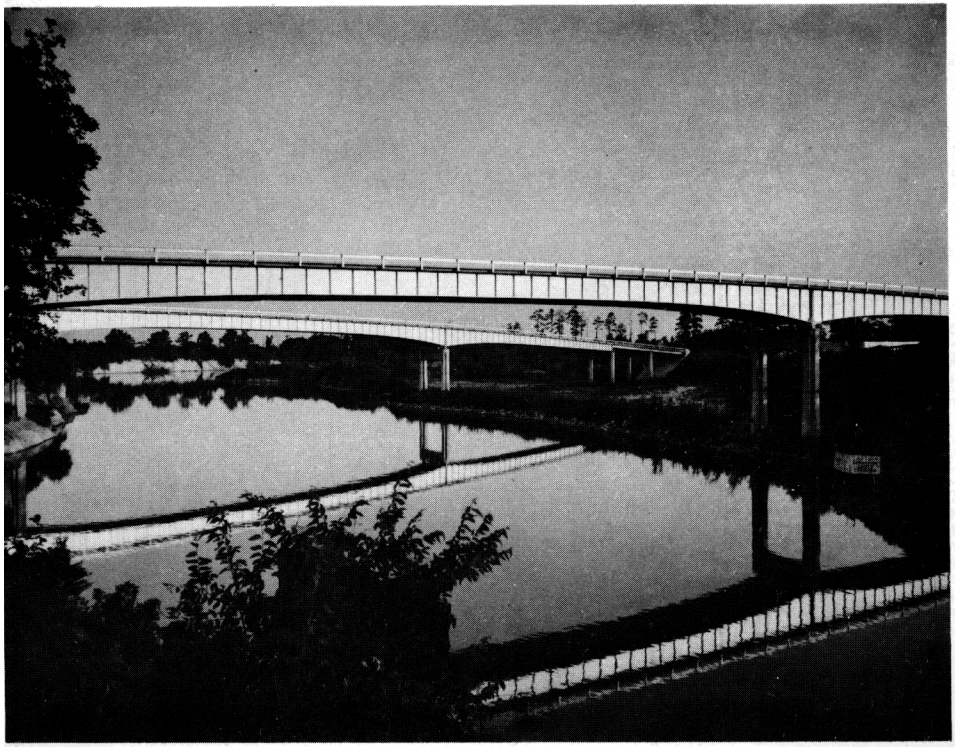
CONSTRUCTION BULLETIN C-5



TEXAS HIGHWAY DEPARTMENT

FOREWORD

This Bulletin has been prepared by the Bridge Division of the Texas Highway Department to be used in conjunction with the Standard Specifications for the fabrication of welded structures.

The Bulletin has been prepared to include the pertinent portions of fabrication from the Standard Specifications of the American Welding Society, and incorporting those changes to be included in the next AWS Specifications.

No attempt has been made to include any design criteria or such in this Bulletin.

JANUARY 1961

TABLE OF CONTENTS

Section 6

SECTION 1 - GENERAL PROVISIONS

101. Application.

1. This bulletin in conjunction with Item 441, "Steel Structures", Item 442, "Metal for Structures", and Item 450, "Railing" of the Standard Specification shall govern the fabrication of welded structures. All welding operations, processes, equipment, materials, workmanship, and inspection shall conform to the requirements of these specifications. When reference is made to the AWS Standard Specification, the latest edition of the "Standard Specifications for Railway and Highway Bridges" shall be used.

2. Unless otherwise specified, these provisions shall apply to both carbon and alloy steels.

102. Definitions.

The welding terms used in these specifications shall be interpreted according to the definitions given in the AWS Standard Welding Terms and Their Definitions.

103. General.

1. All welds, including tack welds that are to be incorporated in the final welds, shall be made by a certified welder and shall be of sound qualtiy as final welds. Tack welds shall be cleaned and thoroughly fused with the final weld. Defective, cracked, or broken tack welds shall be removed before final welding.

2. Welds shall be as required by the design drawings. The location or size shall not be changed without approval of the Engineer.

3. The welder shall place his identification mark with crayon or paint near the welds made by him.

4. No welding will be allowed when the air temperature is lower than 20 F, when surfaces are wet or exposed to rain, snow, or wind, or when operators are exposed to inclement conditions that will hamper good workmanship.

5. Any moisture present at the point of welding shall be driven off by heat before welding commences. Wind breaks shall be required for the protection of all welding operations.

6. Preparation of material and assembly of parts shall be in accordance with Item 441, "Steel Structures" of the Standard Specifications.

104. Welding Procedures.

1. A welding procedure shall be submitted and approved by the Engineer prior to the beginning of fabrication of welded structural members. Submission shall be made to the Bridge Division, Austin, Texas.

2. The welding procedure shall include joint types to be used, sequence of placing weld metal in the joints, type of electrodes by AWS designation, size of electrodes, methods of cleaning (gouging, chipping, grinding, etc.), positioning and type of jigs for automatic welding, type of equipment to be used, wire type and size, type and grade of fluxing material; volts, amps and speed of travel used for making qualification tests; copies of all required qualification tests; and such other pertinent information necessary to the welded fabrication.

105. Welding Processes.

These specifications include specific provisions for shielded metal-arc welding and automatic submerged arc welding. Other welding processes not covered will be permitted only with the specific approval of the Engineer and with the qualification of all joint welding procedures to be used.

106. Base Metal.

Base metal shall be in accordance with Item 442, "Metal for Structures" of the Standard Specifications.

107. Peening.

1. Peening of multilayer welds may be used only if authorized by the Engineer and directed by him. Care shall be exercised to prevent overpeening which may cause overlapping, scaling, cracking, flaking, or excessive cold working of weld and base metal. No peening shall be done on the root or surface layers of a weld.

108. Cleaning and Protective Coatings.

1. Welded joints shall not be painted until after the work has been completed and accepted. Painting shall be in accordance with the Standard Specifications. The surfaces to be painted shall be cleaned of spatter, rust, loose scale, and oil. Slag shall be cleaned from all welds.

2. Welds that are to be galvanized shall be sand blasted to remove every particle of slag.

SECTION 2 - FILLER METAL

201. Electrodes For Manual Shielded Metal Arc Welding.

1. Electrodes shall conform to the requirements of ASTM A 233 (AWS Designation A 5.1). Class of electrode required will be as shown herein. Electrode shall be used only with the type of current, the polarity, and in the positions permitted by the subject specifications.

Type of Steel And Thickness	Type of Weld	
	Groove Welds	Fillet Welds
A 373 Under 1-1/4" A 53 Pipe Railing	E6010, E6011, E6020, E7015, E7016, E7018	E6010, E6011, E6012, E6013, E6014, E6020, E7015, E7016, E7018, E7024
A 373 1-1/4" and over	E7015, E7016, E7018	
A 441, A 36 API Pipe Railing	E7015, E7016, E7018	E7015, E7016, E7018
A 7, A 373, (Secondary Members)		E6010, E6011, E6012, E6013, E6014, E7015, E7016, E7018
A 441, A 36 (Secondary Members)		E7015, E7016, E7018
Reinforcing Steel	E7015, E7016, E7018	E7015, E7016, E7018

TABLE 1

Classifications of Electrodes Permitted

2. Electrodes which have dried out and cracked, or those which have been wet, shall not be used.

3. Electrodes of the low hydrogen type shall be dried for at least 2 hours at a temperature above 250 F before such are used. Electrodes so dried that are not used within 4 hours after this drying shall be redried before use. Electrodes which have been wet shall not be used. Storage of all low hydrogen electrodes shall be in suitable ovens.

