
USACE / NAVFAC / AFCEC / NASA UFGS-05 50 14 (November 2008)

Preparing Activity: USACE Superseding
UFGS-05 50 14. (August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2013

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SECTION 05 50 14

STRUCTURAL METAL FABRICATIONS 11/08

NOTE: This guide specification covers the requirements for general workmanship applicable to the fabrication, assembly and testing of various items of metalwork and machine work. This section was originally developed for USACE Civil Works projects.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

1.1 UNIT PRICES

NOTE: If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 22 00.00 10.

1.1.1.1 Payment

[Payment will be made for costs associated with metalwork fabrication and machine work not specifically provided for elsewhere, which includes costs for materials, fabricating work, shop and field painting, galvanizing or other metallic coatings and the installation of metal items shown or required by these specifications unless otherwise specified. Where payment is based on scale weights, no payment will be made for material in excess of a variation from the net weight calculated from the dimensions shown on the approved detail drawings of 4 percent for fabricated shapes, bars and plates and 5 percent for castings and forgings. Except where specifically indicated or specified, no separate payment will be made for bolts, nuts, pins, washers, studs and strap hangers and the cost of such items must be included in the unit prices of items on which they are used.] [No separate payment will be made for the inspection of welds listed in paragraph NONDESTRUCTIVE EXAMINATION of this section.]

1.1.1.2 Measurement

[Metalwork fabrication and machine work for which payment is not otherwise specifically provided in these specifications, will be measured for payment based upon computed weights per fabricated piece, assembly or cast piece for the various metals as classified on the approved detail drawings except as indicated below. Indicate computed weights on the detail drawings submitted for approval. Approval of the detail drawings will constitute acceptance of the computed weights shown thereon. When measurement of complicated shapes can be determined more readily by scale weights per fabricated piece, cast piece or assembly the use of certified scale weights will be approved as the basis for measurement.]

- a. [Computed Weights: Use the net calculated weights based on the dimensions indicated on the detail drawings for payment. Compute the weight of rolled shapes and plates on the basis of their nominal weights and dimensions. In calculating the net weights deduct all copes, cuts and open holes except rivet and bolt. Calculating additional weight for overweight allowance, protective coatings, allowance for milling, grip length of rivets and bolts and butt and groove welds is not allowed. Compute the weight of castings including fillets on the basis of the dimensions shown on the detail drawings with deductions for all openings and cuts in the finished casting. Include within computed weights for fillet welds, rivets, bolts and cut washers in accordance with the following:

ALLOWANCES FOR WEIGHT OF EQUAL-LEG FILLET WELDS	
Leg of weld in millimeters inches	Kilograms per meterPounds per foot Length of weld
31/8	0.0450.03
53/16	0.0890.06
61/4	0.1600.11
85/16	0.2500.17
103/8	0.3600.24

ALLOWANCES FOR WEIGHT OF EQUAL-LEG FILLET WELDS	
Leg of weld in millimeters inches	Kilograms per meterPounds per foot Length of weld
117/16	0.4900.33
131/2	0.6300.42
165/8	0.9800.66
193/4	1.4000.96
227/8	1.9001.30
251	2.5001.70
Note: For unequal-leg fillet welds the weight corresponding to the smaller leg in the above listing must be multiplied by the ratio of the longer leg to the smaller leg.	

ALLOWANCES FOR WEIGHT OF RIVET HEADS	
Diameter in millimeters inches	KilogramsPounds per 100 heads
131/2	1.84
165/8	3.27
193/4	5.412
227/8	8.218
251	12.026
291-1/8	16.036
321-1/4	22.048
351-3/8	27.059
381-1/2	37.082
Note: Allowances for rivets are based on weight data given in AISC Manual for high button type and must apply to all types.	

ALLOWANCES FOR WEIGHT OF BOLTS - REGULAR SIZE	
Diameter in Millimeters Inches	Kilograms Pounds per 100 units
13 1/2	6.12 13.5
16 5/8	12.20 27.0
19 3/4	20.00 44.0
22 7/8	31.30 69.0
25 1	46.70 103.0
29 1-1/8	68.50 151.0
32 1-1/4	92.10 203.0

ALLOWANCES FOR WEIGHT OF BOLTS - HEAVY SIZE	
Diameter in millimeters inches	Kilograms Pounds per 100 heads
13 1/2	9.12 20.0
16 5/8	16.33 36.0
19 3/4	27.76 61.0
22 7/8	41.79 92.0
25 1	61.21 135.0
29 1-1/8	86.21 190.0
32 1-1/4	113.02 250.0
38 1-1/2	195.04 430.0
44 1-3/4	311.06 685.0
50 2	454.01 1000.0
57 2-1/4	635.01 1400.0
64 2-1/2	855.01 1885.0
70 2-3/4	1100.02 2430.0
75 3	1460.03 210.0

Note: Allowances for bolts are based on weight data given in AISC manual. Allowances consist of weight of square head, bolt shank (in and projecting beyond nut) and hexagonal nut and must apply to all type bolts without modification. Projections beyond nuts are assumed equal to 1/2 the bolt diameter up to M50 2 inch size bolts and 25 mm 1 inch for bolt sizes M50 2 inch and above. Where the number and size of another type of bolt would result in a significant difference in a pay

item the allowances given above should be supplemented to include the additional type of bolt.

ALLOWANCES FOR WEIGHT OF CUT WASHERS	
Diameter in millimeters inches	KilogramsPounds per 100 heads
131/2	2.024.45
165/8	4.048.90
193/4	5.9413.10
227/8	7.2115.90
251	9.7121.40
291-1/8	11.7025.9
321-1/4	15.2033.50
351-3/8	20.1044.30
381-1/2	22.0048.40
441-3/4	28.8063.60
502	35.9079.20
572-1/4	48.50107.00
642-1/2	57.60127.00
702-3/4	68.90152.00
753	84.40186.00
Note: Each unit comprise cut washer and bolt shank in depth of washer.	

