SECTION 602 - REINFORCING STEEL

602.01 Description. This section describes furnishing, storing, and placing reinforcing steel (also referred to as rebar, bar, or reinforcement).

602.02 Materials.

Reinforcing Steel 709.01

Submit certificate of compliance for reinforcing steel. When steel bars, other than bars conforming to ASTM A 706, are to be spliced by welding, or when requested by the Engineer, submit six copies of certified mill test reports showing physical and chemical analyses for each heat and size of reinforcing steel.

602.03 Construction.

(A) Order Lists and Bending Diagrams. Submit six copies of reinforcing steel order lists and bending diagrams to the Engineer prior to fabrication. Assume absolute responsibility for accuracy of lists and diagrams.

(B) Storage, Surface Condition, and Protection of Reinforcement. Store reinforcing steel above ground surface on platforms, skids, or other supports. Protect reinforcing steel from mechanical damage and surface deterioration caused by exposure to corrosion-producing conditions. When placed in the work, reinforcing steel shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other coatings that would destroy or reduce bond. Reinforcing steel shall be free from injurious defects such as cracks and laminations. Bonded rust, surface seams, surface irregularities, or mill scale shall not be cause for rejection, provided minimum dimensions, cross-sectional area, and tensile properties of a hand-wire-brushed specimen meet physical requirements for size and grade of steel specified.

(C) Fabrication.

(1) Bending. Bend reinforcing steel cold. Do not field bend bars that are partially embedded in concrete, except as indicated in the contract documents or permitted by the Engineer.

Bend or straighten bars in a manner that shall not damage the material. Bars having cracks or splits at bends will be rejected. Unless otherwise indicated in the contract documents, bend steel only once at the same location.

(2) Hooks and Bend Dimensions. Dimensions of hooks and diameters of bends shall be in accordance with the contract documents. When dimensions of hooks or diameter of bends are not indicated in the contract documents, they shall conform to AASHTO

LRFD Bridge Design Specifications, Second Edition, Article 5.10.2 – Hooks and Bends.

(3) Identification. Ship reinforcing steel in standard bundles. Tag bundles of reinforcing bars showing quantity, grade, size, and identification that allows for checking, sorting, and placing. Tag bundles of welded wire fabric reinforcement showing quantity, style designation, width, and length.

(D) Placing and Fastening. Place and fasten reinforcing steel bars in accordance with recommended practices and procedures in CRSI *Placing Reinforcing Bars*. Accurately place reinforcing steel and hold firmly in position indicated in the contract documents by wiring at intersections and splices; and by using bar supports accepted by the Engineer that have sufficient strength to resist crushing under applied loads. Unless otherwise indicated in the contract documents, place reinforcing steel within tolerances conforming to Table 602.03-1 – Placement Tolerances. Begin concrete placement only after the Engineer inspects and accepts reinforcing steel position.

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TABLE 602.03-1 - PLACEMENT TOLERANCES	
Clear distance to side forms and resulting concrete surfaces and clear distance to formed and resulting concrete soffits in direction of tolerance:	
Members size 4 inches or less	+ 1/4 inch
.....	- 3/8 inch
Member size over 4 inches but not over 12 inches	± 3/8 inch
Member size over 12 inches but not over 2 feet	± 1//2 inch
Member size over 2 feet.....	± 1 inch
Concrete cover measured perpendicular to concrete surface in direction of tolerance:[1,2]	
Member size 12 inches or less.....	- 3/8 inch
Member size over 12 inches	- 1/2 inch
Distance between unbundled bars (providing that distance between reinforcement shall not be less than the greater of d_b or 1 inch)[3]	One-quarter specified distance not to exceed 1 inch
Distance between bundled bars:	
2 bar bundles	Not less than the greater of 1 inch or $1.4d_b$
3 bar bundles	$1.7d_b$
4 bar bundles	$2d_b$
Spacing of non-prestressed reinforcement, deviation from specified location:[4]	
Slabs and walls other than stirrups and ties.....	± 3 inches
Stirrups.....	Beam depth in inches/12 X 1 inch
Ties	Least width of column in inches/12 X 1 inch
Longitudinal location of bends and ends of bars:	
At discontinuous ends of brackets and corbels	± 1/2 inch
At discontinuous ends of other members	± 1 inch
At other locations	± 2 inches
Embedded length of bars and length of bar laps:	
No. 3 through No. 11.....	- 1 inch
No. 14 and No. 18 bar sizes (embedment only)	- 2 inches

Notes:

1 Reduction in cover shall not exceed one-third specified concrete cover.

2 Reduction in cover to formed soffits shall not exceed 1/4 inch.

3 d_b = Diameter of individual bar

4 Total number of bars shall not be less than that specified.

Maintain proper clearance between reinforcing steel and boundaries of concrete by precast concrete bar supports of equal compressive strength as concrete to be placed around them, and of shape and dimensions accepted by the Engineer.