202. Electrodes and Flux For Submerged Arc Welding.

1. For structural carbon steel of the A 7 and A 373 classifications, the bare electrodes and granular fusible material (flux) used in combination for submerged arc welding shall be capable of producing weld metal have the following properties when deposited in a multiple pass weld made in accordance with the requirements of Section 302.

Tensile Strength (Range)	62,000 to 80,000 psi.
Yield Point, Min.	45,000 psi.
Elongation in 2 in., Min.	25%

For structural low alloy steel A 441 and High yield Carbon Steel A 36, the bare wire electrodes and the fluxing material used in combination for submerged arc welding shall be capable of producing weld metal having the following properties:

Tensile Strength (Range)	70,000 psi to 90,000
Yield Point, Min.	55,000 psi
Elongation in 2 in. Min.	22%

2. When required by the Engineer, the capability of the electrodes and granular fusible material (flux) to produce weld metal having these properties and to produce satisfactory welded joints shall be demonstrated by appropriate tests.

203. Condition of Fluxing Material.

1. Flux used for submerged arc welding shall be thoroughly dry and free from contamination from all foreign materials. Flux which shows evidence of moisture pick up shall be dried by heating to above 250 F for a minimum of 2 hours. Flux which has been used but not fused shall be screened before reuse. Flux which has been fused in welding shall not be reused.

SECTION 3 - WORKMANSHIP & TECHNIQUE

301. Control of Distortion and Shrinkage Stresses.

1. In assembling and joining parts of a structure or of built-up members and in welding reinforcing parts to members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. A backstep, wandering, or other approved sequence of welding shall be used.

2. All welds shall be deposited in a sequence that will balance the applied heat of welding on various sides while the welding progresses.

3. Before the commencement of welding on a member or structure in which severe shrinkage stresses or distortion is likely to occur, a complete program for welding sequence and distortion control shall be worked out between the Contractor and the Engineer.

4. The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other towards points where they have a greater relative freedom of movement.

5. Joints expected to have large shrinkage shall be welded before joints expected to have lesser shrinkage and with as little restraint as possible.

6. All shop splices in each component part of built-up members shall be made before such component part is welded to other parts of the member, unless otherwise approved by the Engineer.

7. In making butt-welded splices in rolled or built-up members of H, I, or box section, the web splices and flange splices shall be made with an alternating sequence to properly balance the heat input and shrinkage between the component parts, in accordance with the general sequence as required in Item 448, "Structural Welding".

8. In welding of cover plates to beams or girders, welding shall be done in such manner to prevent distortion to the main structural member. The welding may be done alternately on each side of the cover plate or simultaneously by the use of two welders. In any case heat input must be balanced.

302. Procedures For Manual Shielded Arc Welding.

1. The work shall be positioned for flat welding whenever practicable.

2. Classification of electrode shall be in accordance with Table 1.

3. The size of electrodes, arc length, voltage, and amperage shall be suitable

for the thickness of the material, type of groove, welding positions, and other circumstances attending the work.

4. The maximum size of electrode used shall be as follows:

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

(b). 1/4 inch for root passes of fillet welds made in the flat position and groove welds made in the flat position with backing having a root opening greater than 1/4 inch.

(c). 5/16 inch for all welds, except for root passes, made in the flat position.

(d). 5/32 inch for groove welds made in the vertical and overhead position, except that 3/16 inch may be used when the welder has been certified to do so by the Department.

(e). 5/32 inch for welds made with low hydrogen electrodes in the vertical and overhead position.

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

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

(a). one-fourth inch for root passes of groove welds.

(b). one-eighth inch for subsequent layers of welds made in the flat position.

(c). three-sixteenth inch for subsequent layers of welds made in the vertical, overhead, or horizontal position.

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

7. The maximum size of fillet weld which can be made in one pass shall be three-eighth of an inch, except that fillet welds made vertically upward may be one-half of an inch.

8. For vertical welding the progression for all passes shall be upward with a backstep sequence being used.

9. Before welding over previously deposited metal, all slag shall be removed and the weld and adjacent base metal shall be brushed clean. This requirement shall apply not only to successive layers but also to successive beads and to the crater area when welding is resumed after any interruption.

10. All butt welds, except when produced with the aid of backing, shall have the root of the initial weld gouged, chipped, or ground to sound metal before welding is started from the second side.

11. Groove welds shall begin and terminate on extension bars. Edge preparation and thickness of extension bars shall be the same as that of the member being welded and shall extend a minimum of three-fourths of an inch beyond the

joint. Extension bars shall be removed with a cutting torch upon completion and cooling of the weld and the flange edges shall be ground smooth.

12. Any defects exposed by the grinding shall be cleaned, filled with weld metal and reground to a uniform finish. All grinding shall be parallel to the direction of stress. Excess grinding of the parent metal shall be avoided.

13. Preheat ahead of welding of both fillet and groove welds will be as required as follows:

Thickness At Point of Welding .Plates-Shapes or Bars	Minimum Preheat and Interpass Temperature		
	A 373 & A 7		A 441 and A 36
	Low Hydrogen Electrodes	All Other Electrodes	Low Hydrogen Electrodes
Less than One Inch	None	None	100°F
1 inch to 2 inch	None	100°F+25°F per 1/4" over 1" Thickness	100°F+25°F per 1/4" over 1" Thickness
Over 2 inch	100°F+25°F per 1/4" over 2" Thickness	200°F+25°F per 1/4" over 2" Thickness	200°F+25°F per 1/4" over 2" Thickness

Table 2

Preheat and Interpass Temperatures
for Manual Welding

14. When preheating of the base metal is required, it shall be performed in such manner that the surfaces of both parts shall be at or above the specified temperature within 2 inches of the point of welding.

15. Intermittent fillet welds will be permitted for stiffeners on beams or girders and shall conform to all of the following:

(a). Minimum length of each weld shall be 1-1/2 inches.
(b). At least 25% of the joint shall be welded.
(c). Maximum clear spacing end to end of welds shall be 12 times the thickness of the thinner part but not more than 6 inches.

(d). Where intermittent welds are used, chain intermittent welding is preferable to staggered intermittent welding.

(f). Minimum length of weld at ends of stiffeners shall be 6 inches.

303. Procedures For Submerged Arc Welding.

1. All submerged arc welds on flange and web butt splices, flange to web fillets, fillets and butt splices on main chord members, and built-up columns shall be made in the flat position. Welds for attaching cover plates, stiffeners, built-up shoes, etc., may be made in the horizontal position.

2. The electrode and flux to be used in combination shall conform to the requirements of Par. 202.

3. The maximum size of electrode used shall be 1/4 inch.

4. The thickness of weld layers, except root and surface layers, shall not exceed 1/4 inch. A split layer (stringer) technique shall be used in making multiple pass welds when the width between surfaces to be welded exceeds 5/8 inch.

5. Neither the depth nor the maximum width of the cross section of the weld metal area, at any point in a single pass weld or weld pass, shall exceed the width of the face of the weld or weld pass.

6. The welding current, voltage, and speed of travel shall be such that each pass will have complete fusion with the adjacent base metal and weld metal with no overlap or undercutting. The maximum current to be used for any pass that has fusion to both faces of a groove shall be 600 amp. When using the split-layer or stringer technique, the currents may be higher.

7. In the welding of joints designed as stress carrying members, the use of semi-automatic ("Squirt-Gun") welding will not be allowed unless altered to provide automatic guidance.

