

Item No. 723 Structural Welding

723.1 Description

This item shall consist of field welding of structural steel and reinforcing steel.

Provisions are made herein for the welding of the types of steel listed in Table 2, using the manual shielded metal-arc process, semiautomatic (manual) gas metal-arc welding and flux cored arc welding processes. Other welding processes may be permitted with the specific approval of the Engineer and with qualification of the welding procedure.

Shop fabrication and welding shall conform to Item No. 721, "Steel Structures" and TXDOT Bulletin C-5.

723.2 General

All welds including tack welds to be incorporated shall be made by a certified welder. Tack welds shall be cleaned and fused thoroughly with the final weld. Defective, cracked or broken tack welds shall be removed.

Certification for welders shall conform to TXDOT Bulletin C-6. Miscellaneous welds may be made by a welder qualified conforming to "Welder Qualification", below.

Welds shall be as indicated. The location or size shall not be changed without approval of the Engineer.

The welder shall identify groove welds made by the welder with paint or indelible ink.

Welding will not be allowed when air temperature is lower than 20 F, surfaces are wet or exposed to rain, snow or wind or when operators are exposed to inclement conditions that will hamper their performance.

Moisture present at the point of welding shall be driven off conforming with Table 3, before welding commences. Wind breaks shall be required for the protection of all welding operations.

There shall be no temporary welds for transportation, erection or other purposes on main members, except at locations more than 1/6 the depth of the web from the flanges of beams and girders as indicated or as approved by the Engineer.

ASTM A 514/517 steels shall maintain all groove welds in main members and in flanges of beams and girders subject to tensile stress or reversals of stress shall be finished smooth and flush on all surfaces, including edges, by grinding in the direction of applied stress leaving the surface free from depressions. Chipping may be used provided it is followed by such grinding. Parts joined by groove welds connecting plates of unequal thickness or width shall have a smooth transition between offset surfaces at a slope not greater than 1 in 4 with the surface of either part. The surfaces shall be ground so that the radii at the points of transition shall be 4 inches minimum.

All groove welds, except when produced with the aid of backing, shall have the root of the initial weld gouged, chipped or other-wise removed to sound metal before welding

is started from the second side, except that back gouging will not be required when welding steel piling or armor joints with E 6010 electrodes. The back side shall be thoroughly cleaned before placing backup pass.

When backing for welds is left in place to become a part of the structure, it shall be a single length insofar as possible. Where more than a single length is needed, they shall be joined by full penetration butt welds. The surfaces of this butt weld shall be ground flush as necessary to obtain proper fit-up in the weld joint.

Before welding over previously deposited metal, all slag shall be removed and the weld and adjacent base metal shall be cleaned. This requirement shall apply equally to successive layers, successive beads and the crater area.

Arc strikes outside the area of permanent weld must be avoided on all steels. Where they do occur, resulting cracks and blemishes shall be ground out to a smooth contour and checked to insure soundness.

Stringer bead technique shall be used where possible for groove welds on all types of steel. Weaving will not be permitted for ASTM A 514/517 steel except in vertical welding, where a weave not exceeding 2 electrode diameters is permissible for manual shielded metal-arc process.

In all welding processes the progression for all passes in vertical welding shall be upward using a back step sequence.

Groove welds shall begin and terminate at the ends of a joint 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 3/4 inch beyond the joint. Extension bars shall be removed with a cutting torch or arc-air gouging upon completion of the weld and the flange edges shall be ground smooth.

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 flange. Excess grinding of the parent metal shall be avoided.

723.3 Materials

Electrodes for manual shielded metal arc welding shall conform to the requirements of the latest edition of "Specification 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", ASW A5.5.

All electrodes and combination of electrode shielding for gas metal-arc welding for producing weld metal with a minimum specified yield point not exceeding 60,000 psi shall conform to the requirements in the latest edition, "Specification for Mild Steel Electrodes for Gas Metal-Arc Welding", AWS A5.18, AWS A5.28 or "Specification for Mild Steel Electrodes for Flux Cored Arc Welding", AWS A5.20, applicable for the classifications producing weld metal having a minimum impact strength of 20 ft/lb, Charpy V-notch, at a temperature of 0 F or below.