Unless otherwise indicated in the contract documents, bar supports and their spacing shall conform to recommendations in Chapter 3 – Bar Supports of CRSI *Manual of Standard Practice* (*MOSP*). Steel wire bar supports shall be Class 1 (plastic-protected) bar supports, as described in CRSI *MOSP*. All-plastic bar supports will be allowed for vertical construction only.

Separate bar layers using precast concrete blocks or other bar supports accepted by the Engineer. Use of pebbles, pieces of broken stone or brick, metal pipes, or wooden blocks will not be allowed.

Maintain minimum 2-1/2 bar diameters for center-to-center spacing of parallel bars. Minimum clear distance between bundles of bars and adjacent bundles or single bars shall be not less than the following: bundles of two bars, 2 times diameter of larger bar; bundles of three bars, 2-1/2 times diameter of largest bar; bundles of four bars, 3 times diameter of largest bar.

In no case shall clear distance between bars or bundles of bars be less than 1-1/2 times maximum coarse aggregate size or less than 1-1/2 inches, whichever is greater.

Except in decks where parallel reinforcing steel is placed in two or more layers, with clear distance between layers not exceeding 6 inches, place bars in upper layers directly above those in bottom layer, and maintain clear distance between layers of not less than 1 inch or the nominal bar diameter, whichever is greater.

Tie bundled bars together at a distance of not more than 6 feet on centers along length of bar. Limit maximum number of bars in bundle to two bars for No. 14 and No. 18 bars and four bars for other sizes. Bundling bars by tack welding will not be allowed.

Individual bars in bundle that are cut off within span of member shall be terminated at different points, with at least a 40-bar diameter stagger.

Unless otherwise indicated in the contract documents, concrete cover for unprotected main reinforcing steel shall conform to Table 602.03-2 - Concrete Cover (Main Bars). Cover for rebar mechanical connections shall be same as for reinforcing steel.

Cover to ties and stirrups may be 1/2 inch less than values specified in Table 602.03-2 – Concrete Cover (Main Bars) but shall not be less than 1 inch.

TABLE 602.03-2 - CONCRETE COVER (MAIN BARS)

Exposure Condition	Cover (Inches)
Direct exposure to salt or brackish water	4
Cast against and permanently exposed to earth	3
Exterior (exposed to earth or weather):	2
Interior (not exposed to weather or in contact with ground): Up to No. 11 bar No. 14 and No. 18 bars	 1-1/2 2
Precast soffit form panels	3/4
Precast reinforced piles Noncorrosive environments Corrosive environments[1]	 2 3
Precast prestressed piles	2
Cast-in-place piles: Noncorrosive environments Corrosive environments[2] Shells Auger-cast, tremie concrete, or slurry construction	 2 3 2 3

Notes:
[1] Environments where concrete will be exposed to external sources of chlorides in service, such as brackish water, seawater, or spray from these sources.

(E) Splicing of Bars.

(1) General. Furnish reinforcing steel in full lengths in accordance with the contract, except in the following cases:

(a) Unless otherwise indicated in the contract documents, when required lengths of bars No. 4 through No. 11 are longer than 40 feet, bars may be spliced by lapping, butt welding, mechanical butt splicing, or mechanical lap splicing.

(b) Lap splicing for bars No. 14 and No. 18 will not be allowed. When required lengths of these bars are longer than commercially available lengths, use butt welding or mechanical butt splicing.

Welded lap splicing and mechanical lap splicing may only be used for bars No. 4, 5, and 6.

Welded splices will not be allowed in decks.

Reinforcing steel may be made continuous at locations where splices are indicated in the contract documents, at the Contractor's option.

Submit splice locations. Locate splices in areas of low stresses. Splicing bottom reinforcing steel at or near centerline of span and splicing top reinforcing steel at or near continuous support will not be allowed.