8. After the current, voltage, and speed of travel are established and welding is being done on the structure, variation from the approved procedure shall not exceed the following:

Welding Current $\pm$ 10%
Arc Voltage $\pm$ 7%
Speed of Travel $\pm$ 10%

9. Surfaces on which submerged arc welds are to be deposited and adjacent faying surfaces shall be clean as specified in Section 18 of Item 441,"Steel Structures" and shall be free of moisture.

10. Each weld pass shall have all slag removed before any additional weld is

deposited on it.

11. Groove welds shall be terminated at the end of a joint with the use of extension bars or run-off plates. The bars shall be a minimum of 3 inches in length, of the same edge preparation as the splice to be joined, and of the same approximate thickness. After the completion and cooling of the weld the extension bars shall be removed, the flange edges ground smooth, edge defects filled with weld metal and reground to a smooth finish. The grinding shall be parallel to the direction of stress.

12. Run-off plates shall be required at the ends of fillet welds of main members of sufficient length to insure that the welds are terminated beyond the ends of the member used in the structure.

13. Roots of groove welds may be sealed with a root pass made by manual shielded metal-arc welding with E 7015, E 7016, or E 7018 electrodes when such sealing is necessary to prevent burn through of the initial submerged arc welding pass.

14. Preheat ahead of the welding of both fillet and groove welds shall be required as follows:

A 373 Steel	
2" Thickness and under	None
Over 2" thickness	100 F + 25 F per 1/4" increase in thickness.
A 441 and A 36 Steels	
3/4" Thickness and under	None
Over 3/4"	100 F + 25 F per 1/4" increase in thickness

15. Flux shall not be removed from the weld until cooling has been completed, except for short sections for visual inspection.

16. In lieu of fillet welds of the size shown, a full butt weld may be used when the joint type is applicable, provided that the welds are made in accordance with all the requirements for butt joints. Particular attention shall be given to the requirements of subparagraph 5 of Paragraph 303 as to the depth of fusion with respect to width of weld metal.

PROCEDURES FOR SUBMERGED ARC WELDING

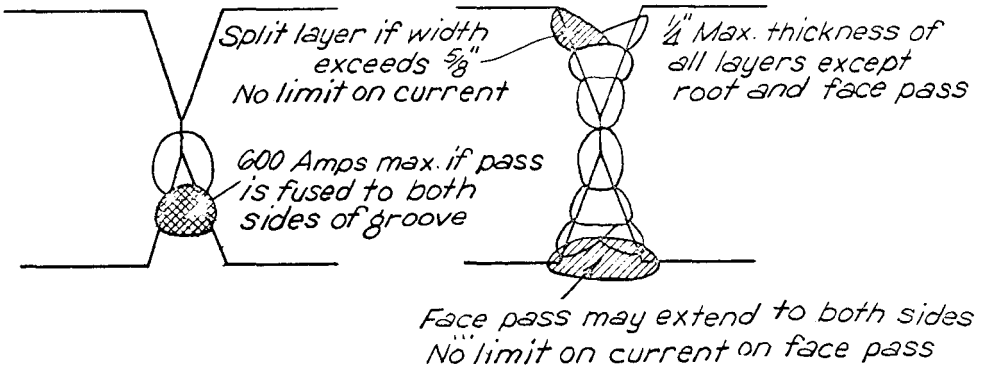


Figure 1

304. Quality of Welds.

1. Weld metal shall be sound throughout. There shall be no cracks in any weld or weld pass.

2. Welds shall be free from overlap and the base metal free from undercutting.

3. All craters shall be filled to the full cross section of the welds.

305. Corrections.

1. When welding is unsatisfactory or indicates inferior workmanship, the following corrective measures will be required by the Engineer whose specific approval shall be obtained for making each correction:

(a). Where requirements prescribe the removal of part of the weld or a portion of the base metal, such removal shall be by chipping, grinding, oxygen gouging, arc-air gouging, or by a combination of the above.

(b). Where corrections require the deposition of additional weld metal, the sides of the area to be welded shall have not less than a 1 to 1 slope to allow sufficient room for depositing new metal.

(c). Defective or unsound welds shall be corrected either by removing and replacing the entire weld, or as follows:

(1). Excessive convexity. Reduce to size by removal of excess weld metal by grinding.

(2). Shrinkage cracks, cracks in base metal, craters, and excessive

porosity. Remove defective portions of base and weld metal down to sound metal, and deposit additional sound weld metal.

(3). Undercutting, undersize, and excessive concavity. Clean and deposit additional weld metal.

(4). Overlapping and incomplete fusion. Remove and replace the defective portion of weld.

(5). Slag inclusions. Remove those parts of the weld containing slag and fill with sound weld metal.

(6). Removal of adjacent base metal during welding. Clean and form full size by depositing additional weld metal.

2. Where corrections require the deposition of additional weld metal, the electrode used shall be smaller than the electrode used for making the weld. Surfaces shall be cleaned thoroughly before rewelding.

3. A cracked weld shall be removed throughout its length, unless the extent of the crack can be ascertained to be limited, in which case the weld shall be removed 2 inches beyond each end of the crack and repairs made.

4. 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 removal of welds or members or both before making the necessary corrections, or else the deficiency shall be compensated by additional work according to a revised design approved by the Engineer.

5. Improperly fitted and misaligned parts shall be cut apart and rewelded. Members distorted by the heat of welding shall be straightened by mechanical means or by the carefully supervised application of a limited amount of localized heat. Heated areas shall not exceed 1200 F. as measured by Tempil-sticks. Parts to be heated for straightening shall be substantially free of stress from external forces, except when mechanical means are used in conjunction with the application of heat.

SECTION 4 - INSPECTION

401. General.

1. The Inspector designated by the Engineer shall ascertain that all fabrication is performed in accordance with the Specifications.

2. The Inspector shall be allowed free access to the work. He shall be notified in advance of the start of any fabrication operations.

3. The Inspector shall witness the welding and testing of all qualifications tests required, except those made under the supervision of qualified and approved Commercial Testing Laboratories.

4. The Inspector shall inspect all welding and fabrication equipment used in the work to determine that it conforms with the pertinent standard requirements of the latest AWS Specifications for such equipment.

5. When the quality of a welder s or welding operator's work appears to be below the requirements of these Specifications, the Inspector shall require testing of his qualification by requalification.

6. The Inspector shall require requalification of any welder or welding operator who has not been employed at the process for which he has been qualified for a period exceeding six months.

7. The Contractor shall comply with all requests of the Inspector to correct improper workmanship and to remove and replace, or correct as required all welds found defective or deficient.

8. In the event that faulty welding or its removal for rewelding, shall so damage the base metal that in the judgment of the Engineer its retention is not in accordance with the intent of the plans and specifications, the Contractor shall remove and replace the damaged material or shall compensate for the deficiency in a manner approved by the Engineer.

9. Methods of non-destructive testing and inspection other than radiography will be used when required by the Engineer.

402. Radiographic Inspection.

1. All butt welds designed to carry primary stresses shall meet the following radiographic standards. When subjected to radiographic inspection, the presence of any of the following defects in excess of the limits indicated will result in rejection of the defective weld until corrected.