The following weights, per cubic millimeter inch, will be used in computing weights of metalwork:	
Iron Castings	7.20 mg0.260 pounds
Steel (All Compositions)	7.83 mg0.283 pounds
Copper, Bronze, Brass; Nickel-Copper Alloy	8.61 mg0.311 pounds
Lead	11.30 mg0.409 pounds
Aluminum	2.77 mg0.100 pounds
All Other Metals	7.83 mg0.283 pounds

-] b. [Scale Weights - Shop scale weight measurements must be made in the presence of the Contracting Officer unless otherwise specifically authorized. The weight of erection bolts, nuts and washers boxes, crates and other containers used for packing and the materials used for supporting members during transportation must not be included in the scale weights. Contractor to prepare the shipping lists required in

paragraph SUBMITTALS in a format to allow the correct allocation of the scale weights of individual metal parts and members to the applicable payment classifications. Failure to comply with this requirement to the satisfaction of the Contracting Officer will necessitate measurement of computed weights. The weight of shop applied permanent protective coatings will not be deducted from scale weights.]

1.1.3 Unit of Measure

Unit of measure: per kg pound.

1.2 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ALUMINUM ASSOCIATION (AA)

AA ADM (2010) Aluminum Design Manual

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

ANSI/AGMA 2005 (2003D; R 2008) Design Manual for Bevel Gears

ANSI/AGMA 6001 (2008E) Design and Selection of Components for Enclosed Gear Drives

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2012; Errata 2011) Structural Welding Code - Steel

AWS D1.2/D1.2M (2008) Structural Welding Code - Aluminum

ASME INTERNATIONAL (ASME)

ASME B4.1	(1967; R 2009) Preferred Limits and Fits for Cylindrical Parts
ASME B46.1	(2009) Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2012) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A325	(2010) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2013) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A380/A380M	(2013) Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A490	(2012) Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A490M	(2012) Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)
ASTM A514/A514M	(2005; R 2009) Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A780/A780M	(2009) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B177/B177M	(2011) Standard Guide for Engineering Chromium Electroplating
ASTM B766	(1986; R 2008) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM D962	(1981; E 2008; R 2008) Aluminum Powder and Paste Pigments for Paints
ASTM E165/E165M	(2012) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E446	(2010) Radiographs for Steel Castings Up

to 2 In. (51mm) in Thickness

ASTM E709

(2008) Standard Guide for Magnetic Particle Examination

ASTM E94

(2004; R 2010) Radiographic Examination

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings[; G][; G, [_____]]

SD-03 Product Data

Welding of Structural Steel[; G][; G, [_____]]

Welding of Aluminum[; G][; G, [_____]]

Structural Steel Welding Repairs[; G][; G, [_____]]

Materials Orders

Materials List
Shipping Bill

SD-06 Test Reports

Tests, Inspections, and Verifications

SD-07 Certificates

Qualification of Welders and Welding Operators
Application Qualification for Steel Studs[; G][; G, [____]]
Welding of Aluminum[; G][; G, [____]]

1.4 QUALITY ASSURANCE

1.4.1 Qualification of Welders and Welding Operators

NOTE: All three of the codes permitted for
qualification should be retained except where the
requirements of a particular structure require being
more restrictive.

Certify that the qualification of welders and welding operators and tack welders who will perform structural steel welding have been qualified for the particular type of work to be done in accordance with the requirements of [AWS D1.1/D1.1M, Section 4,] or [ASME BPVC SEC IX, Section IX], prior to commencing fabrication.

- a. List the qualified welders by name and specify the code and procedures under which qualified and the date of qualification within the certification. Prior qualification will be accepted if welders have performed satisfactory work under the code for which qualified within the preceding three months. Welders are required to repeat the qualifying tests when their work indicates a reasonable doubt as to proficiency. Those passing the requalification tests will be recertified. Those not passing will be disqualified until passing. Contractor incurs all expenses in connection with qualification and requalification.
- b. Perform welding of aluminum conforming to AA ADM or AWS D1.2/D1.2M, Sections 1 through 7, 9 and 10. The welding process and welding operators shall be prequalified as required by AWS D1.2/D1.2M, Section 5 or AA ADM, Subsection 7.2.4 in accordance with the methods described in ASME BPVC SEC IX, Section IX. Furnish for approval a certified report giving the results of the qualifying tests, and a complete schedule of the welding process for each aluminum fabrication to be welded prior to commencing fabrication prior to commencing welding.
- c. Maintain an approved inspection system and perform required inspections in accordance with Contract Clause CONTRACTOR INSPECTION SYSTEM. Welding will be subjected to inspection to determine conformance with the requirements of AWS D1.1/D1.1M, the approved welding procedures and provisions stated in other sections of these specifications.

1.4.2 Detail Drawings

Submit detail drawings for metalwork and machine work, prior to

fabrication, include within the detail drawings catalog cuts, templates, fabrication and assembly details and type, grade and class of material as appropriate. Elements of fabricated items inadvertently omitted on contract drawings shall be detailed by the fabricator and indicated on the detail drawings.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Materials Orders

NOTE: The number of copies of purchase orders, mill orders, shop order and work orders to be specified by insertion in this paragraph should be determined on the basis of all factors involved in the anticipate inspection procedure. The number required will normally range from 3 to 5, depending upon whether mill or shop inspection is to be performed by personnel of the contracting district office or by inspection forces of another district or agency.

Furnish [_____] copies of purchase orders, mill orders, shop orders and work orders for all materials orders prior to the use of the materials in the work. Where mill tests are required, purchase orders include the test site address and the name of the testing agency.

2.1.2 Materials List

Submit a list of the materials to be used in the fabrication of each item at the time of submittal of detail drawings.

2.1.3 Shipping Bill

Submit a shipping bill or memorandum of each shipment of finished pieces or members to the project site giving the designation mark and weight of each item, the number of items, the total weight, and the car initial and number if shipped by rail in carload lots. Promptly mail duplicate copies of shipping bills to [_____].

