

Preparing Activity: USACE

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2011

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08/09

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SECTION 05 59 13

FABRICATION OF HYDRAULIC STEEL STRUCTURES 08/09

NOTE: This guide specification covers the requirements for general workmanship applicable to the fabrication, assembly and testing of fracture critical Hydraulic Steel Structures..

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

NOTE: This specification is intended for the fabrication of NEW Hydraulic Steel Structures. Fracture critical hydraulic steel structures (HSS) are critical life safety structures that require added quality control. Fracture critical HSS or components of HSS are those portions whose failure would lead to collapse of the structure and potential life loss.

The results of the Hydraulic Steel Structures inspection program, undertaken by USACE, has shown that fracture critical fabrication without added oversight has led to a lack of understanding of the techniques required to ensure life safety.

This guide specification is intended to ensure fracture critical structures are properly manufactured according to updated welding criteria and ensures that quality control is exercised

throughout the fabrication process in accordance with ER 1110-2-8157. This specification should be used for the design of fracture critical HSS structures and HSS structures subjected to dynamic loads. Bulkheads/stoplogs or other HSS structures, not fabricated with fracture critical components or subject to static load only, may be fabricated to this specification when an added level of quality control is required. Use of this specification for the repair of existing structures is not recommended and would require numerous modifications to ensure compatibility of existing steel with fracture critical requirements.

As of May 2009 all references have been updated to the current edition. The version of the reference being selected is critical considering the need for certain supplements. Changing the version of the ASTM reference such as ASTM A709 will affect the supplement required for toughness testing. For example, the supplement requirements in the older editions of A709 was S83 and S84. The current edition of A709-08 does not have supplement S83 or S84, S83 applied toughness requirements for non-fracture critical elements, or S84 applied toughness requirements for fracture critical elements. These requirements are defined in ASTM A6 Supplement S5 (Charpy Testing) and Section 10 of ASTM A709. Do not change reference years specified without verifying requirements. SPECSINTACT may require the use of an older version depending on the reference database your version of SPECSINTACT is checking against. Be careful when checking your references.

Take great care in adding references to additional steels (ASTM A36, A572, A992 etc.) as these steels do not provide toughness requirements for fracture critical structures and are NOT addressed as acceptable base metals in AWS D1.5. The following items are likely manufactured from steels that do not comply with AWS D1.5 and must be specifically addressed with a weld procedure generated for qualification such as:

1. Rub/Guide Blocks
2. Chain
3. Pipe or Tubing for Guardrail etc.
4. Ancillary items such as anode attachments etc.

In all instances where alternate materials, other than A709 steel are used, specific weld procedures must be generated to address the mixing of base metals in a given joint configuration. If the engineer chooses to add alternate base metals to the list of approved base metals then he/she must ensure that these metals are only permitted for individual components where these materials are required and must additionally ensure that pre-qualification records and qualified weld procedures for mixing

basemetals are specifically required in the
submittal section of this guide specification.

Note that AASHTO HB-17, Standard Specifications for Highway Bridges, needs to be added to the list of references if slip critical connections and testing are required. See the slip critical testing requirements as defined in the note provided in the paragraph Bolted Connections. In addition, add reference to ASTM A490 REVA if A490 bolts are specified under that same paragraph. The references to A490 and HB-17 have been removed from this guide specification in order to ensure that the specification compiles properly.

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 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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO/AWS D1.5M/D1.5 (2008; Errata 2009) Bridge Welding Code

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT SNT-TC-1A (2006) Recommended Practice No. SNT-TC-1A:
Personnel Qualification and Certification
in Nondestructive Testing and ANSI/ASNT
CP-105: Training Outlines for
Qualification of Nondestructive Testing
Personnel

AMERICAN WELDING SOCIETY (AWS)

AWS QC1 (2007) Standard for AWS Certification of Welding Inspectors

ASTM INTERNATIONAL (ASTM)

ASTM A 325 (2010) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A 563 (2007a) Standard Specification for Carbon and Alloy Steel Nuts

ASTM A 709/A 709M (2010) Standard Specification for Structural Steel for Bridges

ASTM E 165 (2009) Standard Test Method for Liquid Penetrant Examination

ASTM E 709 (2008) Standard Guide for Magnetic Particle Examination

ASTM F 436 (2010) Hardened Steel Washers

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2008; Change 1-2010; Change 3-2010; Errata 1-2010) Safety and Health Requirements Manual

1.2 SYSTEM DESCRIPTION

NOTE: Insert a list of structures that will be fabricated according to this specification. Note that other Division 5 specifications (Miscellaneous metals etc.) would enable structures to be fabricated according to AWS D1.1 and would permit the use of basemetal without toughness requirements etc. If more than one Division 5 specification is included in the specification package, then any item not listed below will be fabricated to a separate specification.

AWS D1.5 section 1.1.3 specifies that all references to "Engineer" approval in D1.5 refer to the State Bridge Engineer. The paragraph below addresses this to ensure that the proper authority/responsibility is given to the Engineer of record.