(a). Sections of welds that are shown by radiographv to have any of the following imperfections shall be judged unacceptable:

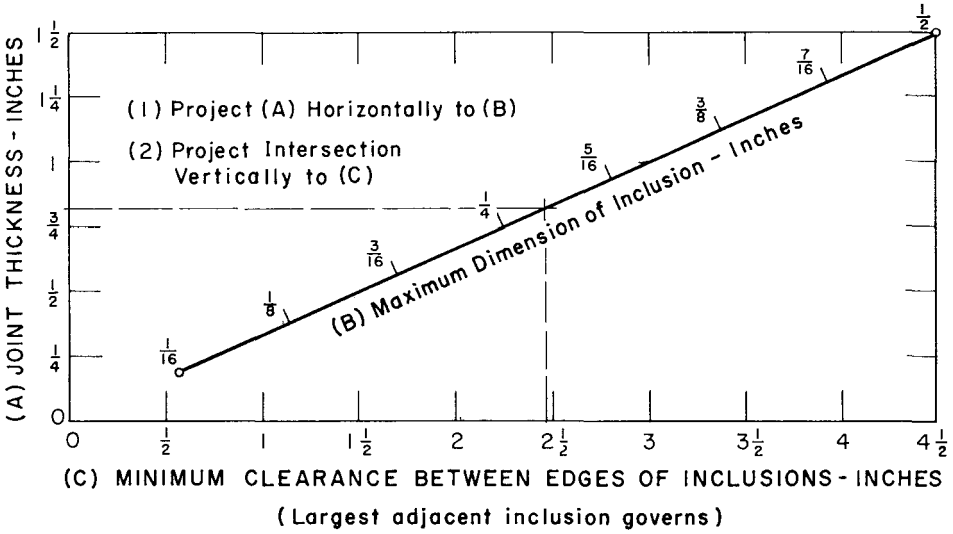
Cracking, regardless of length or location, incomplete fusion, overlapping, or lack of complete penetration.

(b). Sections of welds that have imperfections greater than shown below shall be unacceptable:

(1). Inclusions less than one-sixteenth of an inch in greatest dimension including slag, porosity, and other deleterious material, shall be permitted if well dispersed so that the sum of the greatest dimensions of the inclusions in any linear inch of welded joint shall not exceed three-eights of an inch.

(2). Inclusions one-sixteenth of an inch or larger in greatest dimension shall be permitted providing such defects do not exceed the limits shown on Figure 2 or paragraph (1) above.

(3). There shall be no inclusion greater than one-sixteenth of an inch, within one inch of the edge of part or member at the joint or point of restraint.



NOTES:

1. The distance from the edge of an inclusion to the free edge of plate or toe of a flange fillet weld shall be equal to or greater than the clearance between inclusions.

2. Inclusions with any dimension greater than 1/2" are not acceptable.

3. For joint thicknesses greater than 1-1/2" the minimum allowable dimension and spacing of inclusions shall be the same as for 1-1/2" joints.

4. Values of (B) obtained by projecting horizontally from (A) are maximum values. Any value of (B) smaller than the maximum is satisfactory.

5. Values of (C) obtained by projecting vertically from (B) are minimum values. Any value of (C) larger than the minimum is satisfactory.

Figure 2

RADIOGRAPHIC STANDARDS FOR ALLOWABLE INCLUSIONS

403. Inspection of Stud Welding.

1. The studs shall be of the size and length as required on the plans. They shall be free of rust, scale or pits, and free from oil at the time of welding.

2. The studs shall be welded to the steel by means of a portable welding gun as recommended by the manufacturer for the size studs furnished. The power source shall furnish satisfactory voltage and current to operate the gun adequately.

3. If two or more guns are to be activated by the same power source, they shall be interlocked so that only one gun can operate at a time and so that the generator has fully recovered from operating one gun before the next gun is activated.

4. Before starting any stud welding, or if the stud welding equipment has been idle for more than one hour, two trial studs shall be welded to a test plate. These studs shall be bend down to the plate by striking with a hammer. This shall be done until the two trial studs show no failure.

5. After the studs have been welded to the beam, they shall be inspected to see if there are any studs which show less than 90 percent of a full fillet around the base of the stud. Ten percent of those showing less than 90 percent fillet, but no more than ten studs shall be hammered towards the center of the member to approximately 30 degrees off the vertical. These studs shall show no signs of failure. All which show failure shall be replaced.

6. If some of the studs show failure, the Inspector shall hammer a representative number of the remaining studs forcibly with a hammer. If the stud does not yield a solid ringing sound, it shall be bent the 30 degrees, and if it shows any sign of failure, it shall be replaced.

7. Before replacing a new stud where one has been removed, the area shall be ground free of any metal left from the old weld, or in the case of a pull-out of metal, the pocket shall be filled with weld metal using low hydrogen electrodes and ground flush.

8. All studs shall show complete fusion and a minimum of 90 percent fillet at the base. Deficiencies shall be corrected by a manual weld of not less than a 1/8" fillet over the defective area.

9. The finished studs shall be sound and of uniform quality, free from inclusions, segregations, pipes, laps, cracks, or other defects.

SECTION 5 - QUALIFICATIONS

501. Prequalified Joints.

1. Joints which conform to the details specified in Appendix A and B and which are welded in accordance with these specifications may be used at the option of the fabricator without performing joint procedure qualification tests. No deviation in dimensions shown in Appendix A and B will be allowed unless shown on the contract plans. Fillet welds shown on contract plans and conforming to details shown in Appendix E may be used without joint precedure qualification.

2. Joint details may depart from those details only if the fabricator submits to the Engineer his proposed joints with his joint welding procedure and at his own expense demonstrates their adequacy by performing the tests specified by Section 502 below.

502. Tests for Qualifying Joints.

Test Specimens shall be made using materials and joint details to be used in construction. Thickness of material shall be the maximum to be used in the work but need not exceed 1-1/2 inches, except that joints requiring full penetration shall be tested in each thickness to be used.

The required tests for each type of joint shall be as shown in Table 3

Table 3

Procedure Qualification Tests

Type of Joint	Face Bend	Root Bend	Side Bend	Reduced Section Tensile	Etched Macro-Section	Hardness	Fillet Break
Groove Butt							
3/4 and Under	1	1		2	2	2	
Over 3/4			2	2	2	2	
Tee & Corner					2	2	
Fillet					2	2	1

NOTES:

1. Bend tests and reduced section tensile test shall be made and tested according to T. H. D. Bulletin C-6.

2. See Appendix C for fillet weld test.

3. Etched-Macro-Section shall meet penetration and visual requirements. The maximum Brinell Hardness of the weld metal and heat affected zone shall be not greater than:

$$\frac{\text{(Maximum Specified Tensile Strength of Parent Metal)}}{500} \text{ plus } 50.$$

503. Filler Metal Procedure Qualification.

1. For ASTM Designation A 441 and A 36 Steels, the electrodes for manual welding and the wire and flux used for submerged arc welding shall be subjected to a reduced section tensile tests and a free bend test prior to approval of its use. Tests shall be made and tested according to THD Bulletin C-6 The tests shall show that the material will produce the values required by Section 201 and 202. Unless changes are made in materials, Filler Metal Qualification shall be good for a period of six months.

2. For ASTM Designation A 7 and A 373 Steels, the materials need not be qualified if the fabricating plant can show a satisfactory record of service with the same materials to be used. If this cannot be furnished, the tests required under 503, 1 above will be required.

504. Automatic Welding Procedure Qualification.

To establish the current, voltage, and speed of travel to be used to guide the quality of work required as to appearance, soundness, ductility, etc., test specimen will be required prior to the beginning of work. If no changes are made in equipment, materials or personnel for subsequent work, such qualification shall be good for a period of 6 months.