2.2 FABRICATION

2.2.1 Structural Fabrication

Material shall be straight before being laid off or worked. Perform straightening, if necessary, by methods that will not impair the metal. Sharp kinks or bends will be cause for rejection of the material. Material with welds will not be accepted except where welding is definitely specified, indicated or otherwise approved. Make bends using approved dies, press brakes or bending rolls. Where heating is required, take precautions to avoid overheating the metal and allow it to cool in a manner that will not impair the original properties of the metal. Proposed flame cutting of material, other than structural steel, will be subject to approval and shall be indicated on detail drawings. Shearing shall be accurate and all portions of the work neatly finished. Corners shall be square and true unless otherwise shown. Re-entrant cuts shall be filleted

to a minimum radius of 19 mm 3/4 inch unless otherwise approved. Provide finished members free of twists, bends and open joints. Bolts, nuts and screws shall be tight.

2.2.1.1 Dimensional Tolerances for Structural Work

Measure dimensions using an approved calibrated steel tape of approximately the same temperature as the material being measured. The overall dimensions of an assembled structural unit shall be within the tolerances indicated on the drawings or as specified in the particular section of these specifications for the item of work. Where tolerances are not specified in other sections of these specifications or shown, an allowable variation of 1 mm 1/32 inch is permissible in the overall length of component members with both ends milled; component members without milled ends shall not deviate from the dimensions shown by more than 2 mm 1/16 inch for members 9 m 30 feet or less in length, and by more than 3 mm 1/8 inch for members over 9 m 30 feet in length.

2.2.1.2 Structural Steel Fabrication

Structural steel may be cut by mechanically guided or hand-guided torches, provided an accurate profile with a surface that is smooth and free from cracks and notches is obtained. Prepare surfaces and edges in accordance with AWS D1.1/D1.1M, Subsection 3.2. Where structural steel is not to be welded, chipping or grinding will not be required except as necessary to remove slag and sharp edges of mechanically guided or hand-guided cuts not exposed to view. Chip, grind or machine to sound metal hand-guided cuts which are to be exposed or visible.

2.2.1.3 Structural Aluminum Fabrication

Lay out and cut aluminum in accordance with the AA ADM, Section 6.

2.2.2 Welding

NOTE: The welding requirements provided are applicable primarily to structural grade steel, low carbon steel castings and aluminum. Where welding of other grades of steel, castings or non-ferrous metals is contemplated, the additional provisions necessary for the welding of these particular metals should be inserted.

2.2.2.1 Welding of Structural Steel

- a. Welding Procedures for Structural Steel - Prequalify welding procedures for structural steel as described in AWS D1.1/D1.1M, Subsection 3.1 or qualify by tests as prescribed in AWS D1.1/D1.1M, Section 4. Properly documented evidence of compliance with all requirements of these specifications for previous qualification tests shall establish a welding procedure as prequalified. For welding procedures qualified by tests, the test welding and specimen testing will be witnessed and the test report document signed by the Contracting Officer. Approval of any welding procedure will not relieve the Contractor of the responsibility for producing a finished structure meeting all requirements of these specifications. The Contractor will be directed or authorized to make any changes in previously approved welding

procedures that are deemed necessary or desirable by the Contractor Officer. Submit a complete schedule of welding procedures for each steel structure to be welded prior to commencing fabrication. The schedule shall conform to the requirements specified in the provisions AWS D1.1/D1.1M, Sections 2, 3, 4, 6, 7 and applicable portions of Section 8. Provide within the schedule detailed procedure specifications and tables or diagrams showing the procedures to be used for each required joint. Include in the welding procedures filler metal, preheat, interpass temperature and stress-relief heat treatment requirements. Each welding procedure shall be clearly identified as being prequalified or required to be qualified by tests. Welding procedures shall show types and locations of welds designated or in the specifications to receive nondestructive examination.

- b. Welding Process - Perform welding of structural steel by an electric arc welding process using a method which excludes the atmosphere from the molten metal and conforms to the applicable provisions of AWS D1.1/D1.1M. Minimize residual stresses, distortion and shrinkage from welding.

c. Welding Technique

NOTE: Vibratory type stress-relief treatment should not be approved as an alternate stress relieving means for applications covered by this specification.

- (1) Filler Metal - The electrode, electrode-flux combination and grade of weld metal shall conform to the appropriate AWS specification for the base metal and welding process being used or be as shown where a specific choice of AWS specification allowables is required. Include the AWS designation of the electrodes to be used in the schedule of welding procedures. Use only low hydrogen electrodes for manual shielded metal-arc welding regardless of the thickness of the steel. Use a controlled temperature storage oven at the job site as prescribed by AWS D1.1/D1.1M, Subsection 3.5 to maintain low moisture of low hydrogen electrodes.
- (2) Preheat and Interpass Temperature - Perform preheating as required by AWS D1.1/D1.1M, Subsection 3.5 or as otherwise specified except that the temperature of the base metal shall be at least 20 degrees C 70 degrees F. Slowly and uniformly preheat the weldments by approved means to the prescribed temperature, held at that temperature until the welding is completed and then permitted to cool slowly in still air.
- (3) Stress-Relief Heat Treatment - Where stress relief heat treatment is specified or shown, perform in accordance with the requirements of AWS D1.1/D1.1M, Subsection 5.8 unless otherwise authorized or directed.
- d. Workmanship - Perform welding workmanship in accordance with AWS D1.1/D1.1M, Section 3 and other applicable requirements of these specifications.
- (1) Preparation of Base Metal - Prior to welding inspect surfaces to be welded to ensure compliance with AWS D1.1/D1.1M, Subsection 3.2.

- (2) Temporary Welds - Make temporary welds, required for fabrication and erection, under the controlled conditions prescribed for permanent work. Make temporary welds using low-hydrogen welding electrodes and by welders qualified for permanent work as specified in these specifications. Conduct preheating for temporary welds as required by AWS D1.1/D1.1M for permanent welds except that the minimum temperature shall be 50 degrees C 120 degrees F in any case. In making temporary welds, arcs shall not be struck in other than weld locations. Remove each temporary weld and grind flush with adjacent surfaces after serving its purpose.
- (3) Tack Welds - Subject tack welds that are to be incorporated into the permanent work to the same quality requirements as the permanent welds; clean and thoroughly fuse them with permanent welds. Perform preheating as specified above for temporary welds. Multiple-pass tack welds shall have cascaded ends. Remove defective tack welds before permanent welding.

