SMAW welding.

A suitable flux shall be used when the Oxy-Acetylene welding process is utilized. The type of flux shall be approved by the D.C.E.S.
The surface of the steel base plate that is to receive the bronze deposit shall be thoroughly cleaned of all dirt, oil, grease, mill scale and oxides by grinding or sandblasting prior to making the deposit.

A sufficient thickness of bronze shall be deposited to allow machining to a minimum retained thickness of 3/32 inch. Upon completion of machining and polishing, the finished surface of the bronze shall show no evidence of cracks, slag, or porosity exceeding the limits specified herein. Unmachined low spots and porosity not to exceed .05 inch in diameter will be allowed in the finished surface provided that the total area of such defects does not exceed .05 percent of the total area of bronze on any one plate and further provided that the total area of such defects in any square inch of the finished surface shall not exceed .01 square inches. Low spots, porosity, voids or holidays larger or more numerous than stated above may be repaired by grinding to sound metal and depositing additional bronze in the defects followed by remachining to the required dimensions.

Warping of the plate shall be counteracted by bending the steel plate in the opposite direction to which warping will take place prior to making the deposit. Any warp remaining in the piece after welding and cooling shall be removed prior to machining.

The bronze surface shall be machined as a "sliding bearing" under the provisions of Art. 202.5, Machining of Contact Surfaces.

At the Contractor's option, bronze surfaced expansion bearings may be fabricated by welding ½ inch thick bronze plate or ½ inch thick bronze sheet to metal backing. The bronze shall conform to ASTM B100, Alloy No. 510, Rolled Copper-Alloy Plate, unless otherwise specified. Attachment shall be by fillet welds or a combination of fillet welds and plug welds or by brazing as approved by the D.C.E.S. If the bronze surface is plane and true within .010 inch after welding, there need be no machining of the bronze surface. Machining shall not reduce the bronze thickness to less than 3/32 inch at any location.

203. WELDING.

203.1. General.

203.1.1. The provisions of this sub-section are intended to describe the welding of structural steels that have a specified minimum yield point not exceeding 50,000 psi. Higher strength steel or steels not listed in the Material Specification for Structural Steel, will be subject to additional requirements as listed in the Contract Documents or may be specified by the D.C.E.S. during approval of the welding procedure specification if the steel was proposed by the Contractor.

203.1.2. ALL WELDERS AND WELDING OPERATORS SHALL BE QUALIFIED BY TESTS PRESCRIBED IN SECTION IV.

203.1.3. Welders shall be provided firm footing at all times. When it is necessary to weld from platforms above the ground, such platforms shall be rigidly braced to prevent movement of the platform during the welding operation.

203.2. Base Metals.

203.2.1. Steel to be welded shall conform to the requirements of the latest edition of one of the following material specifications:

203.2.1.1. Specifications for Structural Steel (ASTM A36)

203.2.1.2. Specifications for High-Strength Low-Alloy Structural Manganese Vanadium Steel (ASTM A441)

203.2.1.3. Specifications for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes (ASTM A500)

203.2.1.4. Specifications for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing (ASTM A501)
203.2.1.5. 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 manufacturer's 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 laminate tearing when the weld residual stresses stress the base metal in the short transverse "x" 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) Classifications E8016-C3 or E8018-C3 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 approval 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 5/8 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 3/8 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 3/16 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.

**TABLE 203.5**

<table>
<thead>
<tr>
<th>Thickness of Thickest Part at Point of Welding — Inches</th>
<th>ASTM A36</th>
<th>ASTM A588</th>
</tr>
</thead>
<tbody>
<tr>
<td>To ¾, Incl.</td>
<td>50°F</td>
<td>100°F (note 5)</td>
</tr>
<tr>
<td>Over ¾ to 1¾ Incl.</td>
<td>70°F</td>
<td>200°F</td>
</tr>
<tr>
<td>Over 1½ to 2¾, Incl.</td>
<td>150°F</td>
<td>300°F</td>
</tr>
<tr>
<td>Over 2½</td>
<td>225°F</td>
<td>350°F</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 heat input from both arcs may be counted).

6. Lateral gusset plates shall be welded to girders flanges using a minimum preheat temperature of 250°F. unless higher temperatures are required by the Table.
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. Electrodes not used within four 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 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.

203.6.3.2. The classification and size of electrode, arc length, voltage and amperage shall be suited to the electrode, 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. In welding in a vertical position, the progressions for all passes shall be upwards. 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 metal before welding is started from the second side. Heat input and preheat must be maintained within the specified requirements when welding A588 steel.
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

203.7.1.1. Single electrode means one electrode connected exclusively to one power source which may consist of one or more power units.

203.7.1.2. Parallel electrode means two electrodes connected electrically in parallel exclusively to the same power source. Both electrodes are usually fed by means of a single electrode feeder. Welding current, when specified, is the total for the two electrodes.

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 3/8 inch diameter.

203.7.2.5. Surfaces on which submerged arc welds are to be deposited and adjacent laying 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 sample 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 deposit in each weld pass shall exceed the width at the surface of the weld pass (see Figure 203.7a 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.
203.9.3. Condition of Flux. Flux used for electroslag welding shall be non-hygrosopic 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 1½ 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. welding 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 ensure 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:

<table>
<thead>
<tr>
<th>Thickness Range</th>
<th>Heat Input Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch to 3/4 inch</td>
<td>35 kilojoules per in.</td>
</tr>
<tr>
<td>Material over 3/4 inch</td>
<td>50 kilojoules per in.</td>
</tr>
</tbody>
</table>

Heat input values shall be calculated by the Contractor for all proposed welding procedures and submitted to the D.C.E.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.E.S. to control shrinkage stresses. All peening shall be performed in accordance with Par. 203.13.8.

203.11.2. Transition of Thicknesses or Widths.

203.11.2.1. When butt joints are used to join material of different thicknesses or widths, there shall be smooth transitions between offset surfaces or edges at a slope of not more than that shown in Fig. 203.11.2. The transition of thickness may be accomplished by sloping weld faces, by chamfering the thicker part, or by a combination of the two methods.

203.11.2.2. Joints made between plates of different widths may be considered the same as those made in plates of equal widths and the unit stress of the parent metal may be used, if the transition is made as shown in Fig. 203.11.2.c. and the following requirements:
(a) The parts joined are of equal thickness.
(b) Weld soundness is established by radiographic testing (tension areas only).
(c) The weld is finished smooth and flush with the base metal as described in Par. 203.17 (tension areas only).

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 buildings 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.
TABLE 203.11.4
JOINT QUALIFICATION TESTS FOR GROOVE WELDS.

<table>
<thead>
<tr>
<th>Maximum Thickness to be Welded in Construction</th>
<th>Test Plate Thickness</th>
<th>Reduced Section Tension See Fig. 401.4a</th>
<th>Root Bend See Fig. 401.4b</th>
<th>Face Bend See Fig. 401.4b</th>
<th>Side Bend See Fig. 401.4b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 3/8 inch</td>
<td>3/8 in.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Over 3/8 in.</td>
<td>1 in.</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

203.11.4.2. Joint details may depart from the details prescribed in Par. 203.11.5 through 203.11.9 only if approved by the D.C.E.S. The Contractor shall submit to the D.C.E.S. his proposed alternate joint details and joint welding procedures, and at his own expense demonstrate their adequacy by the tests described in Table 203.11.4. Welding shall conform to the applicable provisions of Arts. 203.6, 203.7 and 203.8.

203.11.5. Details of Fillet Welds.

203.11.5.1. The details of fillet welds made by manual shielded metal-arc welding; submerged arc welding; or flux cored arc welding permitted by Par. 203.11.4.1 to be used without joint welding procedure qualification are listed in the following Pars. 203.11.5.2 through 203.11.5.5 and detailed in Fig. 203.11.5.

203.11.5.2. The minimum fillet weld size, except that of fillet welds used to reinforce groove welds, shall be as shown in the following table:

TABLE 203.11.5

<table>
<thead>
<tr>
<th>Material Thickness of Thicker Part Joined, in</th>
<th>Minimum Size* of Fillet Weld, in</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 3/4 incl.</td>
<td>1/4**</td>
</tr>
<tr>
<td>Over 3/4 to 1 1/2</td>
<td>5/16</td>
</tr>
<tr>
<td>Over 1 1/2 to 2 1/4</td>
<td>3/8</td>
</tr>
<tr>
<td>Over 2 1/4 to 6</td>
<td>1/2</td>
</tr>
<tr>
<td>Over 6</td>
<td>5/8</td>
</tr>
</tbody>
</table>

*Except that the weld size need not exceed the thickness of the thinner part joined.
**Not permitted for joints carrying primary stress.
Use 5/16 inch.
203.11.5.3. The maximum size of fillet weld that may be used along edges of material shall be:

a. Along edges of material less than 1/4 in. thick, the maximum size may be equal to the thickness of the material.

b. Along edges of material 1/4 in. or more in thickness, the maximum size shall be 1/16 in. less than the thickness of material, unless the weld is especially designated on the drawings to be built out to obtain full throat thickness as illustrated in Fig. 203.11.5, A or B.

203.11.5.4. The minimum length of a fillet weld shall be four times its size and in no case less than 1 1/2 inches.

203.11.5.5. Fillet welds which support a tensile force that is not parallel to the axis of the weld, or which are proportioned to withstand repeated stress shall not terminate at corners of parts or members but shall be returned continuously, full size around the corner for a length equal to twice the weld size where such return can be made in the same plane. End returns shall be indicated on design and detail drawings.

203.11.5.6. Seal welding shall preferably be accomplished by a continuous weld combining the functions of sealing and strength. Seal welds should be detailed as fillet or groove welds on the shop drawings.

203.11.5.7. Fillet welds may be used in skew joints that have an included angle of not less than 60 degrees. Permitted forms of such joints are detailed in Fig. 203.11.5, C and D. These joints may be fabricated with an included angles of less than 60 degrees provided the welding procedure and details are approved by the D.C.E.S.

203.11.6. Plug and Slot Welds.

203.11.6.1. Plug and slot welds will be permitted only when detailed on the plans or as part of an approved repair procedure.
203.11.6.2. Plug and slot welds may be made only in the flat position unless otherwise approved as part of a repair procedure and will be subject to nondestructive tests when stated in the Contract Documents or when ordered by the D.C.E.S. in the approval of a repair procedure.

203.11.7. Complete Joint-Penetration Groove Welds Made by Manual Shielded Metal-Arc Welding.

203.11.7.1. A complete joint penetration groove weld is defined as one which has been made 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.

203.11.7.2. Complete joint penetration groove welds made by manual shielded metal-arc processes in butt, tee and corner joints which may be used without performing the joint welding procedure qualification tests prescribed by Par. 203.11.4.1 are detailed in Fig. 203.11.7 and are subject to the limitations specified in the following Par. 203.11.7.3.