1. The following tests shall be made using the same materials and welding procedure that is to be used in the work.

(a). For butt welds.

A test joint or joints or the same groove preparation and maximum thickness to be welded (1-1/2" maximum) and not less than 12" length, shall be made.

(b). For fillet welds.

A test joint or joints of the same cross section as the material to be welded, not less than 18" in length, shall be made.

(c). The above test joints shall pass a visual inspection to insure that size,

appearance, contour, porosity, undercut and overlap requirements are met.

2. The number and type of tests required shall be as follows:

(a). For welding of ASTM Designation A 441 and A 36 Steels, the tests shown in Table 3 will be required.

(b). For welding of ASTM Designation A 7 and A 373 Steels, the tests shown in Table 3 will be required except that and Reduced Section Tensile tests will not be required.

505. Welder Qualification.

1. For manual welding, the welder shall be qualified in accordance with the requirements of THD Bulletin C-6. Fabricating shops with the proper facilities for administering the tests may do so with the permission of the Engineer, and under the direct supervision of the Materials and Test Division.

2. Welders who are certified for Department work on the date this specification goes into effect need not be requalified provided they have a satisfactory performance record.

506. Welding Operator Qualification.

1. Operators who perform the submerged arc procedure qualification tests shall be automatically qualified. Performance of the same tests, adhering to the operating procedure as approved, will qualify other operators, subject to visual tests and etch tests provided in par. 504 above. No tensile tests, bend tests, or hardness tests will be required.

SECTION 6 - EQUIPMENT

601. Equipment - General Provision.

1. All items of equipment for welding and oxygen cutting shall be so designed and manufactured and be in such condition as to enable qualified welders and welding operators to follow the procedures and attain the results prescribed elsewhere in these Specification.

602. Protective Equipment.

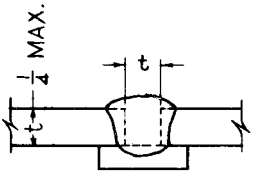
1. All personal protective equipment shall conform to the current American Standard Z49. 1 "Safety in Electric and Gas Welding and Cutting Operations".

2. The Contractor shall enforce the use of approved accessories necessary for the protection and convenience of the welders and welding operators and for the proper and efficient execution of the work.

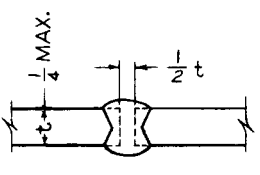
3. Suitable protection against radiation from the arc shall be maintained by the Contractor where arc-welding operations might be viewed within harmful range by persons other than the actual welders, welding operators and inspectors.

APPENDIX A

Prequalified Joints for Manual Welding

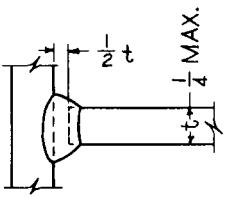


220-A

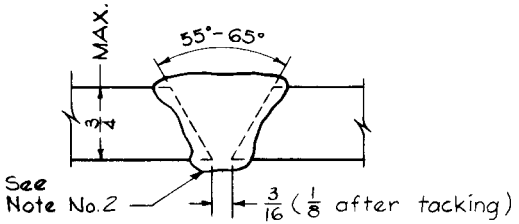


220-B

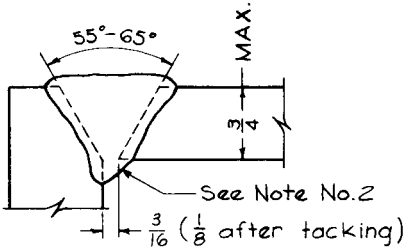
SQUARE, BUTT
(Weld must be centered on joint.)



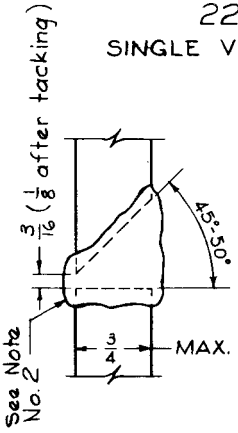
220-BA
SQUARE, TEE OR CORNER



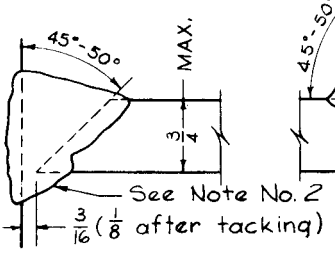
220-C
SINGLE VEE, BUTT



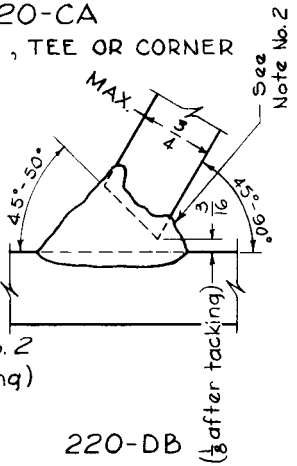
220-CA
SINGLE VEE, TEE OR CORNER



220-D
SINGLE BEVEL, BUTT
Horizontal Position Only



220-DA
SINGLE BEVEL
TEE OR CORNER



220-DB
SINGLE BEVEL, SKEW
TEE OR CORNER

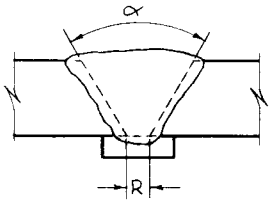
1. Gouge root to sound metal before welding second side.
2. Weld after welding at least one pass on other side.
3. All root openings are minimum.
4. Root opening shown are openings which should be set prior to welding (or after tacking) to obtain sound welds. Lengths of members for fabrication, however, should be determined on the basis of zero root opening.

- MANUAL SHIELDED METAL-ARC WELDED BUTT, TEE AND CORNER JOINTS OF LIMITED THICKNESS

LIMITATIONS FOR JOINTS 220-E AND 220-EA

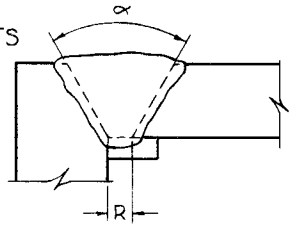
α*	R	Permitted Welding Positions
45°	$\frac{1}{4}$	All positions
30°	$\frac{3}{8}$	Flat and Overhead only.
20°	$\frac{1}{2}$	Flat and Overhead only.

*Limitation of α are: (+5°,-0°)