For weld metal with a minimum specified yield strength exceeding 60,000 psi, the Contractor shall demonstrate that each electrode and flux or combination of electrode and shielding medium proposed for use will produce low alloy weld metal having the mechanical properties listed in Table 1 in the as welded condition.

The mechanical properties shall be determined from a multiple pass weld made in accordance with the test requirements of the latest edition of AWS A5.18, AWS A5.20 or AWS A5.28 as applicable.

Table 1: Required Mechanical Properties for GMAW and FCAW Electrodes					
		Tensile Strength	Yield Strength	Elongation,	Strength
GMAW	FCAW	psi -	psi -	% in 2 inches	ft-lb at 0 F -
Grade	Grade	Minimum	Minimum	Minimum	Minimum
ER80S	E80T	80,000	65,000	18	20
ER90S	E90T	90,000	78,000	17	20
ER100S	E100T	100,000	90,000	16	20
ER110S	E110T	110,000	98,000	15	20

The mechanical property tests for Grades ER100S, E100T and E110T shall be made using ASTM A 514/517 base metal.

All electrodes used on City projects shall be approved by the Engineer. Tests shall be made on electrodes of the same class, size and brand which were manufactured by the same process and with the same materials as the electrodes to be furnished. Tests must be made and approval renewed every 12 months.

For sizes of electrodes not requiring tests by AWS Specifications, test reports shall be furnished for electrodes of the nearest size and of the same classification. The request for approval shall include the manufacturer's certification that the process and material requirements were the same for manufacturing the tested electrodes and those to be furnished and new test reports, shall be submitted if any changes are made in process or materials during the effective period.

Class of electrodes required will be shown in Table 2. Electrodes shall be used with the type of current, the polarity and in the positions permitted by AWS A5.1 and A5.5 for manual shielded metal-arc welding. AWS A5.18 or A5.20 and A5.28 Specifications shall govern for gas metal-arc welding and flux cored arc welding.

Table 2: Classifications of Electrodes Permitted					
Type of Steel	Main Members Groove & Fillet Welds			Secondary Members Groove & Fillet Welds	
Steel Piling,	E6010	E60T-8	E60XX	E60T-8	ER70S-2
A 53 Pipe,	E6011	E70S-1B	E70XX	E7XT-1	ER70S-3
A 500,	E7016	ER70S-2	E702-1B	E7XT-5	ER70S-6
A 501,	E7018	ER70S-3	E70S-2	E7XT-6	ER70S-7
Armor Joints		ER70S-6	E70S-3	E7XT-8	
		ER70S-7	E70S-6		
			E70U-1		
A 36,	E7016	ER70S-2	E7016	ER70S-2	
A 441,	E7018	ER70S-3	E7018	ER70S-3	
A 572 Grade 50	E7XT-1	ER70S-6	E7XT-1	ER70S-6	
A 588,	E7XT-5	ER70S-7	E7XT-5	ER70S-7	
A 242 Deck Plates	E7XT-6		E7Xt-6		
API Pipe	E7XT-8		E7XT-8		
A 514/A 517	E10018M	ER1102	E11018M	ER110S	
2 1/2 inches thick or less	E110T		E110T		
A 514/A 517	E10018M	ER100S	E10018M	ER100S	
Over 2 1/2 inches thick	E100T		E100T		
A 588, A 242,	E8018,C-3		E8018,C-3		
A 618 Weathering Steel	E80T(3)	ER80S(3)	E80T(3) ER80S(3)		
Reinforcing Steel	E7016	E7018			
A 572 Grades 60 and 65 for Light Towers	E8016 E8018	E80T ER80S			

- (1) Use of the same type electrode with the next higher mechanical properties, conforming to AWS A5.1 or A5.5, than those listed will be permitted.
- (2) In joints involving base metals of different yield points or strengths, low hydrogen electrodes applicable to the lower strength base metal may be used.
- (3) Deposited weld metal for weathering steel shall have the following chemical composition: C, maximum percent, 0.12; Minimum percent, 0.51/1.30; P, maximum percent, 0.03; S, maximum percent, 0.04; Si, percent 0.35/0.80; Cu, per-cent, 0.30/0.75; Ni, percent, 0.40/0.80; Cr, percent, 0.45/0.70.