Provide a detailed [Work Plan](#) for fabrication, including descriptions of shop facilities, equipment, number of personnel, and related information prior to the Pre-fabrication Conference, and procedures for safe conduct of the work, careful removal and disposition of materials, protection of property that is to remain undisturbed, and coordination with other work in progress. Include in the procedures a detailed description of the methods

and equipment to be used for each operation, and the sequence of operations in accordance with [EM 385-1-1](#). The Work Plan shall include the recommended measuring system for ensuring dimensional tolerances. The fabrication of the following listed structures under this contract shall be performed according to this section of the specifications:

1. [Spillway Tainter Gates]
 2. [Fishway Intake Bulkheads]
 3. [Main Unit Head Gates]
- a. Material with welds will not be accepted unless the welding is specified or indicated on the drawings or otherwise approved. Welding shall not be started until welding procedures, inspectors, nondestructive testing personnel, welders, welding operators, and tackers have been qualified and approved. Each Contractor performing welding shall maintain records of the test results obtained in welding procedure, and welder, welding operator, and tacker performance qualifications.
 - b. As it is used in these specifications, "The Engineer" refers to the [District] or [AE] engineer of record. The [AASHTO/AWS D1.5M/D1.5](#) definition of "The Engineer" as specified in [AASHTO/AWS D1.5M/D1.5](#) section 1.1.3 shall refer to the [District] or [AE] engineer of record in lieu of the state bridge engineer as specified in section 1.1.3 of [AASHTO/AWS D1.5M/D1.5](#).
 - c. Schedule a Prefabrication Conference as soon as possible after Notice to Proceed and prior to any fabrication. The Prefabrication Conference shall include, at a minimum, the Prime Contractor, Fabricator, the Fabricator's primary QC representative, the COR, the GQAR, and the Engineer of record for the structure or structures being fabricated. The Prefabrication Conference shall occur either at the Fabrication Facilities or a similar location as deemed appropriate.

1.2.1 Weld Tracking Log Template

Submit for approval a weld tracking log template, a minimum of 30 days prior to commencement of fabrication, to identify all necessary components to be addressed in the tracking of all welds for the structures in question. A weld-tracking log will be developed and maintained as described in the following paragraphs.

1.2.2 Weld Tracking Log

Submit a log capable of individually identifying and tracking every weld on the project. Member identification shall follow the numbering scheme shown on the shop drawings. The log shall include the member to be welded, member type (FCM and Non-FCM), type of weld including temporary and tack welds, welding position, applicable WPS reference, AWS joint preparation designation, name or stamping designation of welder, welding operator or tacker, date and time of completion of welding and/or tacking, name and date of CWI visual inspection, NDT testing performed, including the type of inspection, date(s) of inspection, inspector name, and the acceptance criteria used, description of defects found and reason for non-compliance, corrective action taken, or whether the weld is acceptable. Weld identification on the shop drawing shall match weld tracking log identification. A completed log shall be bound together for each structure and two copies shall be submitted to the Contracting Officer immediately upon completion of the fabrication of each structure. Draft copies of NDT

testing shall be furnished to the Contracting Officer upon request and shall be available on the shop floor during any inspection.

1.2.3 Welding Procedure Specifications (WPS)

NOTE: AWS D1.5 1.3.6 defines that Ancillary products can be welded without WPS. Ancillary products are defined as products not subjected to tensile stress when subjected to live load. This requires the Contractor to know what components of the structure are in tension. In addition, Chapter 12 defines attachments less than 100 mm (4 inches) as not fracture critical. Each engineer should define what ancillary attachments he/she is concerned about. An example of this would be the attachment of anodes on the tension flanges of a bulkhead. These attachments are usually short (50 mm (2 inches)) in length and usually "tack" welded on. Ancillary attachments, either subjected to tension or requiring additional inspection other than visual, need to be defined on the drawings and should be mentioned in the specifications as not being omitted from inspection as permitted in D1.5. Seal backing bars, anodes, guides etc. should be specifically excluded from being treated as ancillary items.

Be extremely careful with what items are added to the list below. Some items may not meet the requirements of AWS D1.5 and may need to be addressed separately.

Submit a Welding Procedure Specification (WPS), with attached PQR and supporting test documentation on forms similar or equivalent to the sample forms in [AASHTO/AWS D1.5M/D1.5](#), Annex III, for each weld, including prequalified welds, in accordance with paragraph Welded Connections approved before fabrication is commenced. Welding Procedure Specifications shall be individually identified and shall be referenced on the shop drawings. In case of conflict between this specification and [AASHTO/AWS D1.5M/D1.5](#) as applicable, this specification governs. The following items shall not be considered ancillary items as defined in [AASHTO/AWS D1.5M/D1.5](#) Section 1.3.6 and shall be subjected to the same level of inspection required for primary welds under [AASHTO/AWS D1.5M/D1.5](#):

- a. [Sacrificial Anodes attached to the Gate]
- b. [Guide Shoes]
- c. [etc.]

1.2.4 Fracture Critical Members (FCM)

NOTE: Toughness requirements are necessary to prevent fracture and are measured for the base metal and for the weld metal. The following paragraph defines the toughness requirements for the base metal. These tests are conducted in the mill, prior to shipment of the A709 plate to the fabricator.

Recognize that the Zone of testing required for both completed welds and basemetal is a function of the service location of the structure. Please recognize that the table provided in EM-1110-2-2105 is out of date. It is recommend referencing the zone requirements of ASTM A709 Table 10 for fracture critical members. Temperature zones for services temperature of your structure are defined in AASHTO LRFD Table 6.6.2-1. Specifying a zone in lieu of an energy requirement is beneficial as it ensures that as the AASHTO code changes the energy requirement stays valid.