203.11.7.3. Dimensions of groove welds specified on design or shop drawings may deviate from the dimensions shown in Fig. 203.11.7 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 joints is zero unless dimensioned otherwise. It may be detailed to exceed zero or the specified dimension by not more than 1/16 inch. It may not be detailed less than the specified dimension.
(c) The root opening of the joints 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 J- and U-grooves is minimum. It may be detailed to exceed the dimension shown by not more than 1/8 inch. U-grooves may be prepared prior to or after fitting.
(f) Double-groove welds may have grooves of unequal depth but the depth of the shallower groove shall not be less than one-fourth of the thickness of the thinner part joined.
### Welds

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Square-Groove Weld (1)</th>
<th>Single-Vee-Groove Weld (2)</th>
<th>Single-Bevel-Groove Weld (4)</th>
<th>Arc Gouge (AG)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Butt Joint (B)</strong></td>
<td>![Diagram of Butt Joint (B)]</td>
<td>![Diagram of Single-Vee-Groove Weld (2)]</td>
<td>![Diagram of Single-Bevel-Groove Weld (4)]</td>
<td>![Diagram of Arc Gouge (AG)]</td>
</tr>
<tr>
<td><strong>Tee Joint (T) OR Corner Joint (C)</strong></td>
<td>![Diagram of Tee Joint (T) OR Corner Joint (C)]</td>
<td>![Diagram of Single-Vee-Groove Weld (2)]</td>
<td>![Diagram of Single-Bevel-Groove Weld (4)]</td>
<td>![Diagram of Arc Gouge (AG)]</td>
</tr>
</tbody>
</table>

### Notes:

1. For all joints, except B-L1a and C-L1a, gouge root before welding second side as follows: Air Carbon-arc gouge to sound weld metal before welding the second side. The minimum radius of the gouge shall be ½ inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.7.3 for allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

3. Groove welds in tee and corner joints shall be reinforced with fillet welds equal to T/4 but not more than 3/8 in. T is the thickness of the groove weld, unless otherwise specified.

**Fig. 203.11.7** — COMPLETE JOINT PENETRATION prequalified manual shielded metal-arc welded joints — base metal of LIMITED thickness (L).

*Revised Aug. 1, 1974*
### WELDS

#### VEE-GROOVE WELD

<table>
<thead>
<tr>
<th>JOINTS</th>
<th>SINGLE-VEE-GROOVE (2)</th>
<th>DOUBLE-VEE-GROOVE (3)</th>
<th>SINGLE-BEVEL-GROOVE (4)</th>
<th>DOUBLE-BEVEL-GROOVE (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUTT JOINT (B)</td>
<td>B-U2</td>
<td>B-U4 **</td>
<td>*B-U5a **</td>
<td>*B-U5b **</td>
</tr>
<tr>
<td>TEE JOINT (T) OR CORNER JOINT (C)</td>
<td>C-U2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### LIMITATIONS FOR JOINTS B-U2, B-U3a and C-U2

<table>
<thead>
<tr>
<th>α</th>
<th>Permitted Welding Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>45°</td>
<td>1/4” All Positions</td>
</tr>
<tr>
<td>30°</td>
<td>3/8” Flat and Overhead Only</td>
</tr>
<tr>
<td>20°</td>
<td>1/2” Flat and Overhead Only</td>
</tr>
</tbody>
</table>

#### LIMITATIONS FOR JOINTS TC-U4a, TC-U4b, TC-U5a and TC-U5c

<table>
<thead>
<tr>
<th>α</th>
<th>Permitted Welding Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>45°</td>
<td>1/4” All Positions</td>
</tr>
<tr>
<td>30°</td>
<td>3/8” Flat and Overhead Only</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 1/8 inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.7.3 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

3. Groove welds in tee and corner joints shall be reinforced with fillet welds equal to T/4 but not more than 3/8 in. T is the thickness of the groove weld, unless otherwise specified.

*The use of these welds shall preferably be limited to base metal thickness of 5/8 in. or larger.

**The use of these joints is limited to the horizontal position.

AWS joint detail modified.

Fig. 203.11.7 (CONTINUED) COMPLETE JOINT PREPARATION prequalified manual shielded metal arc welded joints – base metal of UNLIMITED thickness (U).
**NOTEs:**

1. Gage roots of joints without backing as follows:
   
   Air carbon-arc gage to sound weld metal before welding the second side. The minimum radius of the gage shall be ¾ inch. The sides of the gage area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.7.3 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

3. Groove welds in tee and corner joints shall be reinforced with fillet welds equal to T/4 but not more than 3/8 in. T is the thickness of the groove weld, unless otherwise specified.

4. The use of these welds shall preferably be limited to base metal thickness of 5/8 in. or larger.

5. **The use of these joints is limited to the horizontal position.**

6. **Gauge After-Fitting Welds shall be prepared by butting two plates together, full thickness, with zero root opening. The joint shall then be prepared for welding by air carbon-arc gouging to one half the depth of the thinner plate. After welding the groove thus prepared, the joint shall be back gouged from the second side into sound weld metal and then welded. All grooves prepared by this method shall have a minimum radius of ⅜ inch and the sides of the groove shall slope back with a total included angle of 20 degrees.**

AWS joint detail modified.

---

Fig. 203.11.7 (CONTINUED) COMPLETE JOINT PENETRATION prequalified manual shielded metal arc welded joints – base metal of unlimited thickness (#).
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 joints is maximum.
(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.
###方形-沟槽焊缝

** BUTT JOINT (B) **

Welds must be centered on joint.

** B-L1-S **

### Vee-Groove Weld

** SINGLE-VEE-GROOVE (2) **

Weld after welding at least one pass on the other side.

** B-L2a-S **

** B-L2b-S **

** B-L2c-S **

<table>
<thead>
<tr>
<th>T</th>
<th>T₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 1/2&quot; to 1&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>Over 1&quot; to 1 1/2&quot;</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>Over 1 1/2&quot; to 2&quot;</td>
<td>1/8&quot;</td>
</tr>
</tbody>
</table>

** DOUBLE-VEE-GROOVE (3) **

Weld after welding at least one pass on the other side.

** B-L3-S **

<table>
<thead>
<tr>
<th>T</th>
<th>T₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 2&quot; to 2 1/2&quot;</td>
<td>1 1/2&quot;</td>
</tr>
<tr>
<td>2 1/2&quot; to 3&quot;</td>
<td>1 1/2&quot;</td>
</tr>
<tr>
<td>3&quot; to 3 1/2&quot;</td>
<td>2 1/2&quot;</td>
</tr>
<tr>
<td>3 1/2&quot; to 4&quot;</td>
<td>2 1/2&quot;</td>
</tr>
<tr>
<td>4&quot; to 4 1/2&quot;</td>
<td>2 1/2&quot;</td>
</tr>
<tr>
<td>4 1/2&quot; to 5&quot;</td>
<td>3 1/2&quot;</td>
</tr>
<tr>
<td>5&quot; to 6&quot;</td>
<td>3 1/2&quot;</td>
</tr>
</tbody>
</table>

** TEE JOINT (T) OR COR. JOINT (C) **

Weld after welding at least one pass on the other side.

** TC-L1-S **

### LIMITATIONS FOR JOINTS

<table>
<thead>
<tr>
<th>α</th>
<th>R</th>
<th>Max. Thickness (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-L2a-S</td>
<td>30°</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>B-L2b-S</td>
<td>30°</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>B-L2c-S</td>
<td>20°</td>
<td>5/8&quot;</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 1/8 inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.
2. See Par. 203.11.8 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.
3. Groove welds in tee and corner joints shall be reinforced with fillet welds equal to T/4 but not more than 3/8 in. T is the thickness of the groove weld, unless otherwise specified.

**Fig. 203.11.8 – COMPLETE JOINT PENETRATION** prequalified submerged arc welded joints – base metal of LIMITED (L) and UNLIMITED (U) thickness.

**Revised Aug. 1, 1974**
### Bevel-Groove Weld

<table>
<thead>
<tr>
<th>Butt Joint (B)</th>
<th>Single Bevel-Groove (A)</th>
<th>Double Bevel-Groove (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tee Joint (T)</strong> or <strong>Cora Joint (C)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TC-U4a-S</strong></td>
<td><strong>TC-L4a-S</strong></td>
<td><strong>TC-L4b-S</strong></td>
</tr>
<tr>
<td><strong>TC-U4b-S</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual shielded metal-arc or submerged arc fillet weld backing.</td>
<td></td>
<td></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 \( \frac{3}{8} \) inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.
   - See Par. 203.11.8.4 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

2. Groove welds in toe and corner joints shall be reinforced with fillet welds equal to \( T/4 \) but not more than \( 3/8 \) in. \( T \) is the thickness of the groove weld, unless otherwise specified.

**Fig. 203.11.8 (CONTINUED) — COMPLETE JOINT PENETRATION prequalified submerged arc welded joints — base metal of LIMITED (L) and UNLIMITED (U) thickness.**

*Revised Aug. 1, 1974*
### NOTES:

1. Gauge 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 1/4 inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.8.4 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

*Gouge After-Fitting Welds shall be prepared by buttting two plates together, full thickness, with zero root opening. The joint shall then be prepared for welding by air carbon-arc gouging to one half the depth of the thinner plate. After welding the groove thus prepared, the joint shall be back gouged from the second side into sound weld metal and then welded. All grooves prepared by this method shall have a minimum radius of 1/4 inch and the sides of the groove shall slope back with a total included angle of 20 degrees minimum.

---

**Fig. 203.11.8 (CONTINUED) — COMPLETE JOINT PENETRATION prequalified submerged arc welded joints — base metal of LIMITED(L) and UNLIMITED(U) thickness.**
203.11.9. Complete Joint Penetration Groove Welds Made by Flux Cored Arc Welding.

203.11.9.1. A complete penetration groove weld is defined as one which has been made 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.

203.11.9.2. Complete joint penetration groove welds made by the flux cored arc processes in butt, corner and tee joints which may be used without joint welding procedure qualification tests prescribed by Par. 203.11.4.1 are detailed in Fig. 203.11.9 and are subject to the limitations specified in the following Par. 203.11.9.3.

203.11.9.3. Dimensions of groove welds specified on design or detail drawings may deviate from the dimensions shown in Fig. 203.11.9 only within the following limits:

(a) The specified material or weld throat thickness is the maximum nominal thickness that may be used.
(b) The root face of the joints may be detailed to exceed the specified dimension by not more than 1/16 inch. It may not be detailed less than the specified dimension.
(c) The root opening of the joints 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 dimension shown by not more than 10 degrees.
(e) The radius of U- and J-grooves is minimum. It may be detailed to exceed the dimension shown by not more than 1/8 inch. Preparation may be prior to or after fitting.
(f) Double groove welds may have grooves of unequal depth, but the depth of the shallower groove shall not be less than one-fourth the thickness of the thinner part jointed.
NOTES:

1. For all joints without backing, gouge roots as follows: Air carbon-arc gouge to sound weld metal before welding the second side. The minimum radius of the gouge shall be \( \frac{3}{8} \) inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.9.3 for allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

3. Groove welds in tee and corner joints shall be reinforced with fillet welds equal to T/4 but not more than 3/8 in. T is the thickness of the groove weld, unless otherwise specified.

\* AWS joint detail modified.