2.2.2.2 Welding of Steel Castings

Remove unsound material from the surfaces of steel castings, to be incorporated into welded connections, by chipping, machining, air-arc gouging or grinding. Do not weld major connections designed for transfer of stresses if the temperature of the casting is lower than 40 degrees C 100 degrees F. Castings containing over 0.35 percent carbon or over 0.75 percent manganese shall be preheated to a temperature not to exceed 230 degrees C 450 degrees F and conduct welding while the castings are maintained at a temperature above 180 degrees C 350 degrees F. Welding will not be permitted on castings containing carbon in excess of 0.45 percent except on written authorization. Castings requiring welding repairs after the first annealing and castings involving welding fabrication shall be stress-relieved annealed prior to receiving final machining unless otherwise permitted.

2.2.2.3 Welding of Steel Studs

Conform to the requirements of AWS D1.1/D1.1M, Section 7, except as otherwise specified for the procedures for welding steel studs to structural steel, including mechanical, workmanship, technique, stud application qualification, production quality control and fabrication and verification inspection procedures.

- a. Application Qualification for Steel Studs - As a condition of approval of the stud application process, furnish certified test reports and certification that the studs conform to the requirements of AWS D1.1/D1.1M, Subsections 7.2 and 7.3, certified results of the stud manufacturer's stud base qualification test, and certified results of the stud application qualification test as required by AWS D1.1/D1.1M, Subsection 7.6, prior to commencing fabrication, except as otherwise specified.
- b. Production Quality Control - Conform to the requirements of AWS D1.1/D1.1M, Subsection 7.7, except as otherwise specified for quality control for production welding of studs. Studs on which pre-production testing is to be performed shall be welded in the same general position as required on production studs (flat, vertical, overhead or sloping). If the reduction of the length of studs becomes

less than normal as they are welded, stop welding immediately and do not resume until the cause has been corrected.

2.2.3 Bolted Connections

2.2.3.1 Bolted Structural Steel Connections

Provide bolts, nuts and washers of the type specified or indicated. Equip all nuts with washers except for high strength bolts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Where the use of high strength bolts is specified or indicated, the materials, workmanship and installation shall conform to the applicable provisions of [ASTM A325M](#) [ASTM A325](#) or [ASTM A490M](#) [ASTM A490](#).

- a. Bolt holes shall be accurately located, smooth, perpendicular to the member and cylindrical.
- b. Holes for regular bolts shall be drilled or subdrilled and reamed in the shop and not be more than [2 mm](#) [1/16 inch](#) larger than the diameter of the bolt.
- c. Holes for fitted bolts shall be match-reamed or drilled in the shop. Remove burrs resulting from reaming. Keep bolt threads entirely outside of the holes. The body diameter of bolts shall have tolerances as recommended by [ASME B4.1](#) for the class of fit specified. Place fitted bolts in reamed holes by selective assembly to provide an LN-2 fit.
- d. Holes for high strength bolts shall not have diameters more than [2 mm](#) [1/16 inch](#) larger than bolt diameters. If the thickness of the material is not greater than the diameter of the bolts, the holes may be punched. If the thickness of the material is greater than the diameter of the bolts the holes may be drilled full size or subpunched or subdrilled at least [3 mm](#) [1/8 inch](#) smaller than the diameter of the bolts and then reamed to full size. Poor matching of holes will be cause for rejection. Drifting occurring during assembly shall not distort the metal or enlarge the holes. Reaming to a larger diameter of the next standard size bolt will be allowed for slight mismatching.

2.2.3.2 Bolted Aluminum Connections

Conform to the requirements of [AA ADM](#), Section 6 for punching, drilling, reaming and bolting for bolted aluminum connections.

2.2.4 Riveted Connections

2.2.4.1 Riveted Structural Steel Connections

- a. Rivet Holes - Rivet holes shall be accurately spaced, cylindrical, perpendicular to the member and [2 mm](#) [1/16 inch](#) larger than the diameter of the rivet. Countersinking shall be true and square with the hole. If the thickness of the material is not greater than the diameter of the rivet, the holes may be punched full size. If the thickness of the material is greater than the diameter of the rivet, drill the holes full size or subpunched or subdrilled at least [3 mm](#) [1/8 inch](#) smaller than the diameter of the rivet and then reamed to full size in accordance with the following provisions unless otherwise specified or authorized. For shop connections, rivet holes may be drilled full size if the component parts to be riveted are welded, bolted or clamped

together before drilling of rivet holes. For field connections the holes required to be subpunched or subdrilled shall be reamed in the shop if the work is assembled and matchmarked in the shop. For field connections not assembled in the shop, the holes required to be subpunched or subdrilled will be reamed in the field after the work has been assembled and bolted together.

- (1) Punched Holes - Punching shall be accurate. The diameter of the punch is not to be more than 2 mm 1/16 inch greater than the diameter of the rivet. The diameter of the die opening is not to be more than 2 mm 1/16 inch greater than the diameter of the punch. Holes shall be clean cut without torn or ragged edges.
- (2) Reamed and Drilled Holes - Reaming and final drilling is to be done with the component parts of the member assembled and firmly fastened together. Use twist drills for drilling. Use short taper reamers having not less than four flutes for reaming. Make reamed holes smooth by the reamer touching the entire circumference of the hole. Remove outside burrs on reamed holes to the extent of making a 2 mm 1/16 inch chamfer.
- (3) Accuracy of Punched and Drilled Holes - The accuracy of holes punched or drilled full size shall be such that for assembled components with a group of contiguous holes in the same plane 75 percent of the holes will admit a rod equal to the diameter of the cold rivet at right angles to the plane of the connection. The accuracy of holes required to be reamed or drilled after assembly will be such that any group of contiguous holes in the same plane show no offset greater than 1 mm 1/32 inch between adjacent thicknesses of metal. Drifting to enlarge holes is not allowed. Poor matching of holes will be cause for rejection. Reaming to a larger diameter for the next standard size rivet will be allowed for slight mismatching.