ALL FCM's must be designated on drawings. All Tension members and members subject to reversal of stress MUST be designated on the drawings. AWS D1.5 specifically requires this in section 12. In addition, the order of materials according to ASTM A709 requires the loading of each component to be defined. See ASTM A709 Section 10. Not specifying members as FCM on the drawings will change the testing requirements even if the specifications you have written here differ. There are numerous instances in AWS D1.5 (specifics include UT testing requirements) where testing shall be performed to a certain level of acceptance for tension members - such as required in Table 6.3 Note 3 regarding the subtracting of 4dB from indications found at the root of a weld "when such welds are designated as "tension welds" on the drawing.". Neglecting to label tension welds on the drawing will negate these code provisions.

Recognize that there may not be a splice or weld in a member as it was detailed, but that such member may later require splicing or attachments that would require welding to this member under modification. Neglecting to label this member as a tension member would preclude these welds from being properly tested according to D1.5.

Note that AWS Section 6.7.1.2 gives the Contractor considerable leeway regarding what percentage of welds are tested unless they are labeled fracture critical. As a result, if you want a weld to be fully tested as fracture critical you must label the weld fracture critical and if you want testing on any other critical welds you should designate the weld testing by item, both on the drawing and in the specifications. While the standard specifications may require a percentage of welds to be tested, if you want specific welds to be subjected to MT, PT, or UT, ensure that these welds are specified on the drawings. Consider specifying test requirements in the tail of each weld that you want NDT on.

In addition, A709 requires that mill orders for materials designate whether the material is tension or compression (T or F). T refers to non fracture

critical, F refers to fracture critical material. Steel that is ordered without the T or F designation will not be certified for toughness.

Note that A673 allows the mill to certify material for a lower service temperature than is being required. Tests may be performed at a lower service temperature in the mill and this is considered acceptable for higher service temperatures.

Preheat requirements for fracture critical welds are higher than typically specified in previous USACE guide specifications. Refer to Table 12.3 for minimum preheat requirements. Additionally note that preheat requirements are much higher for repair welds as defined in Section 12.17.6. This requires minimum preheat and interpass of 161 degrees C (325 degrees F) for material less than 38 mm (1-1/2 inch) thickness. This requirement will dictate the heat requirements for the entire job and should be accounted for in construction QA visits. The fabricator must have the facilities to preheat higher than the minimum temperatures discussed below if weld repairs are required.

D1.5 Section 12.16.2.1 requires both RT and UT for testing of Tension Butt Joints and Repaired Groove Welds. Do not delete one of these two requirements for fracture critical structures. Both RT and UT are required by code.

Be careful of the use of the term "tack" weld. Note that AWS 3.0 does not provide a definition of a length or size for a tack weld. AWS 3.0 defines a tack weld as: "A weld made to hold the parts of a weldment in proper alignment until the final welds are made." Tack welds are permitted in AWS D1.5 and will be used by fabricators. AWS D1.5 does allow tack welds and does permit them to be made without preheat. All tack welds made must be remelted and incorporated into the final weld. This is further detailed in section 2.1.4.e.(2). While the contractor will use tack welds in fabrication, it is not recommended to use the term tack weld on any drawings due to the ambiguous definition of tack welds described above.

FCM are shown on the Contract Drawings and include all attachments and connections to these members as defined in [AASHTO/AWS D1.5M/D1.5](#). All materials to be welded shall be [ASTM A 709/A 709M](#), grade as specified or shown on the drawings, using killed fine-grain mill practice, unless otherwise shown or specified. Mill repairs of base metal are prohibited. Toughness shall meet the requirements of [ASTM A 709/A 709M](#), Table 10, for Zone [2], unless otherwise indicated or specified. All materials used for the construction of fracture critical components shall meet the requirements of section 10 of [ASTM A 709/A 709M](#) and shall include mill certification showing that the material meets the necessary toughness requirements. Welding for fracture critical members shall meet all

requirements of AASHTO/AWS D1.5M/D1.5 Section 12, including:

- a. 12.5 Welding Processes. All procedures shall be qualified as required.
- b. 12.6 Consumable Requirements. All welding consumables shall be heat or lot-tested by the manufacturer to determine conformance with the requirements of the Fracture Control Plan (FCP). Exceptions are not allowed. Toughness test results shall meet the values specified in Table 12.1 of AASHTO/AWS D1.5M/D1.5. Submit a Fracture Control Plan (FCP) for welding on all Fracture Critical Members (FCM) in accordance with AASHTO/AWS D1.5M/D1.5, Section 12. Welding Procedures, qualifications, and certifications shall be submitted showing compliance with FCP requirements
- c. 12.7 Welding Procedure Specifications (WPS). All procedures, including repair welds, shall be prequalified or qualified by test as required and documented in the WPS and Procedure guidelines of AASHTO/AWS D1.5M/D1.5.
- d. 12.8 Certification and Qualification. Welders and welding operators shall meet the applicable requirements of AASHTO/AWS D1.5M/D1.5.
- e. Material handling and preparation, including thermal cutting, preparation of base metal, and straightening, curving, cambering shall meet the applicable requirements.
- f. 12.13 Tack Welds and Temporary Welds. All welds shall be located within the joint and shall meet the requirements of AASHTO/AWS D1.5M/D1.5, Table 12.2. Temporary welds on FCM are not permitted.
- g. Welding processes, including preheat, interpass temperatures, and postweld thermal treatment shall meet the applicable requirements.
- h. 12.16 Weld Inspection. The Quality Control inspection program shall be documented in the FCP. All inspectors and NDT technicians shall be qualified as required. All butt joints shall be tested with UT and RT. Inspection procedures and documentation are as specified in the applicable sections of AASHTO/AWS D1.5M/D1.5. Cooling times must be strictly adhered to.
- i. 12.17 Repair Welding. Repair welds must be classified as "critical repairs" or "non-critical repairs" for all repair welding. Repair procedures shall follow the minimum provisions unless specified otherwise. Repair procedures must be qualified and approved and subject to the same QA/QC inspection requirements as other welds. Minimum preheat for repair welding shall be as defined in AASHTO/AWS D1.5M/D1.5 section 12.17.6. All weld repairs to fracture critical members shall be considered critical welds in accordance with AASHTO/AWS D1.5M/D1.5 Section 12.17.3 and shall be approved by the engineer of record.