Fig. 203.11.9 – COMPLETE JOINT PENETRATION prequalified FCAW welded joints – base metal of LIMITED (L) thickness.
<table>
<thead>
<tr>
<th>Welds</th>
<th>VEE-GROOVE WELD</th>
<th>BEVEL-GROOVE WELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butt Joint (B)</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td><em>B-U2-F</em></td>
<td><em>B-U3-F</em></td>
<td><em>B-U4-F</em>*</td>
</tr>
</tbody>
</table>

| TEE Joint (T) or Cor. Joint (C) | ![Diagram](image3) | ![Diagram](image4) |
| C-U2-F | TC-U4a-F | TC-U4b-F |

**LIMITATIONS FOR JOINTS**

<table>
<thead>
<tr>
<th>Shielding</th>
<th>Position</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>30°</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Shielded</td>
<td>All</td>
<td>45° 1/4&quot;</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 1/4 inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.9.3 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

3. Groove welds in tee and corner joints shall be reinforced with fillet welds equal to T/4 but not more than 3/8 in. T is the thickness of the groove weld, unless otherwise specified.

*The use of these welds shall be limited to base metal thickness of 3/4 inch or larger.

**These joints are limited to the horizontal position.

AWS joint detail modified.

Fig. 203.11.9 — COMPLETE JOINT PENETRATION prequalified FCAW welded joints — base metal of UNLIMITED (U) thickness.

Revised Aug. 1, 1974
<table>
<thead>
<tr>
<th>JOINTS</th>
<th>U-GROOVE WELD</th>
<th>J-GROOVE WELD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUTT JOINT (B)</strong></td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>B-U6-F</strong></td>
<td><strong>B-U7-F</strong></td>
<td><strong>B-U8-F</strong> **</td>
</tr>
<tr>
<td><strong>C-U6-F</strong></td>
<td><strong>TC-U80-F</strong></td>
<td><strong>TC-U9D-F</strong></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 3/8 inch. The sides of the gouge area shall slope back with a total included angle of 20 degrees minimum.

2. See Par. 203.11.9.3 for all allowable variation of dimensions and Art. 203.12 for workmanship tolerances.

*The use of these welds shall be limited to base metal thickness of 3/8 inch or larger.

**These joints are limited to the horizontal position.

AWS joint detail modified.

Fig. 203.11.9 (CONTINUED) – COMPLETE JOINT PENETRATION prequalified FCAW welded joints – base metal of UNLIMITED (U) thickness.

*Revised Aug. 1, 1974*
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 submitted to the D.C.E.S. 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 modify the as-built geometry of welded assemblies
(e) Members repair welded or modified to correct fabrication errors in cutting, punching, drilling, fitting, etc.

203.20.8. 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 ½ 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 a minimum stick-through of the bolt (beyond the nut) of 1/16 inch. 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 Semi-Finished 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 and 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.
A minimum of 40% of the first one-fourth of the connections fabricated shall be shop assembled as determined by the D.C.E.S. to verify the quality of the holes, the accuracy of alignment and fit of mating pieces. Numerically controlled drilling shall not create a need for fills to produce accurate fit. If satisfactory work is verified by accurately checking the first quarter of the work drilled, shop assembly for verification may be reduced to a minimum of 10% selected at random to represent all connections that were required to be reamed assembled, or drilled from the solid.

All other connections which are drilled with numerical control equipment and are not shop assembled shall be checked for entering and fit of pieces by careful shop measurements made by the Contractor. The Contractor shall be responsible for the dimensions and fit of all pieces, whether shop assembled or not.

204.4.9. Mechanically connected joints and splices in main stress carrying members shall have their abutting parts carefully aligned. Whenever joints are designed with an opening of less than 3/8 inch between pieces to be joined, parts over 1/2 inch in thickness shall have their surfaces parallel and shall have an offset no greater than 1/16 inch from theoretical alignment prior to bolting up. For parts less than 1/2 inch in thickness the above offset may be increased to 1/8 inch maximum. After all bolts are tightened to the specified tension, the parts shall be in contact so that the joint will develop the design friction capability and will prevent exposure of bolt stem to the atmosphere. See Art. 205.7 for web distortion.

204.5. Shop Assembly of Field Welded Connections. The Contractor shall be responsible for the proper preparation of groove joints to be welded in the field. The joints shall be prepared and assembled in the shop to insure that proper joint alignment and fit-up is present at each joint when the correct camber is in the assembled pieces. The Contractor may, at his option, eliminate all shop assembly and joint preparation for field welding provided there is sufficient extra material at each joint to provide for machine oxygen cutting or air carbon-arc gouging of the joint preparation after assembly on the ground prior to erection at the site or assembly in the erected position under the proper conditions of support to provide for camber. All provisions of this specification concerning joint preparation, welding and inspection, shall apply. The members shall be free from twists, bends or other deformations.

204.6. Match-Marking. Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked and a diagram showing such marks, shall be furnished to the Engineer.

204.7. Assembly of Stiffeners.

204.7.1. Intermediate stiffeners and connection plates shall be snipped at the corners and welded to the web and compression flange as specified in Par. 102.4.6.1 unless otherwise detailed on the Contract Plans. When automatic welding procedures are required by the Contract Documents, the fillet welds connecting the stiffener or connection plate to the web shall be started at the end of the stiffener that is adjacent to the tension flange and progress toward the compression flange. At least 90 percent of the stiffener fillet welds shall extend to within 1/8 inch of all snipped corners. The remaining percentage must start or stop within 1/8 inch of the snipe. All fillet welds must have full throat and no unfilled craters at the beginning and end of the weld. Localized undercut of the stiffener at the point where the welding machine is stopped shall not require repair.

204.7.2. Intermediate stiffeners and connection plates may be cut 1/8 inch short and then assembled with the stiffener paint tight against the tension flange and the opposite end welded to the compression flange. The weld size at the compression flange shall be increased to include the gap as required by Par. 203.12.1. Stiffeners shall not be driven in place with sufficient force to distort the flange, web or stiffener.

204.7.3. Tack welds used during stiffener assembly shall begin at least 3 inches from the snipped ends of the stiffener and shall have a minimum length of 1 1/2 inch. This provision is made to prevent the starting and stopping of weld passes on tack welds. All tack welds shall be completely rewelded and incorporated into the final weld.

204.8. Bearing Assemblies. Sole plates or bearing assemblies may be tack-welded to the structural steel in the shop to facilitate shipment. The bearing assemblies shall be welded to the structural steel in the field after proper adjustments have been made to compensate for temperature and deadload deflections. Expansion bearings shall be aligned as required by subsection 307 of these specifications. The center line of sole plates or other fixed portions of bearing assemblies attached to the structural steel, shall not be offset from the center line of the bearing stiffeners or diaphragms by more than 1/8 the thickness of the flange at that location or the thickness of the bearing stiffener or diaphragm, whichever is the lesser amount.
205. DIMENSIONAL TOLERANCES FOR FABRICATED MEMBERS.

The provisions of this sub-section shall apply to all members independent of cross section whether straight or curved. Members heat-curved under the provisions of Section V, Heat-Curving and Cambering of Rolled Beams and Welded Plate Girders shall meet the dimensional tolerances of this sub-section.

205.1. Deviation from Detail Dimensions. Dimensions of shapes and plates shall conform to the tolerances described in ASTM Designation A6 before welding. After welding all members shall conform to the dimensional tolerances of these specifications.

Welded butt joints shall be placed not further than 3⁄8 inch from the point detailed. Intermediate stiffeners may vary ±3⁄16-inch maximum from the point detailed.

Flange and web distortion not within the limits of these specifications may be corrected by heat-shrink procedures when approved by the D.C.E.S.

205.2. Deviation from Detailed Length. Members with ends milled for bearing and members with faced end connection angles, may deviate from the detailed length by ±1/32-inch maximum. All other members may vary from detailed length by ±¼-inch maximum unless otherwise approved by the D.C.E.S.

205.3. Deviation from Straightness of Welded Columns.

Lengths of 45 ft. and under:

\[ \frac{\text{No. of ft. of total length}}{10} \times \frac{1}{8}, \text{but not over } \frac{3}{8} \text{ inch} \]

Lengths over 45 ft.:

\[ \frac{\text{3/8 in.} + \frac{1}{16} \text{ in.}}{10} \times \frac{\text{No. of ft. of total length}}{45} \]

205.4. Deviation from Specified Camber or Straightness – Bridges.

205.4.1. Deviation from Specified Camber or Straightness of Fabricated Members Prior to Shipment from the Shop.

205.4.1.1. Stringers, Girders, Floorbeams—single erection pieces prior to assembly.

-0;

+ 1/4", or

+ 1/4" X \[ \frac{\text{No. of ft. of test length measured as chord}}{10} \], but not to exceed 3/4", or

+ 1/8" X \[ \frac{\text{No. of ft. from nearest end}}{10} \]

which ever is greater.

205.4.1.2. Truss Chord and Web members and Tower leg single erection pieces prior to assembly.

± 1/8" X \[ \frac{\text{No. of ft. of total length}}{10} \], but not to exceed 3/8"
205.12. Deviation from Straightness of Intermediate Stiffeners. The out-of-straightness of intermediate stiffeners shall not exceed ½ inch with due regard to any members which frame into them.

205.13. Deviation from Straightness of Bearing Stiffeners. The out-of-straightness of bearing stiffeners shall not exceed ¾ inch up to 6 feet or ½ 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, "Sampling, Testing and Inspection" 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 shop and mill. 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.

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 casings 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.

Revised Aug. 1, 1974
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 or shall be an initial or initials applied with paint stick. 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.
Anchor bolts, washers, and other anchorage or grillage materials, shall be shipped to suit the requirements of the masonry construction.

The loading, transportation, unloading and piling of structural material shall be conducted so that the metal will be kept clean and free from injury by rough handling.

Structural members shall be suitably supported and braced so that they will not be subjected to stresses in excess of those provided for in the design.

All members, both straight and curved, shall be shipped and stored with their webs vertical unless otherwise approved by the D.C.E.S. When there is doubt about the intensity of stress induced by procedures used to handle, transport or store fabricated members, the D.C.E.S. may require that the Contractor submit his support procedure for approval prior to loading and shipment. Transportation stress calculations shall include an increase of at least 100 percent for dynamic loading.

206.11. Report of Shipment of Structural Material (Form B and GC 4b). The acceptance document for all material subject to shop inspection is the Report of Shipment of Structural Material (Form B and GC 4b). When the steel is shipped from the shop to the project or to non-shop storage, the Inspector shall complete and sign Form B and GC 4b to cover all materials subject to his inspection. This document shall indicate to the Engineer that the structural steel, if not damaged by shipment, storage, erection, or subsequently found to be defective in workmanship or materials, may be paid for under the rules for payment or partial payment established by the Department.

Form B and GC 4b does not tabulate shipment weights for payment. (See Section 616.5, Structural Steel, Basis of Payment.)

206.12. Shipment of Rejected Material or Material Not Offered for Shop Inspection. When the Contract Documents indicate that materials and fabrication will be subject to shop inspection, no materials will be accepted at the project that do not bear the Inspector's mark of acceptance.

If it is determined that materials are not acceptance-marked because they were not offered for shop inspection, or shipped after rejection at the shop, the materials shall be returned to the shop for inspection and correction as necessary.