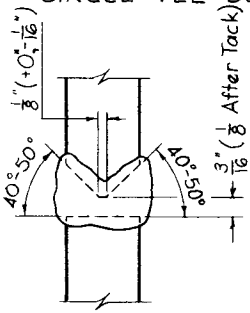
220-E

SINGLE VEE BUTT



220-EA

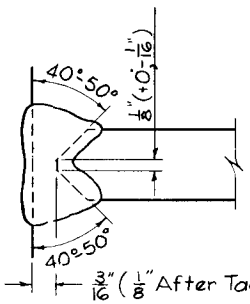
SINGLE VEE TEE OR CORNER



220-K

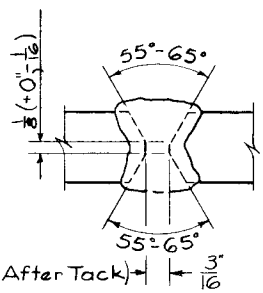
DOUBLE BEVEL BUTT

Horizontal Position only



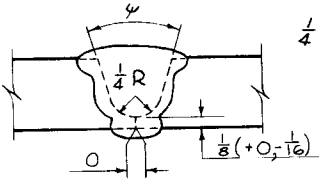
220-KA

DOUBLE BEVEL TEE OR CORNER



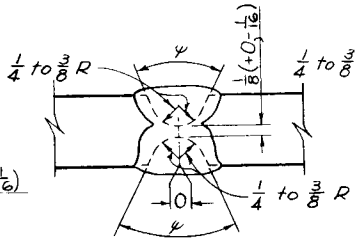
220-G

DOUBLE VEE BUTT



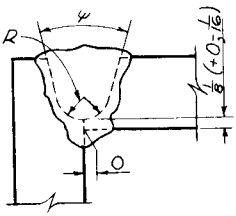
220-L

SINGLE U BUTT



220-M

DOUBLE U BUTT



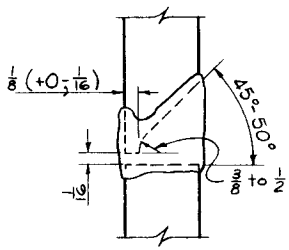
220-LA

SINGLE U CORNER

LIMITATIONS FOR JOINTS 220-L, 220-LA & 220-M

ψ	Permitted Welding Positions
45°	All Positions
20°	Flat and Overhead only

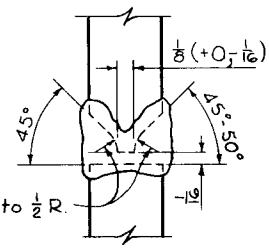
*Limitation of ψ are: (+5°,-0°)



220-N

SINGLE J BUTT

Horizontal Position Only



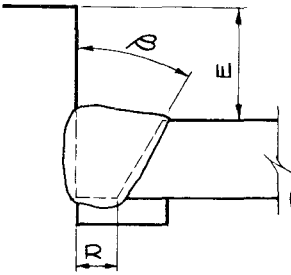
220-P

DOUBLE J BUTT

Horizontal Position Only

Notes for Manual Weld on Page apply to the joints shown on this page

MANUAL SHIELDED METAL-ARC WELDED BUTT, TEE AND CORNER JOINTS OF UNLIMITED THICKNESS

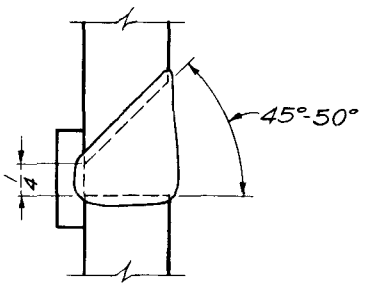


LIMITATIONS FOR JOINTS
220 - HA

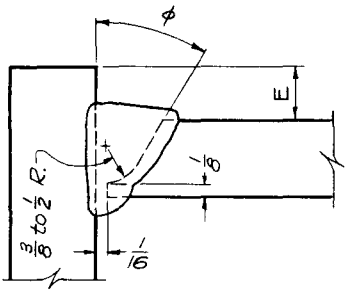
B*	R	Permitted Welding Positions	E
45°	1/4	All Positions	Unlimited
30°	3/8	Flat and Overhead Only.	Not Over 3"

*Limitations on B are: (+5°,-0°)

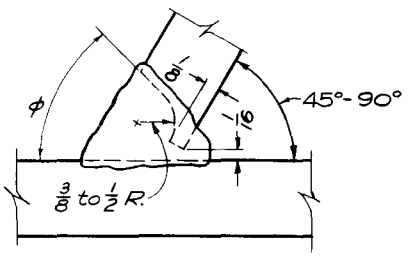
220 - HA
SINGLE BEVEL TEE OR CORNER



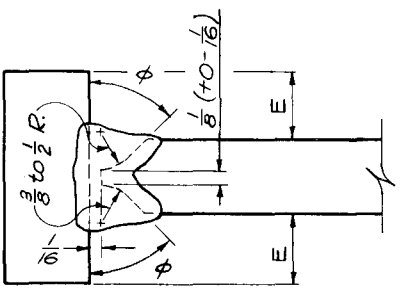
220 - H
SINGLE BEVEL BUTT



220 - NA
SINGLE J TEE OR CORNER



220 - NB
SINGLE J SKEW TEE OR CORNER



220 - PA
DOUBLE J TEE OR CORNER

Notes for Manual Welding on Sheet apply to the joints shown on this sheet.

LIMITATIONS FOR JOINTS
220-NA, 220PA & 220-NB

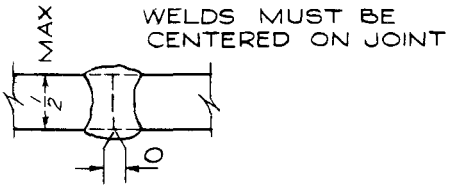
φ	Permitted Welding Positions	E (220-NA) (220-PA)
45°	All Positions	Unlimited
30°	Flat and Overhead Only	Not Over 3"

Limitations on φ are: (+5°,-0°)

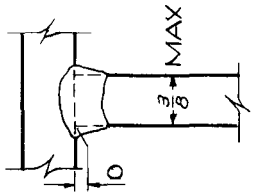
MANUAL SHIELDED METAL-ARC WELDED BUTT, TEE AND CORNER JOINTS OF UNLIMITED THICKNESS

APPENDIX B

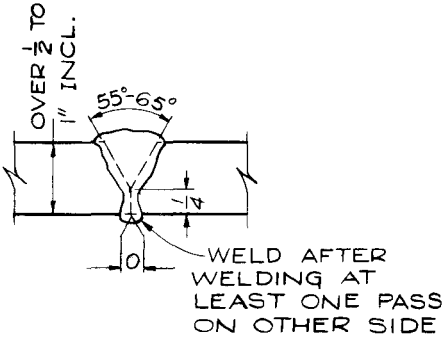
Prequalified Joints for Submerged Arc Welding