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. Submittals should be kept

to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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-01 Preconstruction Submittals

Welding Procedure Specifications (WPS) [; G] [; G, [____]]
Fracture Control Plan (FCP) [; G] [; G, [____]]
Weld Tracking Log Template [; G] [; G, [____]]

SD-02 Shop Drawings

Shop Drawings [; G] [; G, [____]]
Assembly [; G] [; G, [____]]
Welding Repairs - Non-Fracture Critical Members [; G] [; G, [____]]
Welding Repairs - Fracture Critical Members [; G] [; G, [____]]
Delivery/Shipping Plan [; G] [; G, [____]]

SD-03 Product Data

Materials Disposition Record

SD-06 Test Reports

Certified Test Reports [; G] [; G, [____]]
Weld Tracking Log [; G] [; G, [____]]
Witness Points

SD-07 Certificates

Work Plan[; G][; G, [____]]
Qualification of Welders and Welding Operators[; G][; G, [____]]
Inspector Qualifications[; G][; G, [____]]
Qualification of Structural Steel Fabricator[; G][; G, [____]]

SD-09 Manufacturer's Field Reports

Control Dimensions[; G][; G, [____]]

1.4 QUALITY ASSURANCE

Establish **Witness Points** for the Initial QA Inspection, Intermediate QA Inspections, and Final Inspection as follows. Start the Initial QA Inspection after the Government has determined that there is substantial completion of components that comprise a reasonable sampling of each significant FCM and non-FCM details. The extent of completion and details and the date of the Initial QA Inspection shall be determined at the Prefabrication Conference by the Government after discussion with the Contractor. At that time, produce a detailed schedule showing the progression of work and completion of components. This schedule will be updated weekly and provided by e-mail to the Contracting Officer. Give the Contracting Officer two weeks notice prior to the predetermined date for the Initial QA Inspection, including adjustments for changes in schedule. Intermediate QA Inspections will be conducted on an as needed basis and at the discretion of the Government. All QA inspections will follow **AASHTO/AWS D1.5M/D1.5** and AASHTO/NSBA Steel Bridge Collaboration S 4.1 - 2002 Steel Bridge Fabrication QC/QA Guide Specification. Provide unpainted components for each QA NDT and Visual Inspection. At these stages of construction, give the Contracting Officer three working days to inspect the structure. The QA Inspection period shall not commence until after a minimum period of 72 hours after any welding. After the Contracting Officer and the Engineer of Record has inspected the structure, make any changes required to the structure as directed by the Contracting Officer before proceeding with any additional welding. Proceed with the construction until the next witness point is reached, unless it is waived in writing by the Contracting Officer. Each structure fabricated is subject to a Final Fabrication Inspection prior to painting. A Final Fabrication Inspection shall be conducted after the first structure is completed. Final Fabrication Inspections of additional structures shall be scheduled and coordinated with the Contracting Officer and the Engineer of Record. Give the Contracting Officer a minimum notice of two weeks prior to the Final Fabrication Inspection.

1.4.1 Qualification of Welders and Welding Operators

NOTE: AWS D1.5 should remain referenced in this section of the specifications for the qualifications of welders. AWS D1.5 provides additional controls on the qualification of welders to include the prohibition of power tool cleaning between weld passes for the test. In addition, the reference to D1.5 ensures that welders performing fracture critical welds are annually retested according to AWS D1.5 section 12.8.2. AWS D1.1 requires a log showing that a welder who is qualified has continued

to weld in this process in the past 6 months. AWS D1.5 section 12.8.2 additionally stipulates that a welder must be qualified by test within 6 months prior to beginning any work. Qualification according to AWS D1.5. Section 12.8.2 requires both RT and bend testing of welded samples. Note that section 5.23.1.1 now allows a welder who follows a WPS produced for testing to be qualified for that weld and is NOT required to follow the initial qualification requirement of hand tools only. This now means that a welder can qualify by submitting WPS's for testing and avoid the hand tool restriction if being tested according to AWS D1.5, non fracture critical welds. The stipulation of Section 12 ensures that a welder has recently performed these welds and has had his/her welds inspected by RT. Referring to AWS D1.1 only ensures that the welder who is performing the welding has qualified at some point in his/her career. Welders working in a shop may have not welded a CJP overhead weld in 10 years but would still be qualified to perform welding provided someone has signed a log book saying that the welder has been using the process in the last 6 months. A welder who performs a 6 mm (1/4 inch) fillet weld with FCAW who was previously qualified is still qualified according to perform CJP overhead welds provided that he/she has used the FCAW process in the past 6 months. This is an additional reason for referencing AWS D1.5 requirements.