In lieu of this requirement, the State may, at its discretion, allow inspection (see Articles 206.3 through 206.9) to be performed at the project site. This work will be performed by the shop inspector or other representatives of his company and all costs for this inspection in the field shall be borne by the Contractor as a condition of the State's approval of inspection of rejected material in the field.

207. PROTECTIVE COATING AND STORAGE.

207.1. Painting. All structural steel shall receive protective coatings as specified in the Contract Documents. All metal shall, unless otherwise indicated on the Contract Drawings (Plans) or in the specifications, be painted three coats of paint in accordance with Section 635 of the Standard Specifications.

207.2. Weld Cleaning. Slag shall be cleaned from all welds. Welded joints shall not be painted until after the work has been completed and accepted. The surfaces to be painted shall be cleaned of spatter, rust, loose scale, oil, dirt, fume deposits and any other substance that might interfere with proper painting.

All welds shall be brush stripped with one coat of approved shop paint prior to general shop painting.

Welds that are to be galvanized shall be blast cleaned or otherwise treated to remove slag and any other material that will interfere with proper galvanizing.

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207.3. Anchor Bolts. All anchor bolts, including pipe sleeves where required, shall be galvanized in accordance with the requirements of Material Specification 719-01, "Galvanized Coatings and Repair Methods," unless otherwise specified.

207.4. Protective Coating for Machined Surfaces. Machine-finished sliding surfaces in contact (pins, pin holes, sliding surfaces including those in sockets, as at the top of rocker bearings, etc.) shall receive one coat of any common fibrous automotive grease, as soon as machining is complete. Bronze plates in sliding contact shall also be coated with grease. The Contractor shall maintain all protective coatings to prevent corrosion. All protective coatings applied in the shop shall be removed immediately prior to assembly of the members in the field. When the protective coating is removed, the members shall be thoroughly cleaned and then coated with automotive grease before assembly. All other machine-finished surfaces shall be given one coat of the specified shop paint.

207.5. Storage of Materials. Structural material shall be stored above the surface of the ground upon platforms, skids, or other supports, and shall be protected as far as practicable from surface deterioration by exposure to conditions producing rust and shall be kept free from accumulations of dirt, oil, or other foreign matter.

Any defects created by storage at the shop shall be corrected by the Fabricator prior to acceptance for shipment by the Inspector. All fabricated material stored by the Contractor will be subject to inspection by the Engineer and any corrective action required as the result of storage shall be performed by the Contractor.

208. STUD WELDING

208.1. Scope. This section contains provisions for the installation and inspection of steel studs welded to steel, to connect members and connection devices to concrete (as concrete anchors and shear connectors in composite steel-concrete construction), and to fasten other members and appurtenances.

208.2. General Requirements.

208.2.1. Studs shall be of a design suitable for arc welding to steel members with automatically timed stud welding equipment. The type, size or diameter, and length of stud shall be as specified by the drawings, specifications, or special provisions as approved by the Engineer. (See Fig. 208.2.1 for dimensions and tolerances of standard type shear connectors.)

208.2.2. An arc shield (ferrule) of heat-resistant ceramic or other suitable material shall be furnished with each stud.

208.2.3. A suitable deoxidizing and arc-stabilizing flux for welding shall be furnished with each stud of 5/16 inch diameter or larger. Studs less than 5/16 inch in diameter may be furnished with or without flux.

208.2.4. Finish shall be produced by cold heading, cold rolling, or machining. Finished studs shall be of uniform quality and condition, free of injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. A stud with cracks or bursts deeper than one-half of the distance from the periphery of the head to the shank may be cause for rejection.

208.2.5. Additional camber shall be provided in the fabrication of the structural members to compensate for a reduction of camber due to welding of the studs.

208.3. Material Requirements. Studs shall be furnished in accordance with the materials subsection 709.05 of the Standard Specifications.

208.4. Workmanship.

208.4.1. Studs shall be welded to steel members with automatically timed stud welding equipment connected to a suitable power source.

208.4.2. If two or more stud welding guns are to be operated from the same power source, they shall be interlocked so that only one gun can operate at a time, and so that the power source has fully recovered from making one weld before another weld is started.

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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 2½ 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 1½ 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. Quality Control.

208.5.1. The first two stud shear connectors 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 separate plates 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 stud shear connectors, 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 stud shear connectors 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.

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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 fretted by grinding in lieu of filing 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 shear connector 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. Inspection Requirements.

208.6.1. All studs subject to weld repairs in accordance with Par. 208.5.5 and all studs in which the reduction in length due to welding is less than normal shall be struck with a two-pound hammer and bent to an angle of 15 degrees from its original axis. For studs which have been repaired the direction of bending shall be opposite to the repair weld fillet. Studs that crack either in the weld, the base metal, or the shank under inspection or subsequent straightening (see Par. 208.6.4) shall be replaced.

208.6.2. At least one stud in every 100 shall be struck with a two-pound hammer and bent to an angle of 15 degrees from its original axis; or, if threaded, the stud shall be torque-tested with a calibrated torque wrench to the value shown in the Table in Fig. 208.6.2 for the diameter and thread of the stud, in a device similar to that shown in Fig. 208.6.2. If the stud fails, two more of the existing studs shall be bent or torque tested. If either of these two studs fails, all of the studs represented by the tests shall be torque-tested, bent-tested, or rejected.

208.6.3. The Engineer or the Inspector, where conditions warrant, may select a reasonable number of additional studs to be subjected to the tests specified in 208.6.1 and 208.6.2.

208.6.4. The bent stud shear connectors and concrete anchors 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 1 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.

208.6.5. 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.
DIMENSIONS ARE APPROPRIATE TO THE SIZE OF THE STUD. THREADS OF THE STUD SHALL BE CLEAN AND FREE OF LUBRICANT OTHER THAN FOR THE RESIDUE OF CUTTING OIL.

<table>
<thead>
<tr>
<th>Nominal Diameter of Studs, Inches</th>
<th>Threads Per Inch and Series Designated</th>
<th>Testing Torque Foot - Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>28 UNF</td>
<td>6.0</td>
</tr>
<tr>
<td>1/4</td>
<td>20 UNC</td>
<td>4.2</td>
</tr>
<tr>
<td>5/16</td>
<td>24 UNF</td>
<td>9.5</td>
</tr>
<tr>
<td>5/16</td>
<td>18 UNC</td>
<td>8.6</td>
</tr>
<tr>
<td>3/8</td>
<td>24 UNF</td>
<td>17.</td>
</tr>
<tr>
<td>3/8</td>
<td>16 UNC</td>
<td>15.</td>
</tr>
<tr>
<td>7/16</td>
<td>20 UNF</td>
<td>27.</td>
</tr>
<tr>
<td>7/16</td>
<td>14 UNC</td>
<td>24.</td>
</tr>
<tr>
<td>1/2</td>
<td>20 UNF</td>
<td>42.</td>
</tr>
<tr>
<td>1/2</td>
<td>13 UNC</td>
<td>37.</td>
</tr>
<tr>
<td>5/16</td>
<td>18 UNF</td>
<td>60.</td>
</tr>
<tr>
<td>5/16</td>
<td>12 UNC</td>
<td>54.</td>
</tr>
<tr>
<td>5/8</td>
<td>18 UNF</td>
<td>84.</td>
</tr>
<tr>
<td>5/8</td>
<td>11 UNC</td>
<td>74.</td>
</tr>
<tr>
<td>3/4</td>
<td>16 UNF</td>
<td>147.</td>
</tr>
<tr>
<td>3/4</td>
<td>10 UNC</td>
<td>132.</td>
</tr>
<tr>
<td>7/8</td>
<td>14 UNF</td>
<td>234.</td>
</tr>
<tr>
<td>7/8</td>
<td>9 UNC</td>
<td>212.</td>
</tr>
<tr>
<td>1</td>
<td>12 UNF</td>
<td>348.</td>
</tr>
<tr>
<td>1</td>
<td>8 UNC</td>
<td>318.</td>
</tr>
</tbody>
</table>

Fig. 208.6.2 - Torque testing arrangement and table of testing torques.

Fig. 208.2.1 - Dimensions and tolerances, standard type shear connectors.
SECTION III
ERECION

301. FIELD INSPECTION. All work of erection shall be subject to the inspection of the Engineer who shall be
given all facilities required for a thorough inspection of the work. Materials and workmanship subject to shop
inspection will be identified by the acceptance stamp of the Shop Inspector (see Art. 206.9). Materials and
workmanship not required to be shop inspected will be inspected by the Engineer. Certified copies of the results of
tests conducted by the manufacturer shall be furnished to the Engineer in accordance with the requirements of
Material Specification 715-01, Structural Steel.

302. METHODS AND EQUIPMENT. All portions of the proposed structural steel erection procedure, including
changes in loading or modifications to existing structures, shall be described on shop drawings and submitted to the
D.C.E.S. for approval. These shop drawings shall meet all provisions for shop drawings stated in Article 102.

Before starting the erection of any structural steel the Contractor shall inform the Regional Director of
Transportation of any portion of the erection procedure which affects the maintenance of traffic or modifies the
existing pavement.

No erection work shall begin prior to the approval of the erection procedure by the D.C.E.S. and approval of the
traffic maintenance procedure by the Regional Director of Transportation. These approvals shall not be considered
as relieving the Contractor of the responsibility for the safety of his method or equipment used, or for the
responsibility of carrying out the work in accordance with the requirements of the Contract Documents.

303. HANDLING AND STORING MATERIALS. All materials shall be handled and stored in a manner approved by
the Engineer and consistent with the requirements of this manual. No structural material shall, at any time, be
dropped, thrown or dragged upon the ground. Structural material shall be kept clean, properly drained and stored on
proper supports above ground. Girders and beams shall be placed with their webs vertical and shall be adequately
shored, braced and/or clamped to resist any lateral forces which might occur during storage, handling or erection.
Long members such as columns and chords shall be supported at a sufficient number of intermediate locations to
insure that there is no damage from deflection. Permanent distortion caused by handling or storage will be cause for
rejection of damaged materials.

When the Contract Documents and approved shop drawings call for structural material to be painted or given any
other protective coating, the Shop Inspector’s mark of acceptance on the member is intended to indicate that the
paint or other protective coating was acceptable when the material was loaded for shipment. If, because of
prolonged storage, delays in final field painting schedules, or for any other reason, the shop-applied protective
coating deteriorates to the point where it is unacceptable, the Contractor shall restore the original protective coating
to an acceptable condition at no additional cost to the State before continuing with field painting or other field
coatings. The requirements of the Standard Specifications, Section 740, Painting Procedure, shall apply.

If surfaces which are to be connected by field bolting or that are subject to field welding become rusted or
contaminated with any foreign material that would make these connecting procedures unacceptable, the Contractor
shall restore these surfaces at no additional cost to the State by scraping, grinding or wire brushing as necessary to
remove all foreign material and rust that will interfere with welding and bolting.