Before use, all electrodes with low hydrogen coverings conforming to AWS A5.1 shall be dried for not less than 2 hours between 450 F and 500 F and electrodes with low hydrogen coverings conforming to AWS 5.5 for not less than 1 hour at a temperature between 700 F and 800 F. Immediately after drying, electrodes shall be stored in ovens

held at a temperature of at least 250 F. E70 electrodes not used within 4 hours, E80 within 2 hours, E90 within 1 hour, E100 and E110 within 30 minutes after removal from the storage oven shall be redried before use. Electrodes with flux which has been wet, cracked or otherwise damaged, shall not be used. When ASTM A 514/517 steel is used for welding, electrodes shall be dried at least 1 hour at temperatures between 700 F and 800 F before being used. Electrodes may be redried only once.

Suitable facilities for drying and storage of electrodes shall be furnished at the job site, along with thermometers for checking and controlling the oven temperature.

In humid atmospheres, the times allowed for use without redrying may be reduced.

When a gas or gas mixture is used for gas metal-arc or flux cored arc welding, it shall be of a welding grade having a dew point of -40 F or lower. The gas manufacturer shall furnish certification to the Engineer that the gas or gas mixture is suitable for the intended application and will meet the dew point requirements.

Welding wire coils removed from the original package shall be protected or stored to keep their characteristics or welding proper-ties intact. Rusty coils or portions of coils that are rusty shall not be used.

Any deviation from the above electrode designation shall be approved by the Engineer.

723.4 Construction Methods

For any welding process, the parts to be joined by fillet welds shall be brought into as close as possible and shall not be separated more than 3/16 inch. If the separation is 1/16 inch or greater, the leg of the fillet weld shall be increased by the amount of the separation. The separation between faying surfaces of lap joints and of butt joints landing on backing strips shall not exceed 1/16 inch.

Splices of beams and girders joined by groove welds shall be carefully aligned with the center of gravity of both members coinciding or each flange vertically offset equally. Beams and girders with offset webs shall be fit with the webs aligned and the flanges offset laterally.

When flanges are offset or abutting parts differ a thickness or width by more than 1/8 inch, the joint shall be made with the slope of the weld metal to each surface, with a transition not exceeding 1 in 4.

Suitable allowance shall be made for shrinkage and the joint shall never be restrained on both sides in any welding process.

All butt splices shall be made before welding of diaframs or sway bracing in a particular section of a unit. Diaframs and sway bracing may be welded in a unit behind the splice welding to provide stability except where such welding interferes with butt splice adjustments such as at a drop-in segment of a continuous unit. All splices shall be made before welding of beams or girders to shoes.

For manual shielded metal-arc welding, the fit-up procedure listed below shall be used for manual shielded metal-arc welding of groove welds for butt joints:

Members shall be spaced to provide a 3/16 inch root opening at the nearest point. When at other parts of the joint the spacing provides up to and including a 7/16 inch opening correction may be made by buildup not exceeding 1/8 inch on each bevel nose. Openings exceeding 7/16 inch shall require rebeveling of the joint to bring it within the maximum buildup limits prescribed above. Build must be allowed to cool before proceeding with the welding.

All members shall be brought into correct alignment and held in position by acceptable clamps while being welded.

Deviations from the above fit-up procedure shall be approved by the Engineer.

723.5 Procedure

Shrinkage and distortion shall be controlled through the use of an approved procedure. Passes shall be made symmetrically and shall alternate between both sides of the joint.

For manual shielded metal-arc welding, beam and girder splices shall be made as indicated. Welds shall be alternated from side to side to prevent heat buildups on 1 flange edge. The passes must be arranged between the top and bottom flange to maintain balance and symmetry.

The sequence used in welding of splices in all I-beams shall be to first place 4 tacks (1 1/2 to 2 inches) in the web.

For I-beam or for built-up girders, place passes 1, 2 and 3 in the top flange, followed by passes 4, 5 and 6 in the bottom flange.

Gouge out and replace passes 1 and 4, which always are placed in the over position before welding on the web. Next, place passes 7 and 8 in the web after aligning girder webs with short tacks at approximately 8 inches on centers.

Alignment clamps may be removed when sufficient weld has been placed to hold the members together and welding is completed using the sequence indicated.