Submit welder, welding operator and tacker qualification certification for each welder, welding operator or tack welder to the Government Representative/Contracting Officer/ Engineer and approved before fabrication is commenced in accordance with paragraph Welded Connections. A CWI meeting the specified qualifications shall approve all welder qualifications. Welders, welding operators, and tack welders shall be limited to welding procedures for which they are certified. Test welds shall be prepared, welded, and tested in accordance with the requirements of AASHTO/AWS D1.5M/D1.5. Before assigning any welder, welding operator, or tacker to work under this contract, submit the names of the welders, welding operators, and tackers to be employed, and certification that each individual is qualified as specified. The certification shall state the type of welding and positions for which the welder, welding operator, or tacker is qualified, the code and procedure under which the individual is qualified, the date qualified, and the name of the firm and person certifying the qualification tests. The certification shall be kept current for the duration of the contract. Welder and welding operator qualification test records shall be submitted on forms similar or equivalent to the sample forms in AASHTO/AWS D1.5M/D1.5, Annex III. All welders performing fracture critical welds under this specification shall be qualified according to Section 12 of AASHTO/AWS D1.5M/D1.5. All welders performing non fracture critical welds shall be qualified according to Section 6 of AASHTO/AWS D1.5M/D1.5. All qualifications shall be current prior to commencing any work. Submit a log for each welder showing that he/she is current in the process and procedures being proposed for this work.

1.4.2 Inspector Qualifications

All inspectors, performing structural steel inspection in accordance with these specifications, shall be qualified and certified in conformance with **AWS QC1**. Provide an AWS Certified Welding Inspector (CWI) as the primary point of contact for quality control of welding. When several CWI and NDT technicians are working, one primary individual shall be designated as having primary responsibility for all quality control in accordance with **AASHTO/AWS D1.5M/D1.5** Section 6.1.2.2. Non-certified inspectors and certified associate weld inspectors (CAWI) shall not be used for inspection under these specifications. All personnel who perform NDT shall be qualified in accordance with: **ASNT SNT-TC-1A** NDT Level II or III. All personnel performing NDT shall be supervised by personnel possessing a Level III ASNT NDT certification in accordance with **AASHTO/AWS D1.5M/D1.5** section 6.1.3.4 and section 12.16.1.2. Submit copies of certificates showing evidence of qualifications or certifications for welding inspectors and NDT personnel.

1.4.3 Qualification of Structural Steel Fabricator

NOTE: To find AISC certified contractors in the project's region go to:

www.aisc.org

AISC certification audit procedures are described here:

www.qmconline

At the first PDT meeting address the need for certified AISC fabricators. AWS D1.5 Section 12.8 Certification and Qualification reads as follows: "Contractors shall be certified under the AISC (American Institute of Steel Construction) Quality Certification Program Category III, Major Steel Bridges with Fracture Critical Rating, or an equivalent program accepted by the engineer"

In order to perform fracture critical welding in accordance with AWS D1.5 the Contractor must be certified to this level. Do not wave this requirement.

The Contracting Officer may wish to address the value of this work in comparison to the number of fabricators available to perform this work, often suggesting that the fabrication of a small bulkhead should be set aside for a small Contractor. Using AISC certified fabricators ensures that the requirements of AWS D1.5 and these specifications are not new to the Contractor.

The AISC fabricator may or may not possess a paint facility and may sub contract this work. For this reason, the stipulation requiring the fabricator to possess a sophisticated paint system endorsement was removed from this guide specification. The paint

specification should be amended to require the paint applicator to either possess an AISC sophisticated paint system endorsement or be a certified contractor in accordance with SSPC as possessing either a QP 1 Certification (Field Application to Complex Industrial and Marine Structures) or QP 3 Certification Program (Shop Painting Certification Program).

The fabricating plant and fabricator shall be certified under the AISC (American Institute of Steel Construction) Quality Certification Program, Category III, Major Steel Bridges (CBR) category with Fracture Critical endorsement (F) and shall possess five 5 years documented experience on projects of similar scope. Similar scope means projects of similar size and similar amounts of welding and detail types. Submit copies of the AISC certificate indicating that the fabrication plant meets the specified structural steelwork category and documented experience. The [insert items excluded from this requirement, such as wire rope slings, rubber seals etc.] are excluded from the AISC fabricator certification requirements.

1.4.4 Testing by the Government

Material component parts may be subjected to any form of nondestructive testing, as directed by the Contracting Officer. This may include ultrasonic, magnetic partial, 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 and rejected materials or parts shall be replaced and retested at the Contractor's expense.

1.4.5 Shop Drawings

Prepare all shop drawings using a Registered Professional Engineer or under the direct supervision of a Registered Professional Engineer. Elements of fabricated items inadvertently omitted on contract drawings shall be returned to the Engineer of Record for detailing or shall be detailed by the fabricator and so indicated on the shop drawings. Any and all details developed by the fabricator shall be clouded on the shop drawings for separate approval by the Engineer of Record. Any items designed by the Contractor shall be prepared and sealed by a Registered Professional Engineer. No splices shall be included in the structure without approval of the Engineer of Record. All field welds required shall be identified on the shop drawings. Each weld, both shop and field welds, required shall be provided a unique identifier to permit tracking on the weld tracking log. Prior to performing any fabrication of the HSS structures listed in paragraph System Description above, submit complete, detailed shop drawings to the Contracting Officer and Engineer of Record for approval. Shop drawings shall show complete details of materials, tolerances, connections, and proposed welding sequences. Shop drawings shall include catalog cuts, templates, fabrication and assembly details, and type, grade, and class of materials, as appropriate. All FCM, including attachments that meet the FCM definition, shall be identified on the shop drawings as well as all temporary and tack welds. Each member shall be identified following the numbering scheme shown on the drawings. A table shall be provided containing a list of all members and a reference to each material certificate and test report that applies to that member. Shop drawings shall identify weld procedures and NDE required for each weld. Any and all splices shall be included in the shop drawings and clouded for engineer

approval.