Unless otherwise indicated in the contract documents, splices in adjacent reinforcing bars at any particular section shall be staggered. Minimum distance between staggered lap splices or mechanical lap splices shall be equal to the length required for a lapped splice in the largest bar being spliced. Minimum distance between staggered butt splices shall be 2 feet, measured between splice midpoints, along a line that is centered between axes of the adjacent bars.

Number of bars spliced at sections normal to axis of member shall not exceed 33 percent of total main reinforcing steel in member. If bars cross construction joint, embed each end of reinforcing steel a distance equal to required length of lap, on each side of joint.

Deviation in alignment of reinforcing bars at welded or mechanical splice shall not exceed 1/4 inch over a 3-1/2-foot length of bar.

Unless otherwise indicated in the contract documents, splice spiral reinforcing bars either by V-groove welded splice, welded lap splice, or mechanical lap splice. Anchor each unit of spiral reinforcing bars by lapping free end of bar to continuous spiral and using either welded lap splice detail or mechanical lap splice detail.

V-groove welded splice and welded lap splicing shall conform to details indicated in the contract documents and the following requirements:

On V-groove welded splices, reinforcing bars at joint shall not be offset at weld by more than 1/8 inch.

Trim back or shape ends of reinforcing bars to be spliced by V-groove welding by carbon arc, oxyacetylene cutting, or sawing. Trim back sheared surfaces not less than 1/8 inch.

Unless otherwise specified, weld by manual shielded metal-arc process. Use low hydrogen electrodes conforming to requirements of AWS A5.1 for E7016 or E7018 electrodes.

Purchase electrodes in hermetically sealed containers, or dry for two hours at 450 degrees F. to 500 degrees F. before use. Immediately after removal from hermetically sealed containers or from drying ovens, store electrodes in ovens held at temperature of at least 250 degrees F. Redry electrodes not used within four hours after removal from hermetically sealed containers or from drying or storage ovens.

Do not weld in inclement or wet weather unless protection accepted by the Engineer is provided.

Flare welds may be made in one pass. Make butt welds with multiple passes.

Pre-heating or post-heating of ASTM A 706 bars in weld area will not be required.

Tack welding for alignment purposes will be allowed when tack weld will be consumed by subsequent weld.

Visual inspection of completed welds shall show no evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size.

Prequalify welders by requiring them to make procedure and qualification weld that conforms to provisions in Subsection 602.03(E)(4) - Qualification of Welding and Mechanical Splicing. Perform procedure and qualification welding in presence of the Engineer, using materials similar to those to be welded on the Project, in same position as will be encountered in the work.

Individual hoops, made continuous with welded butt splices, may be substituted for bar spiral reinforcement. Welded butt splices for individual hoops shall conform to provisions in Subsection 602.03(E)(3)(a) - Welded Butt Splices.

Except when otherwise indicated in the contract documents, mechanical lap splicing shall conform to details shown on plans, provisions for mechanical butt splices as specified in this subsection; and Subsection 602.03(E)(3)(b) - Mechanical Butt Splices, Subsection 602.03(E)(4) - Qualification of Welding and Mechanical Splicing, and Subsection 602.03(E)(5) - Job Control Tests. Mechanical lap splice shall be unit consisting of a sleeve, in which reinforcing bars are positioned, and a wedge is driven through holes in sleeve, between reinforcing bars.

(2) Lapped Splices. Lapped splices shall consist of reinforcing steel placed in contact and wired together in such a manner as to maintain alignment and provide minimum clearances. Non-contact lapped splices will not be allowed.

Lapped splices will not be allowed at locations where concrete section is insufficient to provide minimum clear distance between splice and nearest adjacent bar, as specified in Subsection 602.03(D) - Placing and Fastening for minimum clear distance between parallel bars or bundles of bars.

Lapped splices in bundled bars shall conform to the following: in bundles of two bars, make lapped splice length same as single bar lapped splice length; in bundles of three bars, make lapped splice length 1.2 times single bar lapped splice length; in bundles of four bars, make splices by butt welding or by mechanical butt splicing.

At lapped splices in wire spiral reinforcement, anchor each end of spiral by a 135-degree hook with 6-inch tail hooked around an intersecting longitudinal bar; and lap wire spiral reinforcement to be spliced at least 80 bar diameters between anchors.