- b. Driving Rivets - Pin and firmly draw together with bolts all components to be riveted before commencing. Heat Rivets uniformly to a light cherry red color at a temperature not over 1070 degrees C 1950 degrees F in a gas, oil or electric furnace constructed so that it can be adjusted to the proper temperature except that an approved coal or coke furnace may be used for heating field rivets. Do not drive rivets after their temperature falls below 540 degrees C 1000 degrees F. When heated and ready for driving, rivets shall be free from slag, scale and adhesive materials. Hot drive rivets with pressure tools. Completely fill the holes with driven rivets. Neatly form rivet heads with dies of approved shape and full size, concentric with the rivet hole and in full contact with the member. Remove loose, burned, badly formed or otherwise defective rivets and replace with care to avoid damage to adjacent metal. Recupping or caulking will not be permitted. Chip or grind flush countersunk rivet with the surface of the plate unless otherwise specified or authorized. Do not paint field rivets until they have been inspected and accepted.

2.2.4.2 Riveted Aluminum Connections

Conform to the requirements of AA ADM, Section 6 for punching, drilling, reaming and riveting for riveted aluminum connections.

2.2.5 Patterns

NOTE: The first bracketed option in this paragraph (third sentence) will be generally used since in most cases it will be to the advantage of the Government not to retain any patterns, or core boxes or templates, and save the expense of repairs, shipment and storage. If the Government has patterns available for loan to the Contractor, subparagraph AVAILABLE PATTERNS should be included, with the appropriate information provided in the bracketed underlined spaces. If the first bracketed option is used and the Government has patterns available for loan to the Contractor, subparagraphs DISPOSITION OF PATTERNS, CORE BOXES, AND TEMPLATES should be suitably modified and included. If the second bracketed option (fourth sentence) is used, subparagraphs FABRICATION OF PATTERNS AND CORE BOXES and DISPOSITION OF PATTERNS, CORE BOXES AND TEMPLATES should be included.

Take care to avoid sharp corners or abrupt changes in cross section; ample fillets are to be used in the construction of patterns. Add, as required, draft and increases in pattern thicknesses to conform to the standard foundry practice applied and as necessary to ensure that all metal thicknesses of the finished castings conform to the dimensions shown and are within the tolerances specified in paragraph INSPECTION OF STEEL CASTINGS. [All patterns [, except those loaned to the Contractor by the Government,] will remain the property of the Contractor.] [Patterns for those parts listed below shall be furnished by the Contractor, become the property of the Government and not be used for work under any other contract unless specifically authorized. All other patterns [, except those loaned to the Contractor by the Government,] will remain the property of the Contractor.]

2.2.5.1 [Fabrication of Patterns and Core Boxes

Substantially make patterns and core boxes that become the property of the Government from thoroughly seasoned Grade B or better sugar pine, northern white pine or an approved equal. Built-up patterns and core boxes shall be securely glued and screwed together. Use approved high grade, water resistant glue that is suitably treated for resistance to fungus and insect infestation. Only light sections are permitted to be nailed. Counterbore and neatly fill screw holes with wood plugs. Dovetail or fasten with pull-out dowels loose pieces. Split patterns and core boxes shall have metal dowels at partings. Skelton or sweep patterns will not be accepted unless specifically authorized. Fill all nail and tool marks on molding surfaces with beeswax and sand all surfaces with No. 0 grade sandpaper. Finish patterns with not less than three coats of an approved phenolic-resin sealer colored in accordance with the standard trade practices for pattern colors. Each pattern, core box and loose piece shall be stamped with the part mark shown. Furnish patterns complete with necessary core boxes and templates.]

[2.2.5.2 Available Patterns

NOTE: The serviceability and general condition of each pattern should be clearly indicated under the heading of "CONDITION."

The patterns listed below are available for loan to the Contractor. They are stored at [_____] and may be secured f.o.b. their place of storage upon request.

PART NO.	PATTERN NO.	CONDITION
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

The Contractor assumes responsibility for the accuracy and adaptability of all parts made with the above listed patterns, as if the parts had been made from new patterns produced under this contract, and bears the expense of correcting any inaccuracies found in them.

]2.2.5.3 [Disposition of Patterns, Core Boxes, and Templates

Substantially make and put together with screws the boxes and crates for the packing and shipment of patterns, core boxes and templates so that they can be used several times. Plainly mark each box and crate to indicate its contents. All patterns, core boxes and templates [including those loaned to the Contractor by the Government] used shall be thoroughly cleaned, crated and delivered in first-class condition with a list of same in duplicate to [_____] before final payment is made. The Contracting Officer reserves the right to withhold payment for final parts made from any pattern until such pattern is delivered. Patterns and core boxes shall be varnished and all templates given a coat of an approved paint before being crated. Replace any pattern, core box or template lost in shipment or damaged.]

2.2.6 Castings

Each casting and castings weighing more than 225 required kg 500 required pounds shall bear cast or stamped heat numbers. Deviations from the dimensions of castings shown shall not exceed amounts that will impair the strength of castings by more than 10 percent as computed from the dimensions shown. Dimensions of castings shown on approved detail drawings are finished dimensions. Castings that are warped or otherwise distorted or that are oversize to an extent that will interfere with proper fit with other parts of the machinery or structure will be rejected. The structure of metal in castings shall be homogeneous and free from excessive nonmetallic inclusions. Excessive segregation of impurities or alloys at critical points in castings will be cause for rejection. Do not make repairs to castings prior to approval. Minor surface imperfections not affecting the strength of casting may be welded in the "green" if approved. Surface imperfections will be considered minor when the depth of the cavity prepared for welding is the lesser of 20 percent of the actual wall thickness or 25 mm 1 inch. Defects other than minor surface imperfections may be welded only when specifically authorized in accordance with the following requirements:

- a. The defects have been entirely removed and are judged not to affect the strength, use or machineability of the castings when properly welded and stress relieved.
- b. The proposed welding procedure, stress relief and method of examination of the repair work have been submitted and approved.