When welding the root passes of beam and girder splices, E7010 electrodes may be used, provided the work is preheated conforming to Table 3. After the root passes are backed up, the E7010 electrode pass shall be completely removed by arc-air gouging and replaced using low hydrogen electrode.

When this procedure is used, it shall be a continuous operation and back gouging and rewelding shall be completed on each splice before starting on another one. The use of E7010 electrodes will not be permitted for welding ASTM A 514/A 517 steel.

For haunch girder splices adjacent to the haunch section, the welding, once started, shall be continuous until a minimum of 50 percent of the welding in both flanges is completed.

Deviation from the above sequence of weld passes shall be approved by the Engineer.

Procedures for all gas metal-arc and flux cored arc welding shall be submitted to the Engineer for approval and shall be qualified prior to any field welding.

All gas metal-arc and flux cored arc welding procedures shall be qualified conforming to Sections 5 and 7 of TXDOT Bulletin C-5. For each joint to be used in construction, the joint details, electrode classification or grade, electrode diameter, voltage, amperage, travel speed, order and relative position of passes, number and thickness of layers, gas flow, dew point of gas, back gouging, method of cleaning and other pertinent information shall be clearly presented in the Procedure Specification. Fillet welds shall conform to details indicated.

Procedures for welding on ASTM A 514/A 517 steel shall be qualified conforming to TXDOT Bulletin C-5 and approved by the Engineer prior to starting work. Variables to be reported shall include welding process, plate thickness, grade of steel, weld position, joint details, type and size of electrode, number and location of passes, welding sequence, back gouging, current and voltage per pass, welding speed, heat, input and maximum interpass temperature. The heat input and maximum interpass temperature shall not exceed the recommendations of the Steel Producer.

The classification and size of electrode, 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.

(1) Manual Shielded Metal-Arc Welding Process

- (a) The maximum size of electrode shall be as follows provided the welder has been certified for its use by the City:
 - 1. 5/16 inch for all welds made in the flat position except root passes.
 - 2. 1/4 inch for horizontal fillet welds.
 - 3. 1/4 inch for root passes of fillet welds made in the flat position and of groove welds made in the flat position with backing and with a root opening of 1/4 inch or more.
 - 4. 5/32 inch for welds made with EXX14 and low hydrogen electrodes in the vertical and overhead positions.
 - 5. 3/16 inch for root passes of groove welds and for all other welds not included under 1, 2, 3 and 4 above.

- (b) The root pass size shall be large enough to prevent cracking. The maximum thickness of layers subsequent to the root pass in fillet welds and of all layers in groove welds shall be:
 - 1. 1/4 inch for root passes of groove welds.
 - 2. 1/8 inch for subsequent layers of welds made in the flat position.
 - 3. 3/16 inch for subsequent layers of welds made in the vertical, overhead and horizontal positions.

- (c) The maximum size fillet weld which may be made in one pass shall be:

1. 3/8 inch in the flat position.
2. 5/16 inch in horizontal or overhead positions.
3. 1/2 inch in the vertical position.

(2) Manual (Semiautomatic) Gas Metal-Arc Welding and Flux Cored Arc Welding Process

- (a) The maximum size electrode used shall be as follows:
 1. 5/32 inch for the flat and horizontal positions.
 2. 3/32 inch for the vertical position.
 3. 5/64 inch for the overhead positions.
- (b) The thickness of weld layers, except root and surface layers shall not exceed 1/4 inch. When the root opening of a groove weld is 1/2 inch or greater, a multiple pass split-layer technique shall be used. The split-layer technique shall be used. The split-layer technique shall be used in making all multiple pass welds when the width of the layer exceeds 5/8 inch for gas metal-arc welding or 3/4 inch for flux cored arc welding.
- (c) The welding current, arc voltage, gas flow, mode of metal transfer and speed of travel shall be such that each pass will have complete fusion with adjacent base metal and weld metal and there will be no overlap, excessive porosity or undercutting.
- (d) Gas metal-arc welding or flux cored arc welding with external gas shielding shall not be done in a draft or wind. An approved shelter of a material and shape capable of reducing the wind velocity in the vicinity of the welding to a maximum of 5 miles per hour shall be furnished by the Contractor
- (e) The maximum size of a fillet weld made in 1 pass shall be:
 1. 1/2 inch for the flat and vertical position.
 2. 3/8 inch for the horizontal position.
 3. 5/16 inch for the overhead position.

