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USACE / NAVFAC / AFCEC / NASA | **UFGS-05 50 14 (August 2018)**

Preparing Activity: USACE | **Superseding UFGS-05 50 14 (May 2014)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021

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SECTION 05 50 14

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08/18

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SECTION 05 50 14

STRUCTURAL METAL FABRICATIONS
08/18

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NOTE: This guide specification covers the requirements for general workmanship applicable to the fabrication, assembly and testing custom fabricated or machined assemblages requiring strict tolerances and specific expertise in detailing, fabrication, and installation. 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 item(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).

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PART 1 GENERAL

1.1 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 Reference Identifier (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.

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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	(2020) Aluminum Design Manual

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA ISO 22849-A12	(2012) Design Recommendations for Bevel Gears
AGMA ISO 23509-A08	(2008) Bevel and Hypoid Gear Geometry
ANSI/AGMA 6001	(2008E; R 2014) Design and Selection of Components for Enclosed Gear Drives

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ANSI/ASNT CP-189	(2016) ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel (ANSI/ASNT CP-105-2006)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B4.1	(1967; R 1994; R 2004; R 2009; R 2020) Preferred Limits and Fits for Cylindrical Parts
ASME B46.1	(2020) Surface Texture, Surface Roughness, Waviness and Lay

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel
AWS D1.2/D1.2M	(2014; Errata 1 2014; Errata 2 2020) Structural Welding Code - Aluminum
AWS QC1	(2016) Specification for AWS Certification of Welding Inspectors

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A380/A380M	(2017) Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B177/B177M	(2011; R 2017) Standard Guide for Engineering Chromium Electroplating
ASTM B766	(1986; R 2015) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM D962	(1981; R 2014) Aluminum Powder and Paste Pigments for Paints
ASTM E94/E94M	(2017) Standard Guide for Radiographic Examination Using Industrial Radiographic Film
ASTM E165/E165M	(2018) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E446	(2014) Radiographs for Steel Castings Up to 2 In. (51mm) in Thickness
ASTM E709	(2015) Standard Guide for Magnetic Particle Examination
ASTM F3125/F3125M	(2019) Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

RESEARCH COUNCIL ON STRUCTURAL CONNECTIONS (RCSC)

RCSC S348	(2014; Errata 2015) RCSC Specification for Structural Joints Using High-strength Bolts

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification 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[, [_____]]

Welding Procedures; G[, [_____]]

Welding Repair Plan

Castings

SD-03 Product Data

Filler Metal

Lubricant

SD-06 Test Reports

Tests, Inspections, and Verifications

SD-07 Certificates

Welding Qualifications

Application Qualification for Steel Studs; G[, [_____]]

Welding of Aluminum

Weld Inspection Log

Certified Welding Inspector

Nondestructive Testing Personnel

1.3 QUALITY ASSURANCE

1.3.1 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. Indicate methods of protecting the work during shipping, storage, field assembly, and installation.

1.3.2 Welding Qualifications

Prior to welding, submit certification for each welder stating the type of welding and positions qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests. [If the qualification date of the welder or welding operator is more than 6 months old, accompany the welding operator's qualification certificate with a current certificate by the welder attesting to the fact that he has been engaged in welding since the date of certification, with no break in welding service greater than 6 months.]

Conform to all requirements specified in [AWS D1.1/D1.1M] and [AA ADM] [or AWS D1.2/D1.2M].

PART 2 PRODUCTS

2.1 FABRICATION

2.1.1 Structural Fabrication

Material must be straight before being laid off or worked. Perform straightening, if necessary, by methods that will not impair the metal. Sharp kinks or bends are 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, is subject to approval and must be indicated on detail drawings. Shearing must be accurate and all portions of the work neatly finished. Make corners square and true unless otherwise shown. Fillet re-entrant cuts to a minimum radius of 19 mm 3/4 inch unless otherwise approved. Provide finished members free of twists, bends and open joints. Tighten bolts, nuts and screws.

2.1.1.1 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 must 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 must 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.

2.1.1.2 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, Prequalification of WPSs Clause. 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.

2.1.1.3 Structural Aluminum Fabrication

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

2.1.2 Welding

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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, insert the additional provisions necessary for the welding of these particular metals.