304. FALSEWORK. All trusses shall be erected on falsework unless otherwise permitted, in writing, by the D.C.E.S.
The falsework shall be properly designed, constructed, and maintained for the loads which will be imposed upon it.
The Contractor shall prepare and submit to the D.C.E.S. for approval, plans for the falsework that he will use during
the erection of the steel. Approval of the Contractor’s falsework plans shall not be considered as relieving the
Contractor of any responsibility.
305. SETTING ANCHOR BOLTS FOR BRIDGE BEARINGS. Anchor bolts for bridge bearings shall be installed in the manner and at the exact locations detailed on the Contract Drawings. Installation shall conform to the requirements of the Standard Specifications, Section 636, Bridge Bearings.

306. PREPARATION OF BEARING AREA. All structural steel to be supported upon a masonry substructure shall have a full and uniform bearing upon the substructure masonry. Structural steel bearing plates or bases shall not be placed upon masonry bearing areas which are improperly finished, deformed or irregular.

All recesses around masonry bearing areas shall be properly drained as approved by the Engineer.

All devices which support structural steel shall be permanently located to correct alignment and elevation and shall be properly finished.

Unless otherwise provided, all structural steel which will bear upon masonry shall be placed on layers of canvas and dull orange primer, a 1/8-inch thick lead sheet, or a bearing pad in accordance with Subsection 728, "Vertical Load Transmitting Devices," as specified.

All vertical load transmitting devices shall be the same size as the bearing or masonry plate it is to support. The holes to accommodate the anchor bolts shall be cleanly and accurately prepared before the material is placed.

307. EXPANSION BEARINGS. The axes of bearings shall be substantially vertical under deadload at an ambient air temperature of 45°F. To achieve this alignment, each bearing shall be accurately set when the steel superstructure is erected. The procedure used for setting the bearings shall take into account any significant difference in temperature and load between the conditions prevailing at the time of setting and the design conditions specified in the Contract Documents. The axes of the bearings shall be checked by the Engineer-in-Charge when the structure is ready for acceptance. If the axes of the bearings are found to be tilted in excess of the following limits, the Contractor shall adjust the bearings by procedures that are approved by the D.C.E.S. prior to the final acceptance of the structure.

For rocker and segmental roller bearings with a height of 12 inches or less, the maximum variation from perfect alignment, taking into account the effect of temperature and load at the time of measurement shall be calculated by the following formula:

\[ M = \pm \left( \frac{1/2'' + \frac{L}{14,000}}{L} \right) \]

\( M \) = Maximum variation from perfect alignment (measured as the horizontal distance between the centerline of the cap plate and the centerline of the masonry plate). Such variations shall not exceed one inch offset or a 5-degree rotation of the movable portion of the bearings from the required alignment, whichever is less.

\( L \) = Total expansion length (the distance in inches between the centerline of the movable bearing being considered and the centerline of the fixed bearing from which motion must progress).

The bearing height is the distance between the upper and lower contact surfaces of the movable portion of the bearing.
The maximum variation of all other bearings of this type, having a height exceeding 12 inches, shall be considered and approved on an individual basis by the D.C.E.S.

For sliding bearings, the maximum variation from perfect alignment between the centerline of the fixed and moveable portions of the bearing device, taking into account the effect of temperature and load at the time of measurement, shall be plus or minus 1 inch provided the moveable portion of the bearing device is fully supported by the fixed portion under all temperature and loading conditions.

If the Contractor is required to adjust the expansion bearings, he may generally do so under the full dead load of the structure following approval of the procedure he proposes to use by the D.C.E.S. He will be required to correct only those bearing devices which are misaligned in excess of the tolerances described herein.

308. STRAIGHTENING BENT STEEL AND CORRECTING CAMBER DEFICIENCIES. All bent structural steel and members containing camber deficiencies shall be straightened or corrected by the proper application of heat in accordance with Section V.

Materials other than steel may be heated only with the permission of the D.C.E.S. Upon completion of straightening or camber corrections, the metal surface shall be carefully inspected for the presence of cracks or other signs of distress. All members requiring straightening or camber corrections shall be considered rejected material until the correction has been completed and accepted. The method of repair proposed by the Contractor shall be submitted on a standard shop drawing for approval of the D.C.E.S. prior to beginning the work. Approval, when granted, shall not relieve the Contractor of his responsibility for the successful completion of the work.

309. ALIGNMENT. Before field bolting or field welding, the structure shall be adjusted to correct grade and alignment and the elevations of panel points (ends of floor beams) properly regulated. Assembly tolerances shall be as described in Subsection 205. Falsework erected to support trusses during assembly shall support the trusses with the accuracy specified in Par. 205.4.2.

310. ASSEMBLING AND BOLTING. Unless erection by the cantilever method is approved, truss spans shall be erected on falswork placed to give the trusses proper camber and alignment. The falswork shall be left in place until all connections are bolted and accepted by the Engineer unless otherwise provided in the Erection Procedure submitted by the Contractor and approved by the D.C.E.S.

Splices and field connections shall have a minimum of one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins or all bolts will be permitted) before the external support systems are removed and connections riveted or bolted unless otherwise specified. Splices and connections carrying traffic during erection will be subject to the approval of the D.C.E.S.
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.
Fig. 401.4 a — Reduced section tension specimen

Radius all corners 1/8" max.

W=1-3/8"

If flame cut, not less than 1/8" shall be removed from edges by machining.

10" Min.

Weld reinforcement machined flush with base metal.

Side bend specimen

Fig. 401.4 b — Face, Root and Side Bend Specimens.
402. WELDER QUALIFICATION

402.1. Tests Required

402.1.1. The qualification tests described herein are specially devised tests to determine the welder's ability to produce sound welds. It is not intended that the qualification tests shall be used as a guide for welding during actual construction. The latter shall be performed in accordance with the requirements of the approved welding procedure.

Section 402 includes the testing procedures for “Shop Welders” and “Field Welders.” Unless otherwise noted, each paragraph describes the testing requirements for both shop or field welding tests. Where the procedures differ, the paragraphs are so noted.

402.1.2. The qualification tests for manual and semi-automatic welders shall be as follows:

402.1.2.1. Limited thickness (SMAW & FCAW) — The test plate shall be as shown in Fig. 402a or b (T = 3/8 in.). This test will qualify the welder for groove welds in material not over 3/4 in. in thickness and for fillet welds in unlimited thickness in the positions indicated in Table 402 qualified by the weld test position.

402.1.2.2. Unlimited Thickness (SMAW & FCAW) — The test plate shall be as shown in Fig. 402a or b (T = 1 in.). This test will qualify the welder for groove and fillet welds in material of unlimited thickness in the positions indicated in Table 402 qualified by the weld test position.

402.1.2.3. Fillet Welds. The test plate shall be as shown in Fig. 402c. This test will qualify the welder for fillet welds in material of unlimited thickness in the positions indicated in Table 402 qualified by the weld test position.

402.1.2.4. Semi-Automatic (SAW). The test plate shall be as shown in Fig. 402d. This test will qualify the welder for groove and fillet welds in material of unlimited thickness in the flat position.

402.2. Base Metal. The base metal used shall comply with Art. 203.2 or the Approved Welding Procedure.

402.3. Welding Procedure

402.3.1. All manual shielded metal-arc welding qualifications shall be performed using 5/32 inch diameter electrodes conforming to the requirements of the latest edition of “Specifications for Mild Steel Covered Arc Welding Electrodes” (AWS A5.1), classification E7018 only.

402.3.2. Qualification of processes other than manual shielded metal arc shall follow the procedure specified by the Approved Welding Procedure.

402.4. Preparation of Test Specimens

402.4.1. All welding of the test plate shall be witnessed by a representative of the State.

402.4.2. At the completion of welding, the State representative shall die stamp the test plate number and identify the witnessing agency; i.e., D.O.T. — Region No.; or Testing Agency under contract to the State.

402.4.3. The weld reinforcement shall be ground flush with the surface of the test plate. Machining may be used to remove excess weld metal but the final surface must be produced by grinding. Either fiber disk or carborundum wheels will produce acceptable grinding results. No surface depressions (lines, gouges, nicks, etc.) may remain.

402.4.4. Test plates reduced in thickness by more than 1/16 inch during the grinding process will be rejected as unfit for testing.
402.4.5. No grinding, air arc gouging, pneumatic chipping or machining of any type will be permitted between passes for any purposes. Interpass slag chipping and cleaning of the test plate must only be accomplished by means of a hand held nonmechanical chipping hammer and/or wire brush.

402.5. Method of Testing Specimens

Method 1: (Field Welder Tests) The test specimens shall be submitted to the Department of Transportation, Bureau of Materials for radiographic testing in accordance with Section VI.

Method 2: (Shop Welder Tests) The Contractor may radiograph the test specimen providing all testing is witnessed by a representative of a Testing Agency under contract to the State, and providing all testing is in accordance with Section VI or the test plates may be submitted to the Bureau of Materials as described in Method 1.

402.6. Test Results. The entire weld shall be radiographed, however, 1 inch at each edge of the 5-inch plate shall be disregarded by the interpreter of the radiograph to allow for starting and stopping of the weld. For acceptable qualification, the weld as revealed by the radiograph shall conform to the requirements of Art. 203.18 Quality of Welds.

402.7. Limitation of Variables. For the qualification of a welder the following rules shall apply:

402.7.1. Qualification established by these procedures shall be considered as qualification to weld or tack weld any steel specified by Art. 203.2.

402.7.2. A welder shall be qualified for each process used.

402.7.3. A welder qualified with an approved electrode and shielding medium combination shall be considered qualified to weld or tack weld with any other approved electrode and shielding medium combination for the process used in the qualification test.

402.7.4. Position of Test Welds. All welds that will be encountered in actual construction shall be classified as being (1) Flat, (2) Horizontal, (3) Vertical, or (4) Overhead, in accordance with the definition of welding positions given in Fig. 402.7. Each procedure shall be tested in the manner stated below for each position for which it is to be qualified.

402.7.4.1. Groove Welds. A change in the position in which welding is done as defined below for groove welds shall require requalification. Test plates shall be welded in the following positions (illustrated in Fig. 402.7b):

(a) Flat Position (1G). The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the upper side.
(b) Horizontal Position (2G). The test plates shall be placed in an approximately vertical plane with the welding groove approximately horizontal.
(c) Vertical Position (3G). The test plates shall be placed in an approximately vertical plane with the welding groove approximately vertical.
(d) Overhead Position (4G). The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the under side.

402.7.4.2. Fillet Welds. A change in the position in which welding is done as defined below for fillet welds shall require requalification. Test plates shall be welded in the following positions (illustrated in Fig. 402.7c):

(a) Flat Position (1F). The test plates shall be so placed that each fillet weld is deposited with its axis approximately horizontal and its throat approximately vertical.

Revised Aug. 1, 1974
(b) Horizontal Position (2F). The test plates shall be so placed that each fillet weld is deposited on the upper side of the horizontal surface and against the vertical surface.

(c) Vertical Position (3F). Each fillet weld shall be made vertically.

(d) Overhead Position (4F). The test plates shall be so placed that each fillet weld is deposited on the under side of the horizontal surface and against the vertical surface.