(3) Preheat

Preheat ahead of welding both groove and fillet welds (including tack welding) will be required as shown in Table 3.

Preheat and interpass temperatures must be sufficient to prevent crack formation. The preheat temperatures shown in Table 3 are minimums and higher preheats may be necessary in highly restrained welds.

When the base metal is below the required temperature, it shall be preheated so the parts being welded are not less than the specified temperature within 3 inches of the point of welding.

For all groove welds, reheat temperature shall be measured on the side opposite to which the heat is applied at points about 3 inches away from the joint.

Preheating equipment shall be adequate to maintain the entire joint at or above the specified temperature. When possible, a joint shall be completely welded before it is allowed to cool below the specified temperature but shall always be welded sufficiently to prevent cracking before cooling is permitted.

Usually preheat and interpass temperatures shall not exceed 400 F for thickness up to 1 1/2 inches and 450 F for greater thickness. These temperatures shall never be exceeded on ASTM A514/517 steels.

The welder shall have and use approved equipment for checking preheat and interpass temperatures at all times while welding is in progress.

Table 3		
Minimum Preheat and Interpass Temperature for Manual Shielded Metal-Arc Welding, Flux Cored Arc Welding or Gas Metal-Arc Welding		
	Manual or Semiautomatic Gas Metal-Arc Welding, Flux Cored Arc Welding or Manual Shielded Metal-Arc Welding with Low Hydrogen Electrodes	
Thickness of Thickest Part at Point of Welding	ASTM A 36; A 242; A 441; A 572 Grades 42,45 and 50; A 588	ASTM A 514/517
To 3/4 inch, incl.	50 F	50 F
Over 3/4 inch to 1 1/2 inches, incl.	70 F	125 F
Over 1 1/2 inches to 2 1/2 inches, incl.	150 F	175 F
Over 2 1/2 inches	225 F	225 F

1. These temperatures are the minimum required for the thinner material shown for each increment and higher preheat on a step basis will be required for the thicker material within each increment. Preheat and interpass temperatures must be sufficient to prevent crack formation and welding shall be carried continuously to completion or to a point that will assure freedom from cracking before the joint is allowed to cool below the minimum specified preheat and interpass temperature. Temperature above those shown may be required for highly restrained welds.
2. When E7010 electrodes are permitted for tacking or temporary root pass, the material shall be pre-heated according to the following:

Thickness of Thickest Part	Preheat for Tacking or Temporary Root Pass
1/2 inch and less	150 F
9/16 inch through 3/4 inch	200 F
13/16 inch through 1 1/2 inches	300 F
Over 1 1/2 inches	400 F

3. When joining steels of different strengths or thickness with groove welds, the preheat and interpass temperatures for the higher strength steel and the average plate thickness shall be used. For fillet welds, the preheat shall be used for the higher strength steel and the thickest plate being welded.
4. When the base metal temperature is below 32 F, preheat to at least 70 F and maintain this minimum temperature during welding.
5. Heat input when welding A 514/517 steel shall not exceed the steel producer's recommendations.
6. When moisture is present on the base metal it shall be preheated to 200 F before welding is started.

723.6 Quality of Welds

Weld metal shall be sound throughout.

There shall be no cracks in any weld or weld pass.

There shall be complete fusion between the weld metal and the base metal and between successive passes throughout the joint.

Welds shall be free from overlap and the base metal free from undercut more than 1/100 inch deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall not be more than 1/32 inch deep when its direction is parallel to the primary stress in the part that is undercut.

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

All welds on ASTM A 514/517 steel shall be visually examined for longitudinal or transverse cracks not less than 48 hours after completion of welding.

723.7 Corrections

When the weld quality is unsatisfactory, the following corrective measures will be required by the Engineer whose specific approval shall be obtained for making each correction.

When requirements prescribe the removal of part of the weld or a portion of the base metal, removal shall be by oxygen gouging or arc-air gouging.

Oxygen gouging shall not be used on ASTM A 514/517 steel or for A 588 weathering steel.

Backgouging of splices in beams and girders or cutouts of defective welds shall be done by arc-air gouging by a welder qualified to make beam and girder splices.

Where corrections require the deposition of additional weld metal, the sides of the area to be welded shall have sufficient slope to permit depositing new metal.