(3) Butt-Jointed Splices. Butt-jointed splices shall be either welded or mechanical splices. Do not locate splices on bent portions of bars. Butt-jointed splices shall be capable of resisting flexural and other load effects due to construction activities, including handling and placing of reinforcing steel. Completed butt splices shall develop not less than 125 percent of specified yield strength of the unspliced bars.

Prior to use in the work, qualify welded and mechanical butt splices by tests made on sample splices, as specified in Subsection 602.03(E)(4) - Qualification of Welding and Mechanical Splicing. Perform job control tests on sample splices representing each lot of mechanical butt splices as specified in Subsection 602.03(E)(5) - Job Control Tests. Test sample splices for qualification and job control

tests for compliance with splice requirements in accordance with the contract. The Contractor shall fabricate and test sample splices and shall submit copy of test results to the Engineer.

(a) Welded Butt Splices. Welded butt splices in reinforcing steel shall be complete joint penetration butt welds conforming to requirements of AWS D1.4 and the contract documents.

Shop-produced resistance butt welds conforming to requirements of the contract documents and produced by fabricator accepted by the Engineer may be used.

Use only joint details and dimensions as shown in Figure 3.2 - Direct Butt Joints of AWS D1.4-98, for making complete joint penetration butt welds of reinforcing steel. Split pipe backing will not be allowed.

Use flat plate in accordance with ASTM A 709, Grade 36, as backing for complete joint penetration butt welds of reinforcing steel. Flat plate shall be 1/4-inch thick, with width as measured perpendicular to bar axis, equal to nominal bar diameter; and length not exceeding twice nominal bar diameter. Fit flat plate backing tightly to bar, with weld root centered on plate. Grind smooth and flush with adjacent surface, bar deformations or obstructions preventing a tight fit. Locate tack welds used to fit backing plates, within weld root area, so that tack welds are completely consumed by finished weld. Do not remove backing plates.

Make butt welds with multiple weld passes using stringer bead, without appreciable weaving motion. Maximum stringer bead width shall be 2.5 times electrode diameter. Perform slagging between each weld pass. Weld reinforcement shall not exceed 1/8 inch in convexity.

Terminate or initiate welds made on unbent portion of cold bent reinforcing steel, at minimum distance of two bar diameters from points of tangency for radius created by cold bending.

Before any electrodes or flux-electrode combinations are used, submit at no increase in contract price or contract time, certified copies of test reports for pertinent tests specified in AWS A5.1, AWS A5.5, AWS A5.18 or AWS A5.20, whichever is applicable, made on electrodes or flux-electrode combinations of the same class, brand, and nearest specified size as the electrodes to be used. Tests may have been made

for process qualification or quality control, and shall have been made within one year prior to manufacture of electrodes and fluxes to be used. Include in report manufacturer's certification that process and material requirements were same for manufacturing tested electrodes and electrodes to be used. Certification shall be as specified in Subsection 106.07 - Certificate of Compliance.

Electrodes for manual shielded metal arc welding of ASTM A 615, Grade 60 bars shall conform to AWS A5.5 for E9018-M or E10018-M electrodes.

Electrodes for manual shielded metal arc welding of ASTM A 706 bars shall conform to AWS A5.5 for E8016-C3 or E8018-C3 electrodes.

Solid and composite electrodes for semiautomatic gas metal-arc and flux-cored arc welding of Grade 40 reinforcing bars shall conform to AWS A5.18 for ER70S-2, ER70S-3, ER70S-6 or ER70S-7 electrodes; or AWS A5.20 for E70T-1, E70T-5, E70T-6 or E70T-8 electrodes.

Electrodes for semiautomatic welding of ASTM A 615, Grade 60 and ASTM A 706 bars shall produce weld metal deposit with properties conforming to Section 5.3.4 in AWS D1.1 for ER80S-Ni1, ER80S-Ni2, ER80S-Ni3, ER80S-D2, E90T1-K2 and E91T1-K2 electrodes.

Prior to welding ASTM A 615 bars, preheat bars for a distance of not less than 6 inches on each side of joint.

For all welding of ASTM A 615, Grade 40 or Grade 60 bars, requirements of Table 5.2 - Minimum Preheat and Interpass Temperatures of AWS D1.4-98 are superseded by the following:

> Minimum preheat and interpass temperatures shall be 400 degrees F. for Grade 40 bars and 600 degrees F. for Grade 60 bars. Immediately after completing welding, cover at least 6 inches of bar on each side of splice with insulated wrapping to control rate of cooling. Keep insulated wrapping in place until bar has cooled below 200 degrees F.