1.5 DELIVERY, STORAGE, AND HANDLING

Notify the Contracting Officer at least 28 days in advance of delivery of the structures. Shipping of the structures shall be at the Contractor's expense. All structures shall be delivered to the [insert delivery address]. Contractor coordination for delivery shall be through the [District Name] District Contracting Officer. The structures shall be arranged on the delivery vehicles such that no damage occurs during shipping. All sling lifting lugs shall be directed up. Submit a [Delivery/Shipping Plan](#) showing orientation and locations of structures on the delivery vehicles prior to shipment for Government approval. Submit drawings providing descriptions of methods of delivering the completed structural units, including details for support during shipment to prevent distortion or other damages, and orientation and location of the structure on transport equipment.

PART 2 PRODUCTS

2.1 FABRICATION

2.1.1 Structural Fabrication

Material shall be straight before being laid off or worked. If straightening is necessary, it shall be done by methods that will not impair the metal. Sharp kinks or bends shall be cause for rejection of the material. Material with welds will not be accepted except where welding is definitely specified, indicated or otherwise approved. Bends shall be made by approved dies, press brakes or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal and it shall be allowed to cool in a manner that will not impair the original properties of the metal. Proposed flame cutting of material, other than structural steel, shall be subject to approval and shall be indicated on detail drawings. Shearing shall be accurate and all portions of the work shall be neatly finished. Corners shall be square and true unless otherwise shown. Re-entrant cuts shall be filleted round to a minimum radius of [25 mm 1 inch](#) in accordance with [AASHTO/AWS D1.5M/D1.5](#) section 3.2.4 unless otherwise indicated or approved. Finished members shall be free of twists, bends and open joints.

a. Dimensional Tolerances for Structural Work.

- (1) Dimensions shall be measured by an approved measuring system. Submit the measuring system for approval with the work plan (i.e. 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 for the item of work. Where tolerances are not specified in other sections of these specifications or shown, a variation of [0.8 mm 1/32 inch](#) is permissible in the overall length of component members with both ends milled and component members without milled ends shall not deviate from the dimensions shown by not more than [1.6 mm 1/16 inch](#) for members [9 m 30 feet](#) or less in length and by not more than [3 mm 1/8 inch](#) for members over [9 m 30 feet](#) in length.
- (2) Structure dimensions indicated on the drawings are based on a structure temperature of [20 degrees C 70 degrees F](#). The Contractor is responsible for any and all dimensional adjustments

to compensate for actual temperature variations during construction.

- b. 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. Surfaces and edges shall be prepared in accordance with AASHTO/AWS D1.5M/D1.5, Subsection 3.2. Hand-guided cuts shall be chipped, ground or machined to sound metal.

2.1.2 Assembly

Provide Assembly Drawings indicating the sequence of fabrication and assembly and provide details for connecting the adjoining fabricated components in the shop. Assembly details shall identify the required order of assembly and details of witness points as described in these specifications.

2.1.3 Materials Disposition Record

Submit three copies of all purchase and mill orders, shop orders for materials and work orders, including all new orders placed by Contractors and old orders extended for each supplier. Furnish, at the time of submittal of shop drawings, a list designating the material to be used for each item. Where mill tests are required, purchase orders shall contain the test site address and the name of the testing agency. Furnish 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 piece, the number of pieces, the total weight, and if shipped by rail in carload lots, the car initial and number. Submit material records before the beginning of fabrication. Additional requirements for this submittal are listed below.

2.1.4 Welded Connections

NOTE: The provisions outlined in this guide specification govern the construction of NEW HSS using appropriately graded ASTM A709 steel with required toughness and weld provisions. The welding requirements specified may not be arbitrarily applied to older steels or steels not meeting toughness requirements (ASTM A36, ASTM A572, ASTM 992 etc.) Use caution when approving alternate base metals for use with AWS D1.5. Alternate base metals will require additional weld processes and testing for each basemetal and weld metal combination. For each alternate base metal specified, the following requirements must be added to this specification:

1. Charpy Testing in accordance with ASTM A709 Table 10 for the temperature zone where the structure will be used.
2. Base metal scanning for defects in accordance with ASTM A578.
3. Prohibition of base metal repairs as specified is supplement S93 of ASTM A709.
4. Handling requirements to prevent damage
5. Prevention of base metal repairs performed by the mill. Fracture critical members produced in

accordance with ASTM A709 are prohibited from having base metal repairs performed by the mill as described in AWS D1.5 in order to ensure that repairs meet toughness requirements. All alternate base metals specified must also be prohibited from base metal repairs performed by the mill and must be certified as being free from repairs.

6. Tracking and labeling requirements in accordance with ASTM A709 to ensure components supplied as tension elements meeting toughness requirements are identified and labeled for quality control tracking purposes.

7. PQR and WPS for each approved alternate base metal and base metal combinations. Each configuration of combined material such as A709 plate spliced to A572 Grade 50 plate must have a unique PQR and WPS generated which shows that the completed weld meets toughness requirements.

a. Welding Procedure.