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 grinding off the excess weld metal.

2. Shrinkage cracks. Cracks in base metal, craters and excessive porosity. Remove defective portions of base and weld metal down to sound metal and replace with 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 the parts of the weld containing slag and replace with sound weld metal.
6. Removal of adjacent base metal during welding. Clean and form full size by depositing additional weld metal.

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

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 metal shall be removed 2 inches beyond each end of the crack and repairs made.

Where work performed after the making of a deficient weld has made the weld inaccessible or has caused new conditions making 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.

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 or other approved methods for steel up to 65,000 psi yield strength. Parts to be heat straightened shall be substantially free of stress from external forces, except when mechanical means are used in conjunction with the application of heat.

Heat straightening of A 514/517 steel shall be done only under rigidly controlled procedures, subject to the approval of the Engineer. In no case shall the maximum temperature of the steel exceed 1100 F. Sharp kinks and bends shall be cause for rejection of the material.

723.8 Radiographic Inspection

Radiographic testing required in the field shall be done at the expense of the Contractor by an approved laboratory as defined by "General Conditions" having prior approval of the Engineer. The testing shall include furnishing all materials, equipment, tools, labor and incidentals necessary to perform the required testing. The Owner may require further tests as necessary conforming to "General Conditions" and may perform additional testing including other types.

Radiographic equipment, procedures, resulting radiographs, identification marks, penetrameters, examination, reports and weld surface preparation shall conform to TXDOT Bulletin C-5. The Engineer will examine and interpret the resulting radiographs.

Radiography shall be done within the time interval specified by the Engineer. Field welds on ASTM A 514/517 steel shall not be radiographed until a minimum of 48 hours after completion of the weld.

When so indicated, welded butt splices shall be radiographed. Radiographic testing shall be as indicated in "Radiographic Inspection", above. Weld quality shall be as follows:

There shall be no cracks and the sum of the greatest dimension of porosity and fusion type defects shall not exceed 1/10 of the nominal bar diameter in inches. The Engineer will examine and interpret the resulting radiographs, which shall become the property of the Owner and remain with the Engineer.

For field welds of splices in material with a specified yield strength of less than 65,000 psi, radiographic inspection will be made of the full flange width of 25 percent of all flange splices and of 1/3 the depth of the web of 25 percent of all web splices on each structure (17 inches minimum length). If unacceptable work is found, an additional radiograph (penalty shot) shall be made on a section welded by the same operator just prior to and just following the section containing the defect. Welds requiring repairs shall be retested by radiography after repairs are made. Necessary repairs shall be made prior to any further work being done.

For field welds of splices in material with a specified yield strength greater than 65,000 psi, radiographic inspection shall be made on all flange and web splices. Welds requiring repairs shall be retested by radiography a minimum of 48 hours after repairs are made.

All radiography (penalty shots and retakes) required because of unacceptable welding shall be performed at the expense of the Contractor.

When radiographic inspection of particular welds is indicated, this shall be in addition to the radiographic inspection required herein.

All resulting radiographs shall become the property of the Owner and remain with the Engineer.

All groove welds designed to carry primary stresses shall be subject to radiographic inspection. When subjected to such inspections, the presence of any of the following defects in excess of the limits indicated will result in rejection of the defective weld until corrected.

1. Sections of welds shown to have any cracking, regardless of length or location, incomplete fusion, overlapping or inadequate penetration shall be judged unacceptable.
2. Inclusions less than 1/16 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 3/8 inch.
3. Inclusions 1/16 inch or larger in greatest dimension shall be permitted provided such defects do not exceed the limits indicated or described above.
4. There shall be no inclusion greater than 1/16 inch within 1 inch of the edge of part or member at the joint or point of restraint.

723.9 Reinforcing Steel

Provisions are made herein for the welding of reinforcing steel by the manual shielded metal-arc process. Other processes may be permitted with the specific approval of the Engineer or may be specified on the plans. When the Cadwell process is permitted, a "C" series splice shall be used with grade 40 reinforcing steel and a "T" series splice shall be used with grade 60 reinforcing steel, unless otherwise indicated.