402.7.5. The qualification test shall be performed within the limitation of variables as listed in Art. 401.6.

402.8. Retests. In case a welder fails to meet the requirements of one or more test welds a retest may be allowed under the following conditions:

(a) A retest may be made within 30 days which shall consist of two test welds of each type on which he failed, all test specimens of which shall meet all the requirements specified for such welds.

(b) A retest may be made provided there is evidence that the welder has had additional training or practice. In this case only one test plate shall be made.

402.9. Period of Effectiveness.

402.9.1. Shop Welders. The welder qualification tests herein specified for "Shop Welders" shall be considered as remaining in effect for three (3) years, unless:

(1) the welder is not engaged in a given process of welding for which he is qualified for a period exceeding six months, or unless

(2) there is some specific reason to question a welder's ability.

In case (1) above, the requalification test need be made only in the 3/8-inch thickness.

Requalification shall be required after three (3) years from the date of test.

402.9.2. Field Welders. A welder who successfully completes the "Field Welder Test" requirements shall be issued a certification card by the Department. The certification shall have a maximum expiration date of three (3) years from the testing date. The Work History Record on the certification must be maintained for the certification to remain valid for the full three years. This record must be signed at least once every six (6) months by an Engineer-in-Charge or by a licensed Professional Engineer and sufficient signatures must be recorded to represent a minimum of six (6) working days using the process qualified for each six (6) month period.

At the end of the three years, the certification may be renewed without retesting provided the welder promptly submits his certification card with a current Work History Record to the Regional Director.

A certification may be revoked at any time if there is some specific reason to question the welder’s ability.

402.10. Records.

402.10.1. Shop Welders. Records of the test results for shop welders shall be kept by the Testing Agency, or Contractor, and shall be available to those authorized to examine them.

402.10.2. Field Welders. Records of the test results for field welders shall be kept by the D.C.E.S.
NOTES:

1. All plate surfaces within the area of the backing strip must be free of mill scale and surface depressions. This includes the top and bottom of the test plates and the backing strip.

2. After welding, the weld reinforcement shall be ground flush with the surface of the plate. Do not remove the backing strip.

3. See Table 402 for type and position limitations.

4. T = 3/8 inch qualifies for limited thickness welding. T = 1 inch qualifies for unlimited thickness welding.

Fig. 402a – Welder qualification test plate for manual shielded metal-arc and semi-automatic flux cored arc welding.
NOTE: The horizontal reference plane is taken to lie always below the weld under consideration. Inclination of axis is measured from the horizontal reference plane toward the vertical. Angle of rotation of face is measured from a line perpendicular to the axis of the weld and lying in a vertical plane containing this axis. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. The angle of rotation of the face of weld is measured in a clockwise direction from this reference position (0°) when looking at point P.

Fig. 402.7 a — Positions of Groove and Fillet Welds.
NOTE: Test plates must remain in these positions until welding is complete.

Fig. 402.7 b – Positions of test plates for groove welds.
Fig. 402.7c — Positions of test plates for fillet welds

403. WELDING OPERATOR QUALIFICATION

403.1. Tests Required.

403.1.1. The qualification tests described herein are specially devised tests to determine the ability of an operator of a machine or automatic welding equipment to produce sound welds. It is not intended that the qualification tests be used as a guide for welding during actual construction. The latter shall be performed in accordance with the requirements of the Approved Welding Procedure.

403.1.2. The test plate shall be as shown in Fig. 403. This test will qualify the welding operator for groove and fillet welding in materials of unlimited thickness in the flat and horizontal position as defined in Fig. 402.7a.

403.1.3. The welding operator performing a successful procedure qualification as described in Par. 403.1.1 shall be considered as meeting the requirements for qualification for that process and test position in material of unlimited thickness.

403.2. Base Metal. The base metal used shall comply with Art. 203.2 or the Approved Welding Procedure.

403.3. Welding Procedure. The operator shall follow the welding procedure specified by the Approved Welding Procedure.

403.4. Test Specimens — Preparation. The inspection and preparation of test specimens shall be in accordance with Art. 402.4.
403.5. Method of Testing Specimens. The method of testing specimens shall be in accordance with Art. 402.5.

403.6. Test Results. The entire weld shall be radiographed. However, 1 ½ inches at each edge of the plate shall be disregarded by the interpreter of the radiograph to allow for starting and stopping of the weld. For acceptable qualification, the weld, as revealed in the radiograph, shall conform to the requirements of Art. 203.18, Quality of Welds.

403.7. Limitation of Variables. For the qualification of a welding operator the following rules shall apply:

403.7.1. Qualification established with any one of the steels permitted by these Specifications shall be considered as qualification to weld any of the other steels.

403.7.2. A welding operator qualified with an approved electrode and shielding medium combination shall be considered qualified to weld with any other approved electrode and shielding medium combination for the process used in the qualification test.

403.7.3. A welding operator qualified to weld with multiple electrodes shall be qualified to weld with a single electrode, but not vice versa.

403.7.4. A change in the position in which welding is done as defined in Par. 402.7.4 shall require requalification.

403.7.5. The qualification test shall be performed within the limitation of variables as listed in Art. 401.6.

403.8. Retests. In case an operator fails to meet the requirements of one or more test welds a retest may be allowed under the following conditions:

(a) A retest may be made within 30 days which shall consist of two test welds of each type on which he failed, all of which shall meet all the requirements specified for such welds.

(b) A retest may be made provided there is evidence that the operator has had additional training or practice. In this case only one test plate shall be made.

403.9. Period of Effectiveness. The operator qualification tests herein specified shall be considered as remaining in effect for 3 years unless:

(1) The operator is not engaged in the given process of welding for which he is qualified for a period exceeding six months; or unless,

(2) There is some specific reason to question the operator’s ability.

403.10. Records. Records of the test results shall be kept by the testing agency or Contractor and shall be available to those authorized to examine them.

404. TACKER QUALIFICATION

404.1. Tests Required.

404.1.1. The qualification tests described herein are specially devised tests to determine the tacker’s ability to produce sound welds. It is not intended that the qualification tests shall be used as a guide for welding during actual construction. The latter shall be performed in accordance with the requirements of the Procedure Qualification.

404.1.2. A tacker shall be qualified by one test plate made in each position in which he is to tack. See Fig. 404 for position of test plates.

404.1.3. The tacker shall make a ½ inch maximum size tack weld approximately 2 inches long on the fillet-weld-break specimen as shown in Fig. 404.1 using a 5/32 inch diameter electrode.

404.2. Base Metal. The base metal used shall comply with Art. 203.2 or the Approved Welding Procedure.

404.3. Welding Procedure. The welder shall follow the procedure specified by the Approved Welding Procedure.

Revised Aug. 1, 1974
NOTES:

1. All plate surfaces within the area of the backing strip must be free of mill scale and surface depressions. This includes the top and bottom of the test plates and the backing strip.

2. After welding, the weld reinforcement shall be ground flush with the surface of the plate. Do not remove the backing strip.

3. For flat position and material of unlimited thickness.

Fig. 403 — Welding operator qualification test plate for automatic submerged arc and automatic flux cored arc welding.

Revised Aug. 1, 1974
404.4. Preparation of Test Specimens. All welding of the test plate shall be witnessed by a representative of the State.

404.5. Method of Testing Specimens. A force shall be applied to the specimen as shown in Fig. 404.5 until rupture occurs. The force may be applied by any convenient means. The surface of the weld and of the fracture shall be examined visually for defects by a representative of the State.

404.6. Test Results Required.

404.6.1. The tack weld shall present a reasonably uniform appearance and shall be free of overlap, cracks and excessive undercut. There shall be no porosity visible on the surface of the tack weld.

404.6.2. The fractured surface of the tack weld shall show complete penetration into the root of the joint and shall exhibit no incomplete fusion to the base metal nor any inclusion or porosity larger than 3/32 inch in greatest dimension.

404.6.3. A tacker who passes the fillet-weld-break test shall be eligible to tack weld all types of joints for the process and in the positions in which he has qualified.

404.7. Limitation of Variables. For the qualification of a tacker the following rules shall apply.

404.7.1. Qualification established with any one of the steels permitted by these Specifications shall be considered as qualification to tack weld any of the other steels.

404.7.2. A tacker qualifying for manual shielded metal-arc welding shall use only 5/32 inch diameter electrodes meeting the requirements of “Specification for Mild Steel Covered Arc Welding Electrodes” (AWS A5.1), Classification E7018 only.

404.7.3. A tacker qualified with an approved electrode and shielding medium combination for a process other than manual shielded metal-arc shall be considered qualified to tack with any other approved electrode and shielding medium combination for the process used in the qualification test.

404.7.4. A tacker shall be qualified for each process used.

404.7.5. A change in the position in which tacking is done as defined in par. 402.7.4 shall require requalification.

404.8. Retests.

404.8.1. In case of failure to pass the above test, the tacker may make one retest without additional training.

404.8.2. If a tacker fails the first retest, he will be required to show evidence of additional training or practice prior to performing a further retest.

404.9. Period of Effectiveness. A tacker who passes the above test shall be considered eligible to perform tack welding for three years in the positions and with the processes for which he is qualified unless there is some specific reason to question his ability. In such case, the tacker shall be required to demonstrate his ability to make sound tack welds by again passing the prescribed tack welding test.

404.10. Records. Records of the test results shall be kept by the testing agency or Contractor and shall be available to those authorized to examine them.

Revised Aug. 1, 1974
a. — Positions for Test Plates.

b. — Fillet-weld-break specimen.

c. — Method of rupturing specimen.

Fig. 404 — Tacker Qualification Test Plate
SECTION V
HEAT-CURVING AND CAMBERING OF ROLLED BEAMS
AND WELDED PLATE GIRDER

501. HEAT-CURVING ROLLED BEAMS AND WELDED PLATE GIRDER. When the plans call for stringers and
  girders to be furnished with a specified horizontal curvature, the rolled beams and welded plate girders which form
  these pieces may be fabricated using heat-curving procedures which conform to the following requirements:

501.1. Scope. This specification pertains to rolled beams and welded
  flange plate girders heat-curved to obtain the required horizontal
  curve. Steels that are manufactured to a specified minimum yield point
  greater than 50,000 psi shall not be heat-curved without the written
  approval of the D.C.E.S.

Members required to be fabricated to a radius smaller than the minimum radius
of curvature stated in the specification shall be fabricated as rolled plate
  girders with the flanges flame cut to the required radius prior to assembly
  to the web.

501.2. Minimum Radius of Curvature. This specification will permit the heat-curving of beams and girders
when the horizontal radius of curvature measured to the centerline of the member web will not be less than
150 feet, and will not be less than the larger of the values calculated (at any and all cross sections throughout
the length of the member) from the following two equations:

\[ R = \frac{14 \cdot b \cdot D}{F_Y \cdot \psi \cdot t} \]

\[ R = \frac{7500 \cdot b}{F_Y \cdot \psi} \]

In these equations, \( F_Y \) is the specified minimum yield point in ksi of the steel in the member web, \( \psi \) is the
ratio of the total cross-sectional area to the cross-sectional area of both flanges, \( b \) is the widest flange width in
inches, \( D \) is the clear distance between flanges in inches, \( t \) is the web thickness in inches, and \( R \) is the radius in
inches.