When welding different grades of reinforcing steel, electrode shall conform to Grade 40 bar requirements and preheat shall conform to Grade 60 bar requirements.

If specified preheat, interpass, or post weld cooling temperatures are not met, remove all weld and heat-affected zone metal and reweld splice.

Protect welding from air currents, drafts, and precipitation in a manner accepted by the Engineer.

Direct butt splicing of reinforcing steel by thermite welding will not be allowed.

(b) Mechanical Butt Splices.

1. General. The following mechanical butt splices may be used: sleeve-filler metal type, sleeve-threaded type, sleeve-swaged type, sleeve-filler grout type, sleeve-lockshear bolt type, two-part sleeve-forged bar type, or two-part sleeve-friction bar type.

Use mechanical butt splices of design accepted by the Engineer. The Engineer's acceptance of a new design will be based upon the following: technical data, including test results, and other proof of satisfactory performance submitted by manufacturer; and test results by the Engineer or the Engineer's authorized representative on manufacturer-furnished sample splices and splice material. Resubmit design if change is made in details or materials previously submitted and accepted.

Total slip of reinforcing steel within splice sleeve, after loading in tension to 30,000 pounds per square inch and relaxing to 3,000 pounds per square inch, shall not exceed values listed in Table 602.03-3 – Allowable Total Slip. Slip shall be measured between gage points that are clear of splice sleeve.

TABLE 602.03-3 - ALLOWABLE TOTAL SLIP	
Bar Size Number	**Total Slip (inch)**
4	0.010
5	0.010
6	0.010
7	0.014
8	0.014
9	0.014
10	0.018
11	0.018
14	0.024
18	0.030

Slip requirements shall not apply to mechanical lap splices.

Splicing procedures shall conform to manufacturer's recommendations, except as modified in this subsection. Make splices using manufacturer's standard equipment, jigs, clamps, and other required accessories.

Cut ends of reinforcing bars to be butt-spliced, nominally square.

Splice sleeves shall have concrete cover of not less than 1-3/4 inches, measured from concrete surface to outside of sleeve. Adjust or relocate stirrups, ties, and other bars, and place additional reinforcing steel, if necessary, to provide planned concrete cover to reinforcing steel.

Submit the following information for each shipment of splice material, as specified in Subsection 106.07 - Certificate of Compliance:

a. Type or series identification of splice material and for sleeve-threaded type sleeves, heat treatment lot number.

b. Bar grade and size number to be spliced, by material.

c. Copy of manufacturer's technical documentation giving complete data on splice material and procedures.

d. Statement that splicing systems and materials used in accordance with manufacturer's procedures shall develop not less than minimum tensile strengths, based on nominal bar area, of 125 percent of specified yield strength of the unspliced bars and shall comply with total slip requirements and other requirements indicated in the contract documents.

e. Statement that splice material conforms, in all respects, to details and materials of a specific design accepted by the Engineer.

2. Sleeve-Filler Metal Mechanical Butt Splices. Sleeve-filler metal type of mechanical butt splices shall consist of a steel splice sleeve that fits closely over the reinforcing bar, with ferrous filler metal in annular space between reinforcing steel and sleeve, and between ends of reinforcing steel. Melt filler metal by exothermic reaction. Splicing process shall not fuse filler metal with reinforcing steel or heat reinforcing steel to its melting point, except for nominal melting of ends of reinforcing steel at mid-length of splice sleeve.

Remove oversize projections and distortions of reinforcing steel within sleeve by grinding.

Clean surfaces of reinforcing steel within sleeve and for 2 inches beyond end of sleeve, of slag, mill scale, rust, and other foreign materials. Clean either by oxyacetylene torch followed by power wire brushing or by abrasive blast cleaning.

Immediately prior to adding filler material to splice sleeve, preheat cleaned bar ends and entire splice sleeve to 300 degrees F. ± 50 degrees F. When gas torches are used for preheating, do not direct flame into the inside of splice sleeve.

In completed splice, sound, non-porous filler metal shall be visible completely around reinforcing steel, at both ends of splice sleeve and at tap hole in center of sleeve.

Fill annular space between reinforcing steel and sleeve with filler material, to the extent that the average depth of any recess, over entire perimeter, caused by use of packing ring, and voids due to other causes, at each end of sleeve, does not exceed 1/2 inch. Depth of recesses and voids will be measured by wire probe inserted to deepest points of recesses and voids.