2.2.7 Machine Work

NOTE: Paragraphs, PIN HOLES, GEARS, SHAFTING, and BEARINGS, should be deleted when the details specified are provided in the machinery section.

Tolerances, allowances and gauges for metal fits between plain, non-threaded, cylindrical parts shall conform to **ASME B4.1** for the class of fit shown or required unless otherwise shown on approved detail drawings. Where fits are not shown they will be suitable as approved. Tolerances for machine-finished surfaces designated by non-decimal dimensions shall be within **400 µm 1/64 inch**. Sufficient machining stock will be allowed on placing pads to ensure true surfaces of solid material. Provide finished contact or bearing surfaces true and exact to secure full contact. Polish journal surfaces and finish all surfaces with sufficient smoothness and accuracy to ensure proper operation when assembled. Parts entering any machine shall be accurately machined and all like parts be interchangeable except that parts assembled together for drilling or reaming of holes or machining will not be required to be interchangeable with like parts. Accurately locate all drilled holes bolts.

2.2.7.1 Finished Surfaces

Provide surface finishes, indicated or specified, in accordance with **ASME B46.1**. Values of required roughness heights are arithmetical average deviations expressed in **micrometers microinches**. These values are maximum. Lesser degrees will be satisfactory unless otherwise indicated. Compliance with surface requirements shall be determined by sense of feel and visual inspection of the work compared to Roughness Comparison Specimens in accordance with the provisions of **ASME B46.1**. Values of roughness width and waviness height shall be consistent with the general type of finish specified by roughness height. Where the finish is not indicated or specified use that which is most suitable for the particular surface, provide the class of fit required and be indicated on the detail drawings by a symbol which conforms to **ASME B46.1** when machine finishing is provided. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable for the intended use will be cause for rejection.

2.2.7.2 Unfinished Surfaces

Lay out all work to secure proper matching of adjoining unfinished surfaces unless otherwise directed. Where there is a large discrepancy between adjoining unfinished surfaces chip and grind smooth or machine to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown and be chipped or ground free of all projections and rough spots. Fill in depressions or holes not affecting the strength or usefulness of the parts in an approved manner.

2.2.7.3 Pin Holes

Pin holes are to be bored true to gauges, smooth, straight and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position.

2.2.7.4 Gears

Provide gears that have machine cut teeth of a form conforming to applicable design requirements of ANSI/AGMA 2005 and ANSI/AGMA 6001 unless otherwise specified or shown.

2.2.7.5 Shafting

Turn or grind shafting with hot-rolled or cold-rolled steel, as required, unless otherwise specified or authorized. Provide fillets where changes in section occur. Cold-finished shafting may be used where keyseating is the only machine work required.

2.2.7.6 Bearings

Bearings may be lined with babbitt or bronze unless otherwise specified or shown. Where the bearing pressure is in excess of 1400 kPa 200 psi, bearings shall be lined with bronze. Pressures on lined bearings shall not exceed [_____] kPa psi of projected area unless otherwise required or authorized. Anti-friction bearings of approved types and of sizes not less than those recommended by the bearing manufacturer for the duty intended will be permitted subject to approval. Properly align all bearings provided with a suitable means of lubrication. Install anti-friction bearings as required to provide for retention of the lubricant and to exclude dirt and grit.

2.2.8 Miscellaneous Provisions

2.2.8.1 Metallic Coatings

- a. Zinc Coatings - Apply zinc coatings in a manner and of a thickness and quality conforming to ASTM A123/A123M. Where zinc coatings are destroyed by cutting, welding or other causes regalvanize the affected areas. Regalvanize coatings 50 g 2 ounces or heavier with a suitable low-melting zinc base alloy similar to the recommendations of the American Hot-Dip Galvanizers Association to the thickness and quality specified for the original zinc coating. Repair coatings less than 50 g 2 ounces in accordance with ASTM A780/A780M.
- b. Cadmium Coatings - Provide cadmium coatings of a quality and thickness conforming to the requirements of ASTM B766 and inspections conforming to the requirements of ASTM E165/E165M, Type [_____].
- c. Chromium Coatings - Apply chromium coatings for engineering in conformance with ASTM B177/B177M.

2.2.8.2 Cleaning of Corrosion-Resisting Steel

Remove oil, paint and other foreign substances from corrosion-resisting steel surfaces after fabrication. Perform cleaning by vapor degreasing or by the use of cleaners of the alkaline, emulsion or solvent type. After the surfaces have been cleaned give a final rinsing with clean water followed by a 24 hour period during which the surfaces are intermittently

wet with clean water and then allowed to dry for the purpose of inspecting the clean surfaces. Visually inspect the surfaces for evidence of paint, oil, grease, welding slag, heat treatment scale, iron rust or other forms of contamination. If evidence of foreign substance is found, clean again in accordance with the applicable provisions of **ASTM A380/A380M**. Furnish the proposed method of treatment for approval. Visually reinspect after treatment. Use only stainless steel or nonmetallic bristle brushes to remove foreign substances. Any contamination occurring subsequent to the initial cleaning shall be removed by one or more of the methods indicated above.

2.2.8.3 Lubrication

The arrangement and details for lubrication shall be as shown. Thoroughly clean and lubricate, with an approved lubricant, all bearing surfaces before erection or assembly.