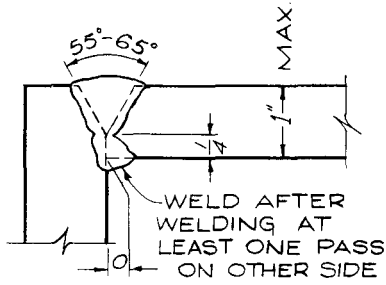
221-A
SQUARE BUTT JOINT



221 - AA
TEE JOINT OR CORNER JOINT

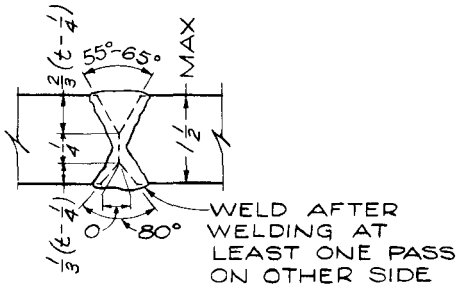


221 - C

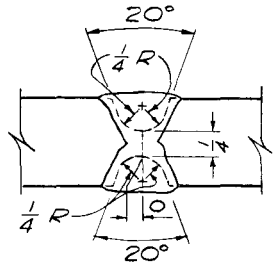


221 - CA

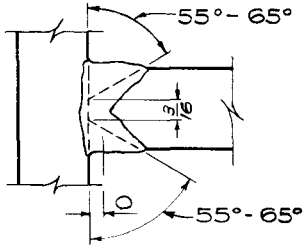
SINGLE VEE BUTT AND CORNER JOINT



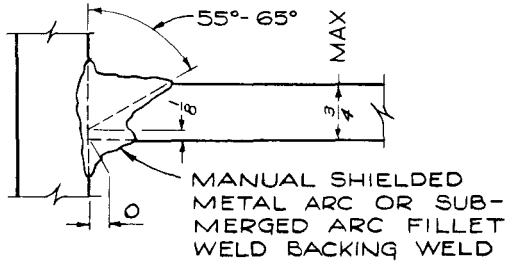
221 - E
DOUBLE VEE BUTT JOINT



221 - F
DOUBLE U BUTT JOINT



221 - KA



221 - HA

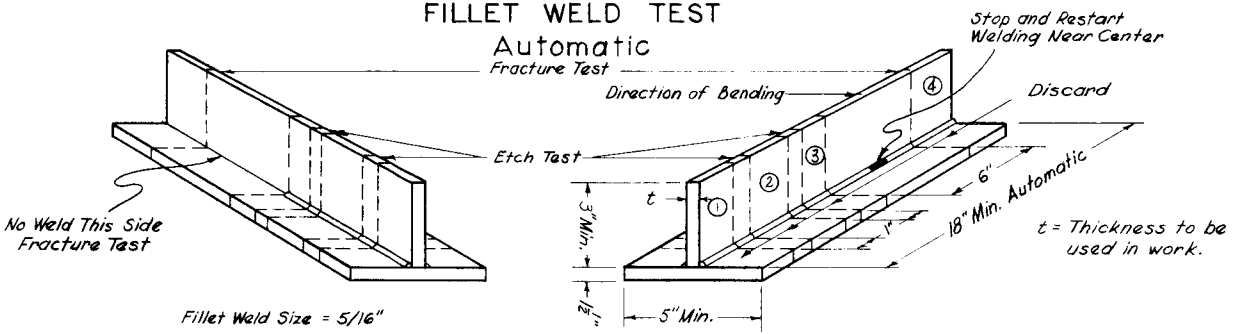
SINGLE AND DOUBLE BEVEL TEE AND CORNER JOINT

APPENDIX C
Procedure Qualification Fillet Weld Test for Submerged Arc Welding

OPERATOR & PROCEDURE QUALIFICATION

FILLET WELD TEST

Automatic



PROCEDURE QUALIFICATION

PREPARATION OF TEST SPECIMENS

Specimens may be sawed, machined, or flame cut from welded test joint.
The ends of etched specimen shall be smooth for etching.

TESTING

Fracture Test

The stem of the 6" Section shall be loaded laterally in such a way that the root of the weld is in tension.
The load shall be steadily increased until the specimen fractures or bends upon itself.

Macro Etch Test

The specimen shall be etched with a suitable solution to give a clear definition of the weld.

RESULTS

Fracture Test

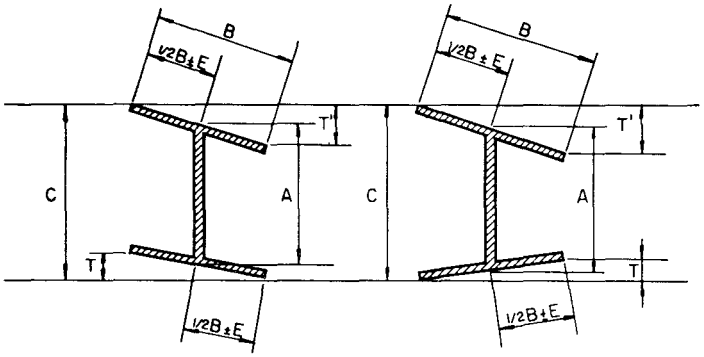
A specimen shall not fracture or if fractured shall not contain defects such as slag, overlap, undercut, etc., totaling more than 1/2". Evidence of cracks in a weld or incomplete root fusion shall constitute grounds for rejection.

Macro Etch Test

The weld shall show fusion to the root but not necessarily beyond root and be free from cracks. Convexity or concavity of welds shall not exceed 1/16". Both legs of weld shall be equal to within 1/16".

APPENDIX D
Fabrication Tolerances

PERMISSIBLE VARIATIONS IN CROSS-SECTION FOR WIDE FLANGE SHAPES.



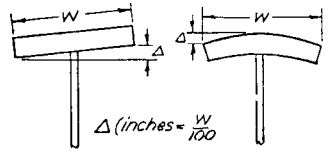
Section Nominal Size, in.	*A*, Depth, in.		*B*, Flange Width, in.		$T + T'$, Flanges Out of Square, max, in.	*E*, Web off Center, max, in.	*C*, Maximum Depth at any Cross-Section over Theoretical Depth, in.
	Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical			
Up to 12, incl.	1/8	1/8	1/4	3/16	1/4	3/16	1/4
Over 12	1/8	1/8	1/4	3/16	5/16	3/16	1/4

A is measured at center line of web.
B is measured parallel to flange.
C is measured parallel to web.

TABLE XIX.—PERMISSIBLE VARIATIONS IN STRAIGHTNESS FOR WIDE FLANGE SHAPES.

Wide Flange Shapes	Permissible Variation
Camber and sweep	$\frac{1}{8}$ in. $\times \frac{\text{number of feet of total length}^a}{10}$
When certain sections[b] with a flange width approximately equal to depth are specified on order as columns:	
Lengths of 45 ft and under	$\frac{1}{8}$ in. $\times \frac{\text{number of feet of total length}}{10}$ but not over $\frac{3}{8}$ in.
Lengths over 45 ft	$\frac{3}{8}$ in. $+ \frac{1}{8}$ in. $\times \frac{\text{number of feet of total length} - 45}{10}$

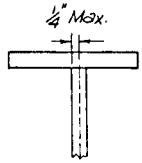
DIMENSIONAL TOLERANCES



TILT OF GIRDER FLANGE

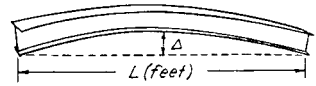
WARPAGE OF GIRDER FLANGE

"A"



DEVIATION BETWEEN CENTERLINE OF WEB AND CENTERLINE OF GIRDER FLANGE

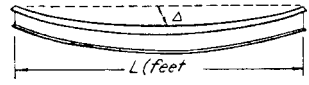
"B"



DEVIATION OF CAMBER OF GIRDERS

Δ (inches) = ± L/320

"C"

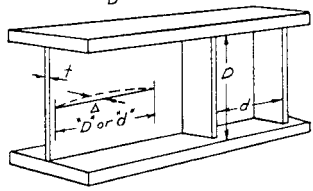


SWEEP OF GIRDERS

Δ (inches = L/80

"D"

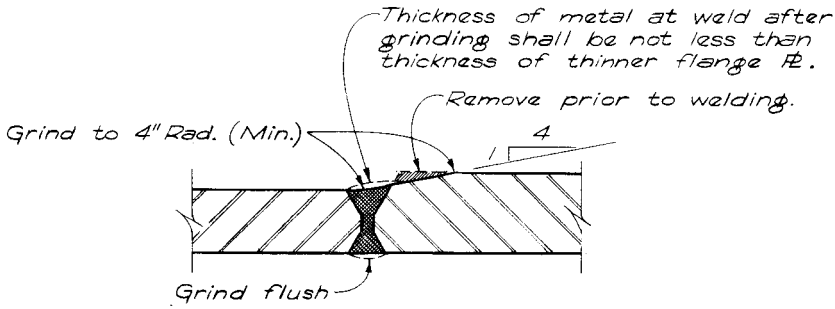
Intermediate stiffeners on both sides of web:
if t = less than D/150 Δ = D/120 or D/120
t = D/150 or more Δ = D/150 or D/150
Intermediate stiffeners on one side of web:
t = less than D/100 Δ = D/100 or D/100
t = D/100 or more Δ = D/150 or D/150
No intermediate stiffeners = D/150