3. Sleeve-Threaded Mechanical Butt Splices. Sleeve-threaded type of mechanical butt splices shall consist of a steel splice sleeve, with tapered interior threads, that joins reinforcing bars with matching tapered threads. Taper threads to such a degree that cross threading will not occur during assembly.

Mark each splice sleeve with heat treatment lot number.

After completion of assembly, tighten splice to torque value recommended by manufacturer.

4. Sleeve-Swaged Mechanical Butt Splices. Sleeve-swaged type of mechanical butt splices shall consist of a seamless steel sleeve applied over ends of reinforcing bar and swaged to bars by means of a hydraulic press.

5. Sleeve-Filler Grout Mechanical Butt Splices. Sleeve-filler grout type of mechanical butt splices shall consist of a steel splice sleeve that fits closely over reinforcing bars with non-shrink grout filler in annular space between reinforcing steel and sleeve, and between ends of reinforcing steel.

Allow no vibration or movement of reinforcing bar or sleeve at splice while splice is developing sufficient

strength to support reinforcing bar. Submit complete details of bracing and clamping system to eliminate vibration or movement at splice during setup of filler, as specified in Subsection 105.03 - Shop Drawings.

6. Sleeve-Lockshear Bolt Mechanical Butt Splices. Sleeve-lockshear bolt type of mechanical butt splices shall consist of a seamless steel sleeve, center hole with centering pin, and bolts that are tightened until bolt heads shear off, leaving bolt ends embedded in reinforcing bar. Seamless steel sleeve shall be either formed into a V configuration or shall have two serrated steel strips welded to inside of sleeve.

7. Two-Part Sleeve-Forged Bar Mechanical Butt Splices. Two-part sleeve-forged bar type of mechanical butt splices shall consist of a shop-machined, two-part threaded steel sleeve that interlocks two hot-forged reinforcing bar ends. Forged bar ends may be either shop-produced or field-produced.

8. Two-Part Sleeve-Friction Bar Mechanical Butt Splices. Two-part sleeve-friction bar type of mechanical butt splices shall consist of a shop machined, two-part threaded steel sleeve whose ends are friction welded, in the shop, to reinforcing bar ends.

(4) Qualification of Welding and Mechanical Splicing. Procedures to be used in splicing reinforcing bars and welders and operators who will apply these procedures shall be qualified by tests performed by the Contractor on sample splices of the type to be used, before making splices in the work.

For welded splices, submit written welding procedure specifications (WPS) and welder qualification tests to be used that conform to requirements in AWS D1.4.

Fabricator accepted by the Engineer shall produce resistance butt welds.

Each operator qualification test for mechanical splices shall consist of two sample splices. Each mechanical splice procedure test shall consist of two sample splices.

For sleeve-filler, sleeve-threaded, sleeve-lockshear bolt, and two-part sleeve friction bar mechanical butt splices, make sample splices on largest reinforcing bar size to be spliced by procedure or

operator being tested, except that No. 14 bars may be substituted for No. 18 bars.

For sleeve-swaged and two-part sleeve-forged mechanical butt splices, and mechanical lap splices, make sample splices on largest reinforcing bar size, of each deformation pattern to be spliced by procedure or operator being tested. When joining new reinforcing bar to existing reinforcing bar, make qualification test sample bars using only deformation patterns of new reinforcing bar to be joined.

If operator is qualified for mechanical splicing of reinforcing bar of a given size, that operator will also be considered qualified for reinforcing bar sizes smaller than those used in making tests.

Perform separate operator qualification test or procedure test for each mechanical splicing position and procedure that operator is expected to use in the work.

Operator and procedure qualification tests may be performed simultaneously.

The Engineer will accept mechanical splice procedures and operators based upon acceptance of previous tests performed on appropriate sample splices.

Submit completed sample splices at least 60 inches long, with splice at mid-length.

Make and test sample splices in the presence of the Engineer or the Engineer's authorized representative, including tests performed by a commercial agency.

(5) Job Control Tests. When mechanical butt splices, shop-produced complete joint penetration butt-welded splices, or shop-produced resistance butt-welded splices are used, submit job control tests from a qualified testing laboratory. Job control test shall consist of fabrication, under conditions used to produce splice, and physical testing of three sample splices for each lot of 150 splices.