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2.1.2.1 Welding of Structural Steel

2.1.2.1.1 Welding Procedures for Structural Steel

Use prequalied welding procedures for structural steel as described in AWS D1.1/D1.1M, Prequalification of WPSs Clause or qualify by tests as prescribed in AWS D1.1/D1.1M, Qualification Clause. For welding procedures qualified by tests, the coupon welding and specimen testing will be witnessed and the test report document signed by the Contracting Officer. Approval of any welding procedure does 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 Contracting Officer.

a. Submit a complete schedule of welding procedures for each steel structure to be welded prior to commencing fabrication. Provide the schedule in conformance with the requirements specified in the provisions of AWS D1.1/D1.1M

b. 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.

Clearly identify each welding procedure as being prequalified or required to be qualified by tests.

c. Show types and locations of welds designated or in the specifications to receive nondestructive testing in the welding procedures.

2.1.2.1.2 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.

2.1.2.1.3 Welding Technique

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

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2.1.2.1.3.1 Filler Metal

Provide the electrode, electrode-flux combination and grade of filler metal conforming 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. Submit filler metal product data. 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, Fabrication Clause to maintain low moisture of low hydrogen electrodes.

2.1.2.1.3.2 Preheat and Interpass Temperature

Perform preheating as required by AWS D1.1/D1.1M, Fabrication Clause or as otherwise specified except that the temperature of the base metal must be at least 20 degrees C 70 degrees F. Slowly and uniformly preheat the joint area 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.

2.1.2.1.3.3 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, Fabrication Clause unless otherwise authorized or directed.

2.1.2.1.4 Workmanship

Perform welding workmanship in accordance with AWS D1.1/D1.1M, Fabrication Clause and other applicable requirements of these specifications.

2.1.2.1.4.1 Preparation of Base Metal

Prior to welding inspect surfaces to be welded to ensure compliance with AWS D1.1/D1.1M, Fabrication Clause.

2.1.2.1.4.2 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 must be 50 degrees C 120 degrees F in any case. In making temporary welds, do not strike arcs in other than weld locations. Remove each temporary weld and grind flush with adjacent surfaces after serving its purpose.

2.1.2.1.4.3 Tack Welds

Tack welds that are to be incorporated into the permanent work are to exhibit the same quality requirements as the permanent welds; clean and thoroughly fuse them with permanent welds. Perform preheating as specified above for temporary welds. Provide cascaded ends on multiple-pass tack welds. Remove defective tack welds before permanent welding.

2.1.2.2 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. Preheat castings containing over 0.35 percent carbon or over 0.75 percent manganese 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 is not 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 must be stress-relieved annealed prior to receiving final machining unless otherwise permitted.

2.1.2.3 Welding of Steel Studs

Welding of steel studs must conform to the requirements of AWS D1.1/D1.1M, Stud WeldingClause, 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.

2.1.2.3.1 Application Qualification for Steel Studs

As a condition of approval of the stud application process, submit certified test reports and certification that the studs conform to the requirements of AWS D1.1/D1.1M, Stud Welding Clause, 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, Stud Welding Clause, prior to commencing fabrication, except as otherwise specified.

2.1.2.3.2 Production Control

Production control of stud welding must conform to the requirements of AWS D1.1/D1.1M, Stud Welding Clause, except as otherwise specified for

quality control for production welding of studs. Weld studs on which pre-production testing is to be performed must be 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.

2.1.2.4 Welding of Aluminum

Welding of aluminum must conform to the requirements of [AA ADM] [and] [AWS D1.2/D1.2M]. Submit 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.

2.1.3 Bolted Connections

2.1.3.1 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, conform the materials, workmanship and installation to the applicable provisions of ASTM F3125/F3125M. Install High Strength Bolts ASTM F3125/F3125M Grade A325 or Grade A490 in accordance with the requirements of RCSC S348. All High Strength Bolted Connections are fully pretensioned to the minimum pretension as specified in RCSC S348. Follow the pre-installation verification procedures outlined in RCSC S348. All other bolted connections are snug tight in accordance with RCSC S348.

a. Accurately locate bolt holes, smooth, perpendicular to the member and cylindrical.

b. Drill or subdrill holes for regular bolts and ream in the shop and not more than 2 mm 1/16 inch larger than the diameter of the bolt.

c. Match-ream or drill holes for fitted bolts in the shop. Remove burrs resulting from reaming. Keep bolt threads entirely outside of the holes. The body diameter of bolts must 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 must 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 cannot distort the metal or enlarge the holes. Reaming to a larger diameter of the next standard size bolt will be allowed for slight mismatching.