- (1) Welding shall conform to the applicable provisions of [AASHTO/AWS D1.5M/D1.5](#). Prior to the start of production welding, submit a complete schedule of welding procedures for a typical structure. The schedule shall conform to the requirements specified in the provisions of [AASHTO/AWS D1.5M/D1.5](#). The schedule shall provide detailed procedure specifications and tables or diagrams showing the procedures to be used for each required joint.
- (2) Submit to the Government Representative/Contracting Officers Representative/Engineer, a Welding Procedure Specification for each weld to be made. Submit Welding Procedure Specifications and Procedure Qualification Records (PQR) to the Government Representative/Contracting Officer for approval before fabrication is commenced. Copies of the Welding Procedure specification and the results of the procedure qualification test for each type of welding which requires procedure qualification shall be submitted for approval. Submit the WPS and PQR with the shop drawings. Each WPS shall be prepared and qualified in accordance with the applicable provisions of [AASHTO/AWS D1.5M/D1.5](#). Welding procedures shall show types and locations of welds designated or specified to receive nondestructive examination and identify the weld as FCM when applicable. A WPS is always required, even if the procedure is considered prequalified in accordance with [AASHTO/AWS D1.5M/D1.5](#). Properly documented evidence of compliance with all requirements of these specifications for previous qualification tests shall establish the welding procedure as prequalified. Each procedure shall be clearly identified as being either prequalified or qualified by tests. If a PQR is performed, a representative of the Government shall witness the test plate welding and the specimen testing. Approval of any procedure, however, will not relieve the Contractor of the responsibility for producing a finished structure meeting all requirements of these specifications. Copies of the WPS shall be made available for reference to the welders, welding operators and tack welders. A CWI meeting the specified qualifications shall approve all WPS's and PQR's.

- b. Welder Performance Qualification of Welders and Welding Operators. Welding operators, welders, and tack welders shall be qualified and requalified if necessary for the particular type of work to be done. Qualification shall be in accordance with AASHTO/AWS D1.5M/D1.5. Before assigning any welder, welding operator, or tacker to work under this contract, submit the names of the welders, welding operators, and tackers to be employed, and certification that each individual is qualified as specified. The certification shall state the type of welding and positions for which the welder, welding operator, or tacker is qualified, the code and procedure under which the individual is qualified, the date qualified, and the name of the firm and person certifying the qualification tests. Copies of the Performance Qualification records shall be submitted to the Government Representative and approved before fabrication is commenced. Require the welder and welding operators to repeat the qualifying tests when, in the opinion of the Government Representative/Contracting Officer's Representative/Engineer, the work indicates a reasonable doubt as to proficiency. In such cases, the welder shall be recertified, as above, after successfully passing the retest; otherwise, he/she shall be disqualified until successfully passing a retest. The period of effectiveness for all welder and welding operator performance qualifications shall be in accordance with AASHTO/AWS D1.5M/D1.5. Keep the certification current for the duration of the contract. All expenses in connection with qualification and requalification shall be borne by the Contractor.
- c. Welding Process. Welding of structural steel shall be by an electric arc welding process using a method which excludes the atmosphere from the molten metal and shall conform to the applicable provisions of AASHTO/AWS D1.5M/D1.5 for all welds. Welding shall be such as to minimize residual stresses, distortion and shrinkage.
- d. Welding Technique.

NOTE: Exposure times for low hydrogen electrodes have changed. AWS D1.5 Section 12.6 now allows electrodes with an "-R" designation to remain exposed to the atmosphere for up to 9 hours instead of 4 hours. Once redried, the exposure time reverts to table 4.7. Electrodes are still only allowed to redry once according to D1.5 12.6.5.7

There are new rules for FCAW wire which require storage requirements similar to low hydrogen SMAW electrodes. Requirements for storage are found in section 12.6.7.4. Duration of exposure times are defined and all wire exposed for 24 hours is not to be used for fracture critical welding.

SMAW electrodes and procedures are the ONLY procedures prequalified in AWS D1.5 Chapter 12 for fracture critical welding. Reference section 12.7.1 for which electrodes are prequalified.

- (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 shall be as shown where a specific choice of AWS specification allowable is required. Weld metal toughness shall meet the requirements of [AASHTO/AWS D1.5M/D1.5](#), Tables, 4.1, 4.2, or 12.1 as applicable. The AWS designation of the electrodes to be used shall be included in the schedule of welding procedures. Only low hydrogen electrodes shall be used for manual shielded metal-arc welding regardless of the thickness of the steel. A controlled temperature storage oven shall be used at the job site as prescribed by [AASHTO/AWS D1.5M/D1.5](#), Subsection 12.6 to maintain low moisture of low hydrogen electrodes. Controlled temperature storage ovens shall be powered at all times. FCAW filler metal shall be subjected to the storage and handling requirements defined in [AASHTO/AWS D1.5M/D1.5](#) section 12.6.7.4. Filler metals and processes shall not be combined in the same joint or weld.

- (2) Preheat and Interpass Temperature - Preheating shall be performed as required by the applicable provisions of [AASHTO/AWS D1.5M/D1.5](#) for all welds except that the temperature of the base metal shall be at least 20 degrees C 70 degrees F. Preheat for fracture critical welds shall be as defined in Table 12.3 and in accordance with the PQR/WPS. The weldments to be preheated shall be slowly and uniformly heated by approved means to the prescribed temperature, held at that temperature until the welding is completed and then permitted to cool slowly as required and in accordance with the approved WPS in order to prevent cracking or distortion.