(1) Base Metal

Reinforcing steel to be welded shall be new billet steel conforming to ASTM A 615 and to the following chemical composition:

Maximum Carbon	0.40 Percent
Maximum Manganese	1.30 Percent

Mill test reports will be required conforming to Item No. 406, "Reinforcing Steel".

(2) Filler Metal

Low hydrogen electrodes as specified in Table 1 shall be required for all welding of reinforcing steel. Drying of electrodes shall be as specified in "Materials", above.

723.10 Preheat and Interpass Temperature

Minimum preheat and interpass temperatures shall be as shown in Table 4.

Table 4		
Preheat and Interpass Temperature for Reinforcing Steel		
Carbon Range	No. 7 & Smaller	No. 8 & Larger
Up to and including 0.30	None	100
0.31 to 0.35 inclusive	None	150
0.36 to 0.40 inclusive	100	250
Unknown	250	400

For widening projects, use carbon content and bar size of new steel to determine preheat required.

723.11 Joint Types

For all bars No. 8 and larger, butt splices will be required. For No. 7 bars and smaller, lap splices will be required.

Fillet welds in lap splices shall be a minimum of 4 inches in length and shall be welded on each side of the lap joint. For bars No. 5 and smaller, welding from one side of the lap will be permitted by the Engineer, when it is impractical to weld from both sides of the joint, but in this case the weld shall be a minimum of 6 inches in length.

Lap welds shall conform to Table 5.

Where possible, all butt splices shall be made in the flat position. All welds for butt splices, except horizontal welds on vertical bars shall be as indicated. The backup strip will be required when access to the splice is from the top only. When bars may be rotated or

access to the splice is available from two sides the double bevel splice may be made and this type weld requires gouging out the root pass similar to a flange splice on structural steel. The root pass may be made using E7010 electrodes for all double beveled splices and the root pass shall be completely removed prior to welding the opposite side. The steel shall be preheated to 400 F if E7010 electrodes are used. Horizontal splices, on vertical bars, shall be as indicated.

Table 5					
Bar Size	A	B, Maximum	T, Minimum	C, Maximum	Electrode Size
No. 4	.04 inch	1/8 inch	1/8 inch	1/16 inch	1/8 inch
No. 5	.05 inch	1/8 inch	3/16 inch	1/16 inch	5/32 inch
No. 6	.06 inch	1/8 inch		1/16 inch	5/32 inch
No. 7	.07 inch	3/16 inch	5/16 inch	1/16 inch	5/32 inch

723.12 Widening Projects

In general, the new reinforcing steel shall be either lap or butt spliced directly to the bar to be extended. When the reinforcement in the old portion of a structure is found to be of the wrong spacing, dowel bars long enough to develop the welded lap or butt splice and also develop the bar in bond, conforming to Item No. 406, "Reinforcing Steel", shall be welded to the old steel and the new reinforcement placed at the correct spacing without welding to the old steel. No measurement or payment will be made for the dowels but will be included in the unit price bid for other items in the contract.

Both old and new reinforcement shall be cleaned thoroughly prior to the preparation of the joint.

723.13 Welder Qualification

All welders shall be certified before working on any material which is to be incorporated into a City project, except for miscellaneous welds as defined below. Each welder must have certification papers conforming to TXDOT Bulletin C-6, showing the type of work the welder is certified to perform. The welder will only be permitted to do work covered by such papers.

Miscellaneous welds of the following types may be made by a welder who is certified for structural or reinforcing steel or a qualified welder:

Armor joints and their supports, Screed Rail and Form Hanger Supports where permitted on Steel units, Reinforcing Steel to R-Bars for lateral stability between Prestressed Beams, Spirals or Bands to reinforcing Bars in Drilled Shaft cages, permanent Metal Deck forms, additional steel added in railing when slip form construction is used and other similar miscellaneous members that have no load carrying capacity in the completed structure.

A qualified welder is an experienced welder who is capable of making welds of sound quality, but does not have certification papers. Prior to welding operations, the Engineer or a representative of the Engineer shall check the welder's ability by a job site Miscellaneous Weld Qualification Test. The Contractor shall furnish all of the material and equipment necessary for the test.

The miscellaneous Weld Qualification Test shall consist of the following:

The welder shall make a single pass fillet weld in the vertical position 1/4 inch maximum size approximately 2 inches long on 1/2 inch plate using 5/32 inch low hydrogen electrodes in the position indicated. The welder shall stop and start again within the 2 inch length of fillet weld.