2.1.3.2 Bolted Aluminum Connections

Conform to the requirements of AA ADM, Section J.3 and M.10 for bolted aluminum connections.

2.1.4 Riveted Aluminum Connections

Conform to the requirements of AA ADM, Section J.4 and M.11 for riveted aluminum connections.

2.1.5 Patterns

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NOTE: Generally retain the first bracketed option in this paragraph (third sentence) 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, include subparagraph AVAILABLE PATTERNS, 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, include subparagraphs FABRICATION OF PATTERNS AND CORE BOXES and DISPOSITION OF PATTERNS, CORE BOXES AND TEMPLATES.

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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,] remain the property of the Contractor.] [Patterns for those parts listed below are furnished by the Contractor, become the property of the Government and cannot be used for work under any other contract unless specifically authorized. All other patterns [, except those loaned to the Contractor by the Government,] remain the property of the Contractor.]

[2.1.5.1 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. Securely glue and screw together built-up patterns and core boxes. 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 must 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. Stamp each pattern, core box and loose piece with the part mark shown. Provide patterns complete with necessary core boxes and templates.

][2.1.5.2 Available Patterns

****
NOTE: Clearly indicate the serviceability and general condition of each pattern 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.

][2.1.5.3 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. Thoroughly clean all patterns, core boxes and templates [including those loaned to the Contractor by the Government] used, crate and deliver 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. Varnish patterns and core boxes and give all templates a coat of an approved paint before being crated. Replace any pattern, core box or template lost in shipment or damaged.

]2.1.6 Castings

Each casting and castings weighing more than 225 required kg 500 required pounds must bear cast or stamped heat numbers. Submit detail drawings for each casting. Deviations from the dimensions of castings shown must not exceed amounts that 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 interfere with proper fit with other parts of the machinery or structure will be rejected. The structure of metal in castings must 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.

2.1.7 Machine Work

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NOTE: Delete paragraphs, PIN HOLES, GEARS, SHAFTING when the details specified are provided in the machinery section.
****

Tolerances, allowances and gauges for metal fits between plain, non-threaded, cylindrical parts 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 must 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. Accurately machine parts entering any machine 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 bolt holes.

2.1.7.1 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 is 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 must 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 make the part unsuitable for the intended use will be cause for rejection.

2.1.7.2 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 must 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.

2.1.7.3 Pin Holes

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

2.1.7.4 Gears

Provide gears that have machine cut teeth of a form conforming to applicable design requirements of AGMA ISO 22849-A12, AGMA ISO 23509-A08 and ANSI/AGMA 6001 unless otherwise specified or shown.

2.1.7.5 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.

2.1.7.6 Bearings

Bearings may be lined with babbit or bronze unless otherwise specified or shown. Where the bearing pressure is in excess of 1400 kPa 200 psi, line bearings with bronze. Pressures on lined bearings must 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.

2.1.8 Miscellaneous Provisions

2.1.8.1 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.

2.1.8.2 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. Remove any contamination occurring subsequent to the initial cleaning by one or more of the methods indicated above.

2.1.8.3 Lubrication

Provide the arrangement and details for lubrication as indicated. Thoroughly clean and lubricate, with an appropriate lubricant, all bearing surfaces before erection or assembly. Prior to use of the lubricant submit for approval product data supporting its use in the assembly that includes the following lubricating properties as they apply, temperature range, protection against corrosion, ability to remain in bearing, ability to seal out contaminants, cooling and friction.

2.1.9 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 must 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 match-mark each piece of a machinery or structural unit 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.

2.2 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 must 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.

2.2.1 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 if the part is found to be sound and by the Contractor if the part is found to be defective. Any defects will be cause for rejection; replace and retest rejected parts at the Contractor's expense.

2.2.2 Tests of Machinery and Structural Units

The details for tests of machinery and structural units must 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 does 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, operate each complete machinery or structural unit 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.

2.2.3 Inspection of Structural Steel Welding

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

2.2.3.1 Visual Examination

All visual inspection will be conducted in accordance with AWS D1.1/D1.1M, by a Certified Welding Inspector. Document this inspection in the Visual Weld Inspection Log. Submit certificates indicating that certified welding inspectors meet the requirements of AWS QC1.