DEVIATION FROM FLATNESS OF GIRDER AND I-BEAM WEBS

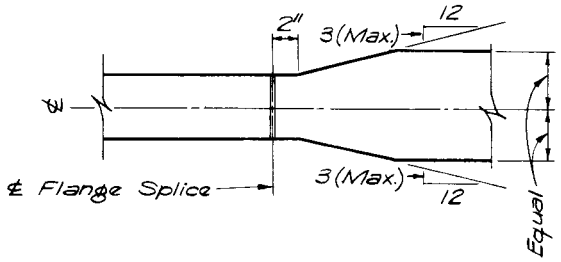
"E"

APPENDIX E
General

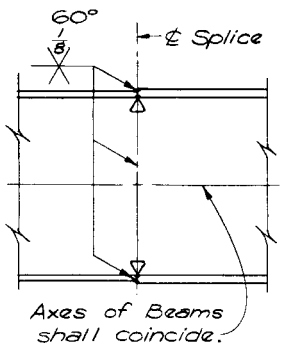


Grinding shall be done in the direction of stress, and in such a manner that the metal is kept below the blue brittle range.

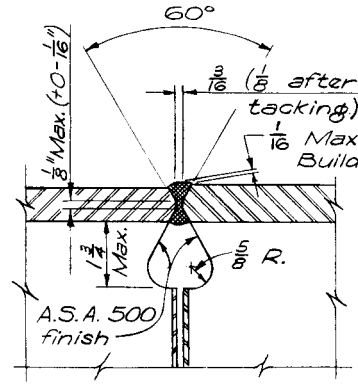
SECTION THRU FLANGE



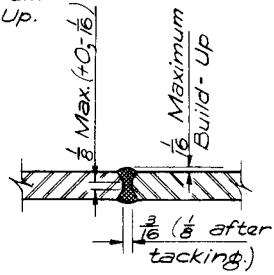
PLAN OF FLANGE



ELEVATION

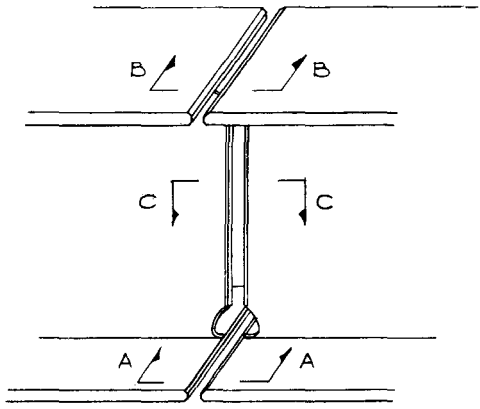


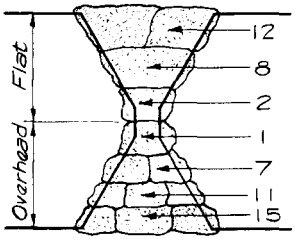
SECTION THRU FLANGE SPLICE

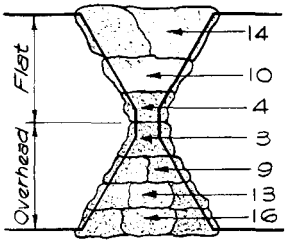


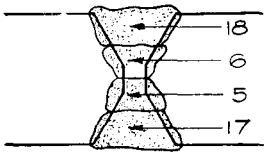
SECTION THRU WEB SPLICE

BEAM AND GIRDER SPLICE DETAILS









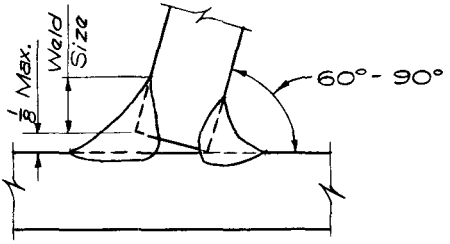
Passes 1 and 2 may be put in the top flange and 3 and 4 in the bottom flange.

SECTION A-A
Bottom Flange

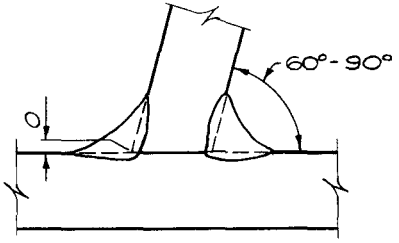
SECTION B-B
Top Flange

SECTION C-C
Web

MANUAL WELDING PROCEDURE FOR SPLICES



C



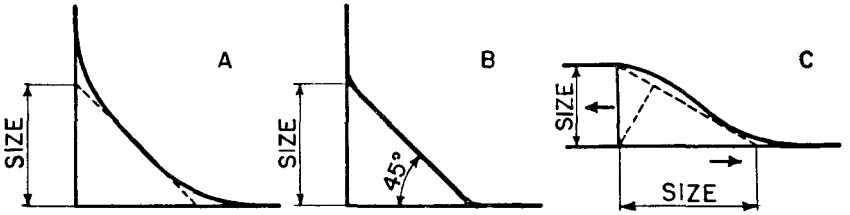
D

SKEWED TEE JOINTS

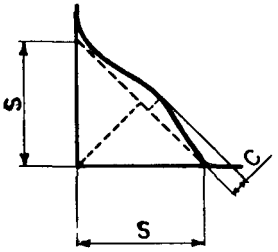
~ Details for Fillet Welds ~

MANUAL SHIELDED METAL-ARC WELDING AND SUBMERGED ARC WELDING

WELD PROFILES.

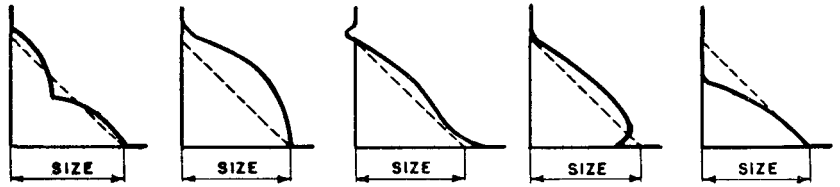


DESIRABLE FILLET WELD PROFILES.



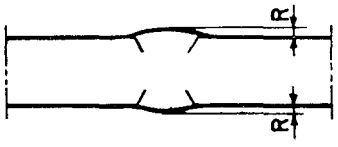
CONVEXITY, C,
SHALL NOT EXCEED
0.1 S + 0.03 INCH.

ACCEPTABLE FILLET WELD PROFILE. D



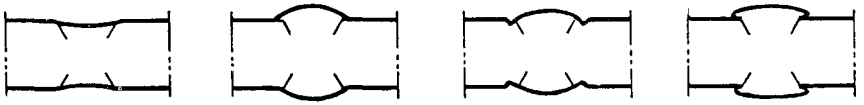
INSUFFICIENT THROAT | EXCESSIVE CONVEXITY | UNDERCUT | OVERLAP | INSUFFICIENT LEG

DEFECTIVE FILLET WELD PROFILES. E



REINFORCEMENT, R,
SHALL NOT EXCEED
1/8 INCH.

ACCEPTABLE BUTT WELD PROFILE. F



INSUFFICIENT THROAT | EXCESSIVE CONVEXITY | UNDERCUT | OVERLAP

DEFECTIVE BUTT WELD PROFILES. G