In addition to the above requirements, the radius shall not be less than 1000 feet when flange thickness
exceeds 3 inches or \( b \) exceeds 30 inches.

501.3. Camber Increase for Dead Load Deflection Caused by Residual Stresses. To compensate for possible
loss of camber of heat-curved girders (camber losses of this nature are also known to occur in straight beams
and girders but to a lesser degree) in service as residual stresses dissipate, the amount of camber in inches at the
point of maximum deflection shall be increased by the amount shown in the following formula:

\[ \Delta \text{Increase} = \frac{0.02L^2F_Y}{E\gamma_o} \]

Distribute \( \Delta \) increase from the point of maximum deflection as a parabola. This distribution shall be
between dead-load points of contraflexure.

\( E \) is the modulus of elasticity in ksi, \( F_Y \) is the specified minimum yield point in ksi of the girder flange, \( \gamma_o \) is
the distance from the neutral axis of the steel member to the extreme outer fiber in inches (maximum distance
for nonsymmetrical sections), and \( L \) is the span length or distance between points of dead-load contraflexure
in inches.

Fifty percent of this camber increase shall be included in the bridge profile because camber loss will not be
complete until after several months of service. The remaining fifty percent of the camber increase shall be
included in the anticipated steel dead-load deflection. This shall include all steel deflection prior to composite
action between the steel superstructure members and any attached concrete designed to act as a composite
section. See Par. 501.13 for web cutting procedures to be followed for heat-curved welded plate girders.

*Any camber increase indicated by the formula shall be approved by the D.C.E.S. who may multiply the
  formula result by a factor of 0.5 to 0.95 based upon experience with long term deflections.
SECTION VI

RADIOGRAPHIC INSPECTION OF GROOVE WELDS IN BUTT JOINTS

601. GENERAL. The procedures and standards herein described are specifically designed to facilitate the performance and recordation of radiographic examination of groove welds in butt joints by X-ray or gamma ray sources. All radiographic inspection performed by State forces, inspection agencies under contract to the State, Contractors or their agents working on State contracts shall conform to the requirements of this specification.

602. EXTENT OF INSPECTION.

602.1. Joints to be Radiographed. All butt joints in primary tension members shall be radiographed. This shall include all tension flange butt welds and the tension portion of web butt welds in stringers and girders. Joints to be radiographed shall also include tension butt welds in columns, bents, towers, rigid frames, arches, truss chords, truss web members and longitudinal stiffener splice welds when attached to the tension areas of members.

Radiographic inspection will be used to determine the soundness of tension butt welds throughout their entire length unless otherwise specified.

When stringers and girders are supported at their ends only, all bottom flange joints are considered to be in tension unless otherwise stated. When members are continuous or cantilevered over a support, the limits of tension in each flange shall be shown on the Contract Plans and on the Shop Drawings. These limits of tension shall include the effects of “Live Loads.”

602.2. Web Splices. Tension areas of web splices in stringers and girders shall be interpreted to represent one-third of the web butt joint length beginning at the tension flange unless otherwise specified. A minimum of 16 inches shall be radiographed regardless of web depth. No more than one-third of the web butt weld length or 16 inches minimum need be radiographed if the length tested is determined to be acceptable. If defects are found in this area which is subject to partial examination, the area shall be extended to insure that the limits of the rejectable discontinuities have been discovered and repaired. If the extended area examined contains gross defects in the opinion of the Inspector, the complete weld shall be radiographed. When a web joint is subject to reversal of stress the entire web and both flange joints shall be radiographed.

602.3. Field Splices. Butt welded field splices in structural members shall be subject to 100 percent coverage by radiographic inspection unless otherwise specified.

602.4. Repairs. “Spot” inspection and “spot” radiography shall not be used except for the examination of localized repairs in welds previously rejected by radiographic tests. Repair radiographs shall be made using 17-inch long film and shall represent a minimum length of weld equal to the repair excavation plus 3 inches each side.

602.5. Radiographic Inspection of Welds Considered to be Shear or Compression Welds. Any groove weld in a butt joint may be subject to radiographic inspection regardless of the direction of stress if required by the Contract Documents or ordered by the Inspector. The Inspector shall order the radiographic inspection of compression and shear butt welds in pieces where 10 percent or more of the length of the tension butt welds are found to contain rejectable defects. The Inspector may only order radiograph inspection of compression and shear welds where there is a basis to assume they are defective as described above.

602.6. Fraudulent Radiographs. The State may order new and separate radiographic inspection of all butt welds in all structural steel fabricated for the State in a given shop when there is evidence that the Fabricator has submitted fraudulent radiographs or reports.

603. RADIOGRAPHIC TECHNIQUE AND EQUIPMENT. The welds shall be radiographed utilizing techniques and equipment that will have sufficient sensitivity to properly delineate at least two penetrators on each radiograph. Penetrators shall conform to the requirements of this specification. Radiographic quality shall be such that identification numbers of penetrators and the 2T hole shall show clearly on the radiograph, except that when Numbers 5, 7 and 10 penetrators are required, the slit shall appear clearly on the radiograph and the 2T hole need not appear clearly.
The density difference between the image of the holes or slit and the penetrator image shall be the same as that between the edge of the penetrator and the adjacent film area.

Penetrameters that do not show clearly on the radiographs as described shall cause the rejection of the radiograph by the Inspector or the D.C.E.S. Penetramter images shall be of sufficient clarity to permit the measurement of both the dimensions of the penetrator and the diameter of the holes.

604. PREPARATION OF JOINTS. All joints shall be prepared for radiography by grinding as described in Article 203.17, Weld Profiles, as contained in this Manual.

Backing bars and runoff tabs shall be removed prior to preparation by grinding.

605. PREPARATION FOR EXPOSURE. All film cassettes shall be loaded with two fine grain films of the same specification. Appropriate lead screens shall be used. A center screen is recommended when the steel thickness exceeds 1 1/4 inches. The loaded cassette shall be held in intimate contact with the steel by a process that will avoid film pressure marks. The back side of the cassette shall be protected from scatter radiation for its full length by a lead sheet.

Radiographs shall be made with a single source of radiation placed on a line directly above and perpendicular to the plane of interest. In general, this will be the center of the length to be examined. The source-to-subject distance shall be not less than the total length of film being exposed. In addition, the source-to-subject distance shall not be less than the amount shown in the following table:

<table>
<thead>
<tr>
<th>Maximum Thickness of Weld Under Examination (T)</th>
<th>Minimum Source-to Subject Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4” to 2” incl.</td>
<td>24”</td>
</tr>
<tr>
<td>&gt; 2” to 2 1/2” incl.</td>
<td>18”</td>
</tr>
<tr>
<td>&gt; 2 1/2”</td>
<td>7”</td>
</tr>
</tbody>
</table>

606. RADIOGRAPHIC SOURCE. X-ray or Iridium 192 may be used as a source for all radiography. Cobalt 60 may only be used as a radioactive source when the steel being radiographed exceeds 3 inches in thickness.

607. PENETRAMETERS. At least two penetrators shall show clearly on each radiograph. The penetrators shall always be placed on the source side of the joint being radiographed.

When a transition in thickness occurs at a welded joint, each film shall clearly show two penetrators on the thinner plate and one penetrator on the thicker plate. When it is necessary to radiograph a joint representing a major change in thickness, the penetrator representing the maximum plate thickness may be placed on the sloping surface of the base metal outside the weld zone.

Penetrators shall be placed parallel to the weld joint with the holes at the outer end as shown in Figure 611. Penetrators shall be of the thickness or thicknesses required by Table 607.

Penetrators shall be manufactured from steel, preferably stainless steel, to conform to the dimensions shown in Figures 607. (a) and 607. (b).

Penetrators shall be identified by number in symbols at least 3/32 inches high.

Each penetrator shall be manufactured with three holes, one of which shall be of a diameter equal to twice the penetrator thickness (2T) but not less than 1/16 inch. The diameter of the two remaining holes shall be selected by the manufacturer. They will ordinarily be equal to three times (3T) and four times (4T) the penetrator thickness but they need not be smaller than 1/16 inch.

Revised Aug. 1, 1974
Fig. 607a — Details of Penetrameters.
Fig. 607 b – Penetrameter (Image Quality Indicator)
704.7. Angle Beam Search Units. Angle beam search units (also referred to as transducers) shall consist of a transducer and an angle wedge. The unit may be comprised of the two separate elements or be an integral unit.

704.7.1. The transducer frequency shall be between 2 and 2.5 MHz, inclusive.

704.7.2. The transducer crystal may vary in size from \( \frac{1}{2} \) to 1 inch in width and from \( \frac{1}{2} \) to 13/16 inches in height (see sketch).

704.7.3. Angle beam search units shall produce a sound beam in the material being tested within plus or minus 2 degrees of the following proper angles: 70°, 60°, or 45°, as described in Figure 700C (II B).

704.7.4. Each search unit shall be marked to clearly indicate the frequency of the transducer, nominal angle of refraction, and index point. The index point location procedure is described in Figure 700C (II A).

704.7.5. Internal reflections from angle beam search units with a screen presentation higher than the horizontal reference line appearing on the screen to the right of the sound entry point shall not occur beyond \( \frac{1}{2} \) inch equivalent distance in steel when the sensitivity is set as follows: 20 dbs. more than that required to produce a maximized horizontal reference line height indication from the 1.5 mm (.06") diameter hole in the International Institute of Welding IIW reference block (Figure 700A).

704.7.6. The dimensions of the search unit shall be such that the closeness of approach to the weld reinforcement shall not exceed the requirements of Figure 700C (II F), Approach Distance of Search Unit. The search unit shall be positioned for maximum indication from the .06-inch diameter hole in the (IIW) calibration block.

704.7.7. The combination of search unit and instrument shall resolve the three holes in the resolution test block shown in Figure 700D. The search unit position is described in Figure 700C (II E). The resolution shall be evaluated with the instrument controls set at normal test settings and with indications from the holes brought to mid screen height.

705. CALIBRATION STANDARDS. The International Institute of Welding’s (IIW) ultrasonic reference block, shown in Figure 700A, shall be the standard used for both distance and sensitivity calibration. More portable reference blocks of other designs may be used provided they meet the requirements of this specification and are referenced back to the IIW Block. Approved designs are shown in Figure 700B. See Fig. 700C for applications. Differences between alternate calibration blocks and the IIW Block shall be accounted for in determining the Reference Level and Defect Rating.

Use of a “corner” reflector for calibration purposes is prohibited.

706. EQUIPMENT CALIBRATION.

706.1. Calibrated Gain Control. The instrument’s gain control (attenuator) shall be checked for correct calibration at two-month intervals in accordance with a procedure approved by the instrument’s manufacturer and shall meet the requirement of Paragraph 704.5.

706.2. Horizontal Linearity. Horizontal linearity shall be checked after each 40 hours of instrument use by techniques prescribed in Paragraph 704.2.
706.3. Checking of Angle Beam Search Units. Each angle beam search unit shall be checked after each 8 hours of use to determine that the contact face is flat, that the sound entry point is correct, and that the beam angle is within the permitted plus or minus 2 degrees tolerance. Tests shall be made using an approved calibration block. Search units which do not meet these requirements shall be corrected or replaced.