The specimen shall be visually examined and the fillet weld shall present a reasonably uniform appearance free of cracks, overlap and undercut. There shall be no porosity visible on the surface of the weld.

The specimen shall be ruptured as indicated by the application of a force or by striking with a hammer.

The fractured surface of the 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 its greatest dimension.

If a welder fails to meet the requirements of this test, a retest may be allowed under the following conditions:

An immediate retest may be made consisting of 2 test welds, as described above and both test specimens shall meet all of the requirements specified.

A retest may be made after 30 days, provided there is evidence that the welder has had further training or practice. In this case the test shall be a single specimen.

Qualification by the test herein specified for miscellaneous welding shall be effective immediately upon satisfactory completion thereof and shall remain in effect for the duration of the project.

Before welding on ASTM A 514/517 steel, a welder must present evidence, satisfactory to the Engineer, of at least 3 months satisfactory experience welding this type of steel over 1 inch thick. In lieu of such experience, a welder, previously qualified for welding with low-hydrogen electrodes or has used the proposed welding process, shall have completed a training course in welding ASTM A 514/517 steel prior to taking the welder qualification test.

Tests for certification of welders for manual shielded metal-arc welding shall conform to TXDOT Bulletin C-6. Tests shall be given by an approved laboratory. For field welding, certification by an approved laboratory will be accepted for a period of 1 month from the time of certification. During this period, the welder will be permitted to work on City projects provided the welder's work is satisfactory. If the welder's work is satisfactory during this period, the City will issue him certification papers, which will permit the welder to work on City projects, as long as the welder continues to do satisfactory work.

A welder must have passed the Basic Qualification Test for Structural Welding in the vertical (3G) and overhead position (4G) conforming to TXDOT Bulletin C-6 prior to welding on any load carrying members. Also, the welder must demonstrate to a City welding inspector a thorough knowledge of, and ability to consistently implement, the required welding procedures and make welds of sound quality and good appearance. Quality of the welds will be checked by radiography.

To work on field splices of beams and girders, a welder must be certified for and be capable of making groove welds in both the vertical and overhead position when using the manual shielded metal-arc process.

For manual (semiautomatic) gas metal-arc welding or flux cored arc welding, welder qualification tests for certification shall qualify conforming to TXDOT Bulletin C-5 and tested conforming to TXDOT Bulletin C-6 as follows:

1. Basic Test Certification for groove welds for unlimited thickness material will also qualify a welder for any equal or lower strength steel or for fillet welding in the position in which the welder is certified, using the same electrode and combination of shielding used for the test.
2. Welders shall be certified in the vertical and overhead position to work on field splices of beams or girders.
3. Tests for certification shall be given by an approved laboratory. Certification papers for gas metal-arc welding or flux cored arc welding issued by an approved laboratory will be handled in a manner similar to that used for the manual shielded metal-arc process.
4. Welders shall be qualified for each process to be used. Qualification for flux cored arc welding will not qualify a welder for gas metal-arc welding or vice versa.
5. Qualification for welding with any grade electrode will automatically qualify a welder for the use of lower grades of electrodes using the same process, i.e., qualification with Grade ER80S/E80S electrode will qualify for Grade ER70S, but not vice versa.

The certification papers issued by the City are the property of the City and may be canceled at any time.

Radiographic inspection shall be made of all qualification test plates of groove welds for the "Basic Qualification Test". If this inspection indicates any lack of fusion, incomplete penetration and defects 1/16 inch or larger in greatest dimension or if the sum of the greatest dimensions of defects less than 1/16 of an inch in greatest dimension exceeds 3/8 inch in any linear inch of weld, the weld shall be considered as failing the soundness test. This radiographic inspection shall apply only to that portion of the welds between the discard strips of the specimens as indicated in Figures 13 and 14 of Appendix B of TXDOT Bulletin C-6. The specimen plates shall be wide enough to provide a minimum of 6 inches of effective weld length for radiographic testing. Mechanical testing shall conform to TXDOT Bulletin C-6.

723.14 Measurement and Payment

Compensation will not be allowed under this item for the work prescribed but shall be included in the unit price item of construction in which this item is used.

End

Ref: 406, 721