A mechanical butt splice lot is defined as 150, or fraction thereof, of the same type of mechanical butt splices used for each combination of bar size and bar deformation pattern that is used in the work.

A shop-produced, complete joint penetration butt-welded splice lot, or shop-produced, resistance butt-welded splice lot, is defined as 150, or fraction thereof, of the same type of welds used for each

combination of bar size and bar deformation pattern that is used in the work.

When joining new reinforcing bar to existing bars, make job control test using only deformation patterns of new reinforcing steel to be joined.

Sample splice shall consist of splice made at job site to connect two 30-inch-long minimum length bars, using same splice materials, position, location, and equipment, and following same procedures as are being used to make splices in the work. Shorter sample splice bars may be used if accepted by the Engineer.

Make and test sample splices in the presence of the Engineer or the Engineer's authorized representative.

Identify sample splices with weatherproof markings prior to shipment to testing laboratory.

For sleeve-threaded mechanical butt splices, fabricate reinforcing bars to be used for job control tests on a random basis, during thread cutting on reinforcing steel of each lot. Ship job control test samples to jobsite with material they represent.

For shop-produced, complete joint penetration butt welds, shop-produced, resistance butt-welded splices, and all types of mechanical butt splices, except sleeve-threaded type, the Engineer will designate when job control test samples are to be fabricated, and will determine limits of lot represented by each job control test.

Should average of test results made on three sample splices, or should more than one sample splice in any job control test fail to meet requirements for splices, all splices represented by that test will be rejected as specified in Subsection 106.08 - Non-Conforming Materials. Rejection shall prevail unless the Contractor, at no increase in contract price or contract time, obtains and submits evidence acceptable to the Engineer, that strength and quality of splices in the work are acceptable.

(6) Nondestructive Splice Tests. The Contractor shall perform required radiographic examinations of complete joint penetration butt-welded splices in accordance with requirements of AWS D 1.4 and as otherwise indicated in the contract documents.

Prior to radiographic examination, welds shall conform to requirements of Subsection 4.4 - Quality of Welds, of AWS D1.4-98.

Perform radiographic examinations on 25 percent of all complete joint penetration butt-welded splices from production lot. Size of production lot will be maximum of 100 splices. The Engineer will select splices that will compose production lot and also splices within each production lot to be radiographically examined.

Should more than 12 percent of splices that have been radiographically examined in any production lot be defective, radiographically examine an additional 25 percent of splices, selected by the Engineer, from same production lot. Should more than 12 percent of cumulative total of splices tested from same production lot be defective, radiographically examine all remaining splices in lot.

Perform additional radiographic examinations due to identification of defective splices, at no increase in contract price or contract time.

Welds found to be defective shall be repaired in accordance with requirements of ANSI/AWS D1.4 at no increase in contract price or contract time.

In addition to radiographic examinations performed by the Contractor, any mechanical or welded splice may be subject to inspection or nondestructive testing by the Engineer. Provide sufficient access facilities in shop and at jobsite to permit the Engineer or the Engineer's authorized representative to perform inspection or testing.

Notify the Engineer in writing 48 hours prior to performing any radiographic examinations.

Radiographic procedure used shall conform to ASME *Boiler and Pressure Vessel Code*, Section V, Article 2 and the following:

Make two exposures for each complete joint penetration butt-welded splice. For each of the two exposures, center radiation source on each bar to be radiographed. Make first exposure with radiation source placed at zero degrees from top of weld and perpendicular to weld root, and identified with station mark of "0." When obstructions prevent zero degree placement of radiation source for first exposure, and when approved in writing by the Engineer, source may be rotated around centerline of reinforcing bar, a maximum of 25 degrees. Make second exposure at 90 degrees to "0" station mark and identify with station mark of "90."

For field-produced, complete joint penetration butt welds, radiograph no more than one weld during one exposure.

For shop-produced, complete joint penetration butt welds, if more than one weld is to be radiographed during one exposure, angle between root line of each weld and direction to radiation source shall be not less than 65 degrees.

Make radiographs by either X-ray or gamma ray. Radiographs made by X-ray or gamma rays shall have densities of not less than 2.3 or more than 3.5, in area of interest. Tolerance of 0.05 in density will be allowed for densitometer variations. Gamma rays shall be from iridium 192 isotope and emitting specimen shall not exceed 0.175 inch in greatest diagonal dimension.