707. CALIBRATION FOR TESTING.

707.1. General. Calibration for sensitivity and horizontal sweep (distance) shall be made by the ultrasonic operator just prior to and at the location of testing of each weld and at intervals of 30 minutes as testing proceeds. Recalibration shall be made each time there is a change of operators, when transducers (search units) or cables are changed, when new batteries are installed, when equipment operating from a 110-volt source is connected to a different power outlet or whenever the electrical circuitry is disturbed in any way.

Ultrasonic test instruments equipped to produce more than one signal intensity (pulse energy) shall be calibrated and operated at the lowest setting (Pulse Energy I) unless otherwise stated in the Ultrasonic Test Report and approved by the D.C.E.S.

Clipping controls, suppression controls or any control whose function is to filter the CRT presentation shall not be used without the prior approval of the D.C.E.S. When the use of these controls is approved, it shall be clearly noted in the ultrasonic test report. The clipping control shall not be changed following calibration or during testing.

707.2. Calibration for straight beam testing.

707.2.1. The horizontal sweep shall be adjusted for distance calibration to present the equivalent of at least two plate thicknesses on the CRT screen.

707.2.2. The sensitivity shall be adjusted at a location free of indications so that the first back reflection from the far side of the plate will be between 40 and 70 percent of full screen height.

707.3. Calibration for angle beam testing.

707.3.1. The horizontal sweep shall be adjusted to represent the actual sound path length by using acceptable distance calibration blocks shown in Figures 700A and 700B. This distance calibration shall be made using either the 5-inch scale or 10-inch scale on the CRT screen, whichever is appropriate, unless joint configuration or thickness prevents full examination of the weld at either of these settings. The search unit position is described in Figure 700C (II D). When areas of joints are to be tested where the sound path is greater than 10 inches, those areas shall be tested with the instrument calibrated to the 15- or 20-inch scale, as appropriate. All other areas of the joint shall be tested with the instrument adjusted to the 10-inch scale.

707.3.2. With the unit adjusted to conform with the requirements of Art. 704 the sensitivity shall be adjusted by the use of the gain control (attenuator) so that a horizontal reference level trace deflection results on the CRT screen with the maximum indication from the 0.06-inch diameter hole in the IFW block or from the equivalent reference reflector in other acceptable calibration blocks. The search unit position is described in Figure 700C (II D). This basic sensitivity then becomes the zero reference level for discontinuity evaluation and shall be recorded on the ultrasonic test reports under "Reference Level," ""b," Figure 700F.

708. TESTING PROCEDURE: GENERAL. A "Y" accompanied with a weld identification number shall be clearly marked on the material adjacent to the weld at the left end or top of each weld which is ultrasonically tested. This identification number shall serve as an orientation direction for weld discontinuity location and as the "Weld Identification" on the Ultrasonic Test Report.

All surfaces to which a search unit is applied shall be free of weld spatter, dirt, grease, oil, loose scale and paint and shall have a flat contour permitting intimate coupling.

Revised Aug. 1, 1974
### Ultrasonic Testing

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Defect Number</th>
<th>Transducer Angle</th>
<th>DECIBELS</th>
<th>DEFECT</th>
<th>Remarks</th>
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<td>12</td>
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</tr>
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</table>

### NOTES:

1. *Use Node I or II - 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.

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
### TABLE 700A

#### PROCEDURE CHART

<table>
<thead>
<tr>
<th>Weld Type</th>
<th>6/16 to 1%</th>
<th>&gt;1/2 to 1</th>
<th>&gt;1 to 1 1/4</th>
<th>&gt;1 1/4 to 2%</th>
<th>&gt;2% to 3%</th>
<th>&gt;3% to 4%</th>
<th>&gt;4% to 5%</th>
<th>&gt;5% to 6%</th>
<th>&gt;6% to 7%</th>
<th>&gt;7% to 8%</th>
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<tbody>
<tr>
<td>Butt</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<td>*</td>
<td>*</td>
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<tr>
<td>Tee</td>
<td>1a</td>
<td>1b</td>
<td>0</td>
<td>1c</td>
<td>F</td>
<td>2</td>
<td>F</td>
<td>3</td>
<td>F</td>
<td>4</td>
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<td>Corner</td>
<td>1a</td>
<td>0</td>
<td>1b</td>
<td>0</td>
<td>1c</td>
<td>F</td>
<td>3</td>
<td>F or XF</td>
<td>2</td>
<td>F or XF</td>
</tr>
<tr>
<td>Electro slag &amp; Electroslag</td>
<td>1a and RT</td>
<td>1b and RT</td>
<td>0</td>
<td>1c and RT</td>
<td>0</td>
<td>2 and RT</td>
<td>0</td>
<td>2 or 3 and RT</td>
<td>0</td>
<td>8 and RT</td>
</tr>
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#### PROCEDURE LEGEND

<table>
<thead>
<tr>
<th>Area of Weld Thickness</th>
<th>NO.</th>
<th>TOP QUARTER</th>
<th>MIDDLE HALF</th>
<th>BOTTOM QUARTER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1a</td>
<td>70° I and II</td>
<td>70° I and II</td>
<td>70° I and II</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>70° I and II</td>
<td>70° I and II</td>
<td>70°</td>
</tr>
<tr>
<td></td>
<td>1c</td>
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<td>70°</td>
<td>70°</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>70° + 80° II</td>
<td>70°</td>
<td>70°</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>70° + 45° II</td>
<td>70°</td>
<td>70°</td>
</tr>
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<td>60° B</td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td>60° B</td>
<td>60°</td>
<td>60°</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>45° B</td>
<td>45°</td>
<td>45°</td>
</tr>
<tr>
<td></td>
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<td>70° A B</td>
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<td>9</td>
<td>70° GA+60° B</td>
<td>70° A B</td>
<td>60° A+70° GB</td>
</tr>
</tbody>
</table>

**LEGEND**

- X — Check from Face “C”
- G — Grind Weld Face Flush
- Q — Not Required
- 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 at scanning level with primary procedure selected from first column.
- ** — Use 10 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.
- RT — Radiographic Inspection
- I — Examine weld in Node I
- II — Examine weld in Node II
- "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.

*Revised Aug. 1, 1974*
TABLE 700A (continued)

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 Aug. 1, 1974
### TABLE 700B – HIGHWAY AND RAILWAY BRIDGES

#### MINIMUM ACCEPTANCE LEVELS (DECIBELS)

<table>
<thead>
<tr>
<th>REFLECTOR SEVERITY</th>
<th>Weld Thickness and Transducer Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5/16 to 3/4</td>
</tr>
<tr>
<td></td>
<td>70°</td>
</tr>
<tr>
<td>Large Reflectors</td>
<td>+14</td>
</tr>
<tr>
<td>Small Reflectors</td>
<td>+15</td>
</tr>
<tr>
<td>Minor Reflectors</td>
<td>+18</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 full penetration double Vee, double “J” and double “U” 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.*
TABLE 700C – BUILDINGS

<table>
<thead>
<tr>
<th>REFLECTOR SEVERITY</th>
<th>MINIMUM ACCEPTANCE LEVELS (DECIBELS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weld Thickness and Transducer Angle</td>
</tr>
<tr>
<td></td>
<td>5/16 to 3/4</td>
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<tr>
<td>Large Reflectors</td>
<td>70°</td>
</tr>
<tr>
<td></td>
<td>+8</td>
</tr>
<tr>
<td>Small Reflectors</td>
<td>+9</td>
</tr>
<tr>
<td>Minor Reflectors</td>
<td>+10</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 3/4" 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 than those of “Minor Reflectors” shall not begin at a distance less than 2L from weld ends carrying primary tensile stress, L being the discontinuity length.

3. Discontinuities in the root-land area of full penetration double Vee, double “I” and double “U” 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.

*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.

**SCANNING LEVELS**

<table>
<thead>
<tr>
<th>Sound Path Distance</th>
<th>Above Zero Reference</th>
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<tbody>
<tr>
<td>to 2½&quot;</td>
<td>+14 db</td>
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<tr>
<td>&gt; 2½ – 5&quot;</td>
<td>+19 db</td>
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<tr>
<td>&gt; 5 – 10&quot;</td>
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<tr>
<td>&gt; 10 – 15&quot;</td>
<td>+39 db</td>
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<tr>
<td>&gt; 15 – 20&quot;</td>
<td>+49 db</td>
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</table>

*Revised Aug. 1, 1974*
SECTION VIII

MAGNETIC PARTICLE INSPECTION

801. GENERAL. The procedures and standards set forth in this section shall be followed whenever magnetic particle inspection is required by the Contract Documents or ordered by the Engineer under the provisions of these Specifications. All magnetic particle inspection performed by State forces, Inspection Agencies under contract to the State, Contractors or their agents shall conform to the requirements of this Specification. Variations in testing procedures or equipment shall be subject to approval by the D.C.E.S.

802. TESTING PROCEDURES AND EQUIPMENT. All testing shall be performed in accordance with the provisions of ASTM Designation E109, Standard Method for Dry Powder Magnetic Particle Inspection, except as modified herein.

802.1. Current. The magnetizing source shall produce rectified half wave direct current. The minimum magnetizing current shall be 400 amperes and shall be not less than 100 amperes per inch of prod spacing. Higher testing currents approaching a current density of 150 amperes per inch of prod spacing are preferred. Arcing must be controlled by proper testing techniques.

802.2. Prod Positioning. The prods shall be oriented in two directions approximately 90 degrees apart at each inspection point, to detect both longitudinal and transverse discontinuities. The prod positions shall overlap as the testing progresses to insure 100% inspection of the areas to be tested.

802.3. Surface Condition. The surface being inspected shall be clean and dry and free of oil, rust, loose mill scale and paint. Grinding may be required to provide proper electrical contact and to remove surface irregularities that interfere with interpretation of test indications.

802.4. Special Equipment. Wherever magnetic particle inspection is performed on ASTM A588 Steel or any steel with a minimum specified yield stress exceeding 50 ksi, aluminum prods shall be used on the test equipment. The use of copper prods will not be permitted on such steels.

803. WITNESSING OF MAGNETIC PARTICLE TESTS. All magnetic particle inspection that is not performed by State forces or an inspection agency under contract to the State shall be witnessed by a representative of the State.

804. PREPARATION AND DISPOSITION OF REPORTS. A test report shall be prepared for each erection piece subject to inspection. The report shall be prepared by the technician performing the test. The report shall contain sufficient information to identify the extent of the weld or base metal inspected, the name of the technician (signature), and the name of the State representative witnessing the work, if required by Paragraph 803. All indications of discontinuities shall be recorded in the test report. The Contract and date of test shall be listed on each report together with the Fabricator’s Shop Order Number and the Erection Mark on the piece.

A complete set of test reports shall be delivered to the D.C.E.S. upon completion of the work.

805. STANDARDS OF ACCEPTANCE. Welds subject to magnetic particle inspection shall have no cracks. Porosity and fusion-type defects shall be evaluated in accordance with the provisions of Sections 615.1, 615.2 or 615.3 as applicable.