2.2.9 Shop Assembly

**NOTE: List structural and machinery units if
required by first sentence of this paragraph.**

Assemble [only those machinery and structural units listed below] [each machinery and structural unit furnished] in the shop to determine the correctness of the fabrication and matching of the component parts unless otherwise specified. Do not exceed those tolerances shown. Closely check each unit assembled to ensure that all necessary clearances have been provided and that binding does not occur in any moving part. Assembly in the shop shall be in the same position as final installation in the field unless otherwise specified. Perform assembly and disassembly work in the presence of the Contracting Officer unless waived in writing. Immediately remedy errors or defects disclosed by the Contractor without cost to the Government. Before disassembly for shipment each piece of a machinery or structural unit shall be match-marked to facilitate erection in the field. Indicate the location of match-marks by circling with a ring of white paint after the shop coat of paint has been applied or as otherwise directed.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Perform material tests and analyses certified by an approved laboratory to demonstrate that materials are in conformity with the specifications. These tests and analyses shall be performed and certified at the Contractor's expense. Perform tests, inspections, and verifications conforming to the requirements of the particular sections of these specifications for the respective items of work unless otherwise specified or authorized. Conduct tests in the presence of the Contracting Officer if so required. Furnish specimens and samples for additional independent tests and analyses upon request by the Contracting Officer. Properly label specimens and samples and prepare for shipment. Submit certified test reports for materials with all materials delivered to the site.

2.3.1 Nondestructive Testing

When doubt exists as to the soundness of any material part, such part may be subjected to any form of nondestructive testing determined by the Contracting Officer. This may include ultrasonic, magnaflux, dye penetrant, x-ray, gamma ray or any other test that will thoroughly

investigate the part in question. The cost of such investigation will be borne by the Government. Any defects will be cause for rejection; replace and retest rejected parts at the Contractor's expense.

2.3.2 Tests of Machinery and Structural Units

The details for tests of machinery and structural units shall conform to the requirements of the particular sections of these specifications covering these items. Assemble each complete machinery and structural unit and test them in the shop, in the presence of the Contracting Officer, unless otherwise directed. Waiving of tests will not relieve the Contractor of responsibility for any fault in operation, workmanship or material that occurs before the completion of the contract or guarantee. After being installed at the site, each complete machinery or structural unit shall be operated through a sufficient number of complete cycles to demonstrate to the satisfaction of the Contracting Officer that it meets the specified operational requirements in all respects.

2.3.3 Inspection of Structural Steel Welding

Nondestructive examination of designated welds will be required. Supplemental examination of any joint or coupon cut from any location in any joint may be required.

2.3.3.1 Visual Examination

For all visual examination of completed welds clean and carefully examine for insufficient throat or leg sizes, cracks, undercutting, overlap, excessive convexity or reinforcement and other surface defects to ensure compliance with the requirements of AWS D1.1/D1.1M, Section 6, subsection 6.9, Part C.

2.3.3.2 Nondestructive Examination

Perform as designated or described in the sections of these specifications, the nondestructive examination of shop and field welds covering the particular items of work.

- a. Testing Agency - The nondestructive examination of welds and the evaluation of examination tests as to the acceptability of the welds shall be performed by a testing agency adequately equipped and competent to perform such services or by the Contractor using suitable equipment and qualified personnel. In either case, written approval of the examination procedures is required and the examination tests shall be made in the presence of the Contracting Officer. The evaluation of examination tests are subject to the approval and all records become the property of the Government.
- b. Examination Procedures - Conform to the following requirements.
 - (1) Ultrasonic Testing - Making, evaluating and reporting ultrasonic testing of welds shall conform to the requirements of AWS D1.1/D1.1M, Section 6, Part C. Provide ultrasonic equipment capable of making a permanent record of the test indications. Make a record of each weld tested.
 - (2) Radiographic Testing - Making, evaluating and reporting radiographic testing of welds shall conform to the requirements of AWS D1.1/D1.1M, Section 6, Parts C and E.

- (3) Magnetic Particle Inspection - Magnetic particle inspection of welds shall conform to the applicable provisions of **ASTM E709**.
- (4) Dye Penetrant Inspection - Perform dye penetrant inspection of welds conforming to the applicable provisions of **ASTM E165/E165M**.
- c. Acceptability of Welds - Welds will be unacceptable if shown to have defects prohibited by **AWS D1.1/D1.1M**, or possess any degree of incomplete fusion, inadequate penetration or undercutting.
- d. Welds to be Subject to Nondestructive Examination

NOTE: List here the type, location and extent of welds to be subjected to nondestructive examination. The welds so listed should also be shown using the appropriate designation of AWS A2.4 "Standard Symbols for Welding, Brazing and Nondestructive Examination".

Complete nondestructive examination of welds should be limited to welds upon which the structure is dependent. Spot nondestructive examination of welds should be used to ensure adequate welding quality and water tightness of seams where required.

Ultrasonic testing should be used for groove welds in tee or corner joints.

Radiographic or ultrasonic testing should be used for groove welds in butt joints.

Magnetic particle inspection may be used for the detection of cracks and other discontinuities at or near the surface of root and surface passes and intermediate layers not exceeding 6 mm (1/4 inch) thickness.

Dye penetrant inspection should be used only for detection of discontinuities that are open to the surface in single pass fillet welds.

Omit this paragraph where nondestructive examination is covered in other sections of the specifications.

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2.3.3.3 Test Coupons

NOTE: For supply contracts a provision similar to that given under contract clauses should be written into this paragraph.

The Government reserves the right to require the Contractor to remove

coupons from completed work when doubt as to soundness cannot be resolved by nondestructive examination. Should tests of any two coupons cut from the work of any welder show strengths less than that specified for the base metal it will be considered evidence of negligence or incompetence and such welder will be removed from the work. When coupons are removed from any part of a structure, repair the members cut in a neat manner with joints of the proper type to develop the full strength of the members. Repaired joints shall be peened as approved or directed to relieve residual stress. The expense for removing and testing coupons, repairing cut members and the nondestructive examination of repairs shall be borne by the Government or the Contractor in accordance with the Contract Clauses INSPECTION AND ACCEPTANCE.

2.3.3.4 Supplemental Examination

When the soundness of any weld is suspected of being deficient due to faulty welding or stresses that might occur during shipment or erection, the Government reserves the right to perform nondestructive supplemental examinations before final acceptance. The cost of such inspection will be borne by the Government.