Place radiographic film perpendicular to radiation source at all times; parallel to root line of weld, unless source placement determines that film must be turned; and as close to weld root as possible.

Maintain minimum source-to-film distance such that radiographs maintain maximum geometric unsharpness of 0.020, regardless of reinforcing bar size.

Place penetrameters on source side of bar and perpendicular to radiation source at all times. Place one penetrameter in center of each bar to be radiographed, perpendicular to weld root, and adjacent to weld. Penetrameter images shall not appear in weld area.

When radiography of more than one weld is being performed per exposure, include minimum of one pentrameter per bar for each exposure, or three penetrameters per exposure. When three penetrameters per exposure are used, place one penetrameter on each of the two outermost bars of the exposure, and place remaining penetrameter on centrally located bar.

Allowable weld buildup of 0.16 inch may be added to total material thickness when determining proper penetrameter selection. No image quality indicator equivalency will be accepted. Wire penetrameters or penetrameter blocks will not be allowed.

Shim penetrameters using radiographically identical material. Penetrameter image densities shall be minimum of 2.0 and maximum of 3.6.

Use Class 1 radiographic film, regardless of reinforcing bar size.

Keep radiographs free of film artifacts and processing defects, including streaks, scratches, pressure marks, or marks made for identifying film or for welding indications.

Clearly identify each splice on each radiograph. Before radiographic inspection begins, radiograph identification and marking system shall be established between the Contractor and the Engineer. Identify film by lead numbers only. Etching, flashing, or writing in identifications of any type will not be permitted. Make each piece of film identification information legible and include, as a minimum, the following information: Contractor's name, date, name of nondestructive testing firm, initials of radiographer, contract number, part number, and weld number. Place the letter "R" and repair number directly after weld number to designate radiograph of a repaired weld.

Develop radiographic film within time range of one minute less to one minute more than film manufacturer's recommended maximum development time. Sight development will not be allowed.

Use processing chemistry with consistent mixture and quality. Keep processing rinses and tanks clean. Maintain records of all developing processes and any chemical changes to developing processes. Submit those records to the Engineer upon request. The Engineer may request, at any time, that a sheet of unexposed film be processed in the presence of the Engineer, to verify processing chemical and rinse quality.

Record results of radiographic interpretations on signed certification and keep copy with film packet.

Include developer temperature, developing time, fixing duration, and rinse times in technique sheets prepared in accordance with ASME *Boiler and Pressure Vessel Code*, Section V, Article 2, Section T-291.

(F) Splicing of Welded Wire Fabric. Overlap flat sheets of welded wire fabric (WWF) to maintain uniform strength. Fasten sheets of WWF at ends and edges. Use edge lap not less than the following: one spacing of cross wires plus 2 inches; or 6 inches; or the numerical value of the longitudinal wire size (W-Size Number) times 4.3 divided by the longitudinal wire spacing in inches.

602.04 Measurement. Reinforcing steel will be paid on a lump sum basis. Measurement for payment will not apply.

The Engineer will base calculated weights in accordance with Table 602.04-1 – Bar Designation, Weight, and Area.

TABLE 602.04-1 - BAR DESIGNATION, WEIGHT, AND AREA		
Bar No.	**Weight Per Linear Foot (Pounds)**	**Area (Square Inches)**
3	0.376	0.11
4	0.668	0.20
5	1.043	0.31
6	1.502	0.44
7	2.044	0.60
8	2.670	0.79
9	3.400	1.00
10	4.303	1.27
11	5.313	1.56
14	7.65	2.25
18	13.60	4.00

602.05 Payment. The Engineer will pay for accepted reinforcing steel on a contract lump sum basis. Payment will be full compensation for the work prescribed in this section and Subsection 109.01 – Schedule of Agreed Prices for Lump Sum Price Items.

Pay under:

Pay Item	**Pay Unit**
Reinforcing Steel for _____	Lump Sum

The Engineer will not pay for clips, wire, or other material used for fastening reinforcement in place separately and will consider the cost for clips, wire, or other material used for fastening reinforcement in place as included in the contract price

of the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

The Engineer will not pay for welded wire fabric or bar mat reinforcement separately and will consider the cost for welded wire fabric or bar mat reinforcement as included in the contract price of the various contract pay items. The cost is for the work prescribed in this section and the contract documents.

END OF SECTION 602