2.2.3.2 Nondestructive Testing

Perform as designated or described in the sections of these specifications, the nondestructive testing of shop and field welds covering the particular items of work. Record final nondestructive testing results in the Weld Inspection Log which identifies final NDT inspection of all welds requiring inspection and submit the log.

2.2.3.2.1 Testing Agency

The nondestructive testing of welds and the evaluation of tests as to the acceptability of the welds must be performed by a testing agency adequately equipped and competent to perform such services or by the Contractor using suitable equipment and qualified personnel. All personnel performing nondestructive testing shall be certified Level I or II in the method of NDT being utilized in accordance with ANSI/ASNT CP-189. Level I inspectors must have direct supervision of a Level II inspector. Submit certification for nondestructive testing personnel prior to all testing. In either case, written approval of the examination procedures

is required and performance of the examination tests must be done in the presence of the Contracting Officer. The evaluation of tests are subject to the approval and all records become the property of the Government.

2.2.3.2.2 Examination Procedures

Conform to the following requirements.

****

NOTE: Where welds are subjected to cyclic loading identify them on the construction documents and include cyclically in the paragraph below.

****

2.2.3.2.2.1 Ultrasonic Testing

Examine, evaluate and report ultrasonic testing of welds in conformance to the requirements of AWS D1.1/D1.1M, Inspection Clause, for [statically] [cyclically] loaded connections. Provide ultrasonic equipment capable of making a permanent record of the test indications. Make a record of each weld tested.

2.2.3.2.2.2 Magnetic Particle Inspection

Conform magnetic particle inspection of welds to the applicable provisions of ASTM E709.

2.2.3.2.2.3 Dye Penetrant Inspection

Perform dye penetrant inspection of welds conforming to the applicable provisions of ASTM E165/E165M.

2.2.3.2.3 Welds to be Subject to Nondestructive Testing

****

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

Limit complete nondestructive testing of welds to welds upon which the structure is dependent. Use spot nondestructive examination of welds to ensure adequate welding quality and water tightness of seams where required.

Use ultrasonic testing for groove welds in tee, corner or buttjoints.

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 in ferritic steel only.

Use dye penetrant inspection only for detection of discontinuities that are open to the surface in

single pass fillet welds.

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

The engineer should determine the appropriate table from AWS D1.1/D1.1M for UT inspection, Static Table 6.2 or Cyclic Table 6.3. Identify cyclically loaded welds on the construction documents.

****

Test [50%][_____] of CJP welds using ultrasonic testing per Table [6.2] [or 6.3] of AWS D1.1/D1.1M. Randomly test [50%][_____] of all PJP and fillet welds or as indicated by magnetic particle or dye penetrant testing.

2.2.3.3 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 testing. 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. Peen repaired joints as approved or directed to relieve residual stress. The expense for removing and testing coupons, repairing cut members and the nondestructive testing of repairs is borne by the Government or the Contractor in accordance with the Contract Clauses INSPECTION AND ACCEPTANCE.

2.2.3.4 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.

2.2.4 Welding Repair Plan

Repair defective welds in accordance with AWS D1.1/D1.1M, Fabrication Clause. Remove defective weld metal to sound metal by use of air carbon-arc or oxygen gouging. 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.

2.2.5 Inspection and Testing of Steel Stud Welding

Perform fabrication and verification inspection and testing of steel stud welding conforming to the requirements of AWS D1.1/D1.1M, Welding Clause except as otherwise specified. The Contracting Officer will serve as the verification inspector. Bend or torque test one stud in every 100,

including 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 as required by AWS D1.1/D1.1M, Stud Welding Clause. 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 the weld, base metal or shank will be rejected and replaced by the Contractor at no additional cost.

2.2.6 Inspection of Steel Castings

****

NOTES: Limit radiographic inspection of castings 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. Radiographic inspection must be done at the casting plant and not on site.

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

****

Perform radiographic inspection of steel castings at the casting plant 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 must conform to the requirements of ASTM E94/E94M. 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 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

appropriate 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 must 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 must 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.

****

Provide concrete subbases and frames and final grout under parts of machines 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, must 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. Protect all finished surfaces. 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 appropriate lubricant 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 --