2.3.4 Structural Steel Welding Repairs

Repair defective welds in the structural steel welding repairs in accordance with AWS D1.1/D1.1M, Subsection 3.7. Remove defective weld metal to sound metal by use of air carbon-arc or oxygen gouging. Do not use oxygen gouging on ASTM A514/A514M steel. Thoroughly clean surfaces before welding. Retest welds that have been repaired by the same methods used in the original inspection. Except for the repair of members cut to remove test coupons and found to have acceptable welds costs of repairs and retesting will be borne by the Contractor. Submit welding repair plans for steel, prior to making repairs.

2.3.5 Inspection and Testing of Steel Stud Welding

NOTE: Provisions for radiographic inspection of castings should be limited to castings upon which the structural integrity of the structure is dependent. The drawings should indicate which castings and what areas are to be radiographed.

Perform fabrication and verification inspection and testing of steel stud welding conforming to the requirements of AWS D1.1/D1.1M, Subsection 7.8 except as otherwise specified. The Contracting Officer will serve as the verification inspector. One stud in every 100 and studs that do not show a full 360 degree weld flash, have been repaired by welding or whose reduction in length due to welding is less than normal shall be bent or torque tested as required by AWS D1.1/D1.1M, Subsection 7.8. If any of these studs fail, bend or torque test two additional studs. If either of the two additional studs fails, all of the studs represented by the tests will be rejected. Studs that crack under testing in either the weld, base metal or shank will be rejected and replaced by the Contractor at no additional cost.

2.3.6 Inspection of Steel Castings

NOTES: Radiographic inspection of castings should be limited to castings upon which the structural integrity of the structure is dependent. The drawings should indicate which castings and what areas are to be radiographed.

Insert applicable type and severity level in the bracketed spaces of the table in this paragraph.

Perform radiographic inspection of steel castings as designated and as described in the section of these specifications covering the particular item of work. The procedure for making, evaluating and reporting the radiographic inspection shall conform to the requirements of [ASTM E94](#). The castings will be unacceptable if shown to have defects of greater severity than the applicable reference standard specified in the following table:

DISCONTINUITY TYPE	SEVERITY LEVELS OR CLASSES
[_____]	[_____]
[_____]	[_____]

Use the applicable referenced standards as illustrated in [ASTM E446](#). The evaluation of the radiographs will be subject to approval and all records will become the property of the Government.

PART 3 EXECUTION

3.1 INSTALLATION

Thoroughly clean all parts to be installed. Remove packing compounds, rust, dirt, grit and other foreign matter. Clean holes and grooves for lubrication. Examine enclosed chambers or passages to make sure that they are free from damaging materials. Where units or items are shipped as assemblies they will be inspected prior to installation. Disassembly, cleaning and lubrication will not be required except where necessary to place the assembly in a clean and properly lubricated condition. Do not use pipe wrenches, cold chisels or other tools likely to cause damage to the surfaces of rods, nuts or other parts used for assembling and tightening parts. Tighten bolts and screws firmly and uniformly but take care not to overstress the threads. When a half nut is used for locking a full nut place the half nut first followed by the full nut. Lubricate threads of all bolts except high strength bolts, nuts and screws with an approved lubricant before assembly. Coat threads of corrosion-resisting steel bolts and nuts with an approved antigalling compound. Driving and drifting bolts or keys will not be permitted.

3.1.1 Alignment and Setting

Accurately align each machinery or structural unit by the use of steel shims or other approved methods so that no binding in any moving parts or distortion of any member occurs before it is fastened in place. The alignment of all parts with respect to each other shall be true within the respective tolerances required. Set true machines to the elevations shown.

3.1.2 Blocking and Wedges

Remove all blocking and wedges used during installation for the support of parts to be grouted in foundations before final grouting unless otherwise directed. Blocking and wedges left in the foundations with approval shall be of steel or iron.

3.1.3 Foundations and Grouting

**NOTE: Required special provisions relative to
concreting and grouting machinery foundations and
bases should be inserted in Section 03 30 53
MISCELLANEOUS CAST-IN-PLACE CONCRETE.**

Concreting of subbases and frames and the final grouting under parts of machines shall be in accordance with the procedures as specified in Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE.

3.2 TESTS

3.2.1 Workmanship

Workmanship must be of the highest grade and in accordance with the best modern practices to conform with the specifications for the item of work being furnished.

3.2.2 Production Welding

Perform production welding conforming to the requirements of AWS D1.1/D1.1M or AWS D1.2/D1.2M, as applicable. Studs, on which pre-production testing is to be performed, shall be welded in the same general position as required on production items (flat, vertical, overhead or sloping). Test and production stud welding will be subjected to visual examination or inspection. If the reduction of the length of studs becomes less than normal as they are welded, stop welding immediately and do not resume until the cause has been corrected.

3.3 PROTECTION OF FINISHED WORK

3.3.1 Machined Surfaces

Thoroughly clean foreign matter off machined surfaces. All finished surfaces shall be protected by suitable means. Oil and wrap unassembled pins and bolts with moisture resistant paper or protect them by other approved means. Wash finished surfaces of ferrous metals to be in bolted contact, with an approved rust inhibitor and coat them with an approved rust resisting compound for temporary protection during fabrication, shipping and storage periods. Paint finished surfaces of metals which will be exposed after installation, except corrosion resisting steel or nonferrous metals as specified in Section 09 97 02 PAINTING: HYDRAULIC STRUCTURES.

3.3.2 Lubrication After Assembly

After assembly fill all lubricating systems with the lubricant specified and apply additional lubricant at intervals as required to maintain the equipment in satisfactory condition until acceptance of the work.

3.3.3 Aluminum

Protect aluminum that will be in contact with grout or concrete from galvanic or corrosive action, with a coat of zinc-chromate primer and a coat of aluminum paint. Protect aluminum in contact with structural steel against galvanic or corrosive action with a coat of zinc-chromate primer and a coat of aluminum paint. Provide aluminum paint consisting of a aluminum paste conforming to **ASTM D962**, spar varnish and thinner compatible with the varnish. Field mix the aluminum paint in proportion of **1 kg 2 pounds** of paste, not more than **4 L one gallon** of spar varnish and not more than **500 mL one pint** of thinner.

-- End of Section --