- e. Workmanship. Workmanship for welding shall be in accordance with [AASHTO/AWS D1.5M/D1.5](#), Section 3 for all welds and other applicable requirements of these specifications

NOTE: AWS D1.5 3.13.3 indicates that backing bars parallel to stress or not subjected to stress need not be removed unless specified on the contract drawings. The guide spec should require backing bars to be removed in order to facilitate inspection according to ER-1110-2-8157.

AWS D1.5 section 12.6.2.2 allows E7018M and E7018-R electrodes to be used for tack welding without preheat. This should be prohibited to avoid concern about tack welds or temporary welds or welds of ancillary items on fracture critical members. Low moisture electrodes are acceptable by the code in this instance because they are less likely to produce hydrogen cracking in the HAZ. AWS D1.5 requires that all tack welds be remelted and incorporated into the final weld. In order to ensure that the tack welds are incorporated and properly remelted the maximum size and minimum length are specified to ensure that small tack welds without preheat are not permitted.

- (1) Preparation of Base Metal. Prior to welding, inspect surfaces to be welded to assure compliance with the applicable sections of [AASHTO/AWS D1.5M/D1.5](#).

- (2) Tack and Temporary Welds. Tack and temporary welds required for fabrication and erection shall be made in accordance with AASHTO/AWS D1.5M/D1.5 under the controlled conditions prescribed herein for permanent work. Tack welds that are to be incorporated into the permanent work shall be subject to the same quality requirements as the permanent welds. Such tack welds shall be cleaned and fused thoroughly with the permanent welds. Multiple-pass tack welds shall have cascaded ends. Defective tack welds shall be removed before permanent welding. All welds shall be made using low-hydrogen welding electrodes and by welders qualified for permanent work as specified elsewhere in these specifications. Preheat shall be as required by AASHTO/AWS D1.5M/D1.5 for permanent tack welds except that the minimum temperature shall be 20 degrees C 70 degrees F in any case, regardless of electrode used. All tack welds which will be incorporated into the final weldment shall be a maximum of 3 mm 1/8 inch with a minimum length of 25 mm 1 inch long spaced at a maximum of 150 mm 6 inch on center. In making temporary welds, arc strikes shall not be struck in other than weld locations. Each temporary weld shall be removed as required by AASHTO/AWS D1.5M/D1.5, Subsection 3.3.8. All arc strikes struck outside the weld zone shall be ground out, filled, and inspected in accordance with AASHTO/AWS D1.5M/D1.5.
- (3) Weld Access Holes. Weld access holes shall be provided as shown on the shop drawings. If the oversite of intersecting out-of-plane welds is encountered, the fabricator shall notify the Contracting Officer for the approval of weld access hole additions in such locations. Payment for the addition of weld access holes not shown on plans will be the Contractor's responsibility.
- (4) Weld Backing Removal. Unless otherwise indicated, all steel weld backing material shall be removed from welded joints prior to testing. All weld backing material that cannot be removed shall be identified on the shop drawings.
- (5) Weld Backing Material Other Than Steel. All weld backing material, other than steel, shall be qualified by testing and shall be included in submitted PQR/WPS. Variation from approved weld backing material will not be permitted and will require the development and testing a new weld procedure which addresses the change in backing material.

2.1.5 Bolted Connections

NOTE: AWS D1.5 3.7.7 allows misdrilled bolt holes to be filled either by welding or by installation of a bolt or may be left open. This provision needs to be addressed in the guide specification to prevent holes in hydraulic structures. In addition, AWS D1.5 C-2.2.3 suggests that plug and slot welds should only be used for the transfer of shear forces due to the high risk of discontinuities in these welds. Reference the discussion above allowing the filling of misaligned holes with either a bolt or to be filled with weld metal. A misaligned overlapped joint with a single bolt hole in it would create a

plug weld in this location.

AWS D1.5 Section 2.9.7 requires that plug welds in material 16 mm (5/8 inch) and greater only need to be welded to $\frac{1}{2}$ the thickness of the material but not less than 16 mm (5/8 inch). If Plug welds are being used for any reason, consider whether they need to be fully filled (such as when used as track plates or guides) and preclude the Section 2.9.7 provisions from applying.

Use of A490 bolts requires the following tension values:

16 mm (5/8 inch)	107 kN (24 kips)
19 mm (3/4 inch)	156 kN (35 kips)
22 mm (7/8 inch)	218 kN (49 kips)
25 mm (1 inch)	285 kN (64 kips)
29 mm (1-1/8 inch)	356 kN (80 kips)
32 mm (1-1/4 inch)	454 kN (102 kips)
35 mm (1-3/8 inch)	538 kN (121 kips)
38 mm (1-1/2 inch)	658 kN (148 kips)

In addition, the reference to A490 RevA must be added in the list of references in paragraph 1.1.

The following information is required for Slip Critical Connections. Slip critical connections may exist in gate splices, lifting eyes, dogging brackets etc. These connections MUST be defined as slip critical on the drawings prior to adding these provisions to the specifications. The use of AASHTO HB-17 is required for rotational capacity testing, as ASTM A325 and RCSC only requires rotational capacity testing for Galvanized fasteners. Bridge connections (and HSS connections) may not be galvanized and therefore would not be subjected to rotational capacity testing unless specifically addressed in this specification.. Note that these tests have not previously been required in the general guide specification.

Bolts:

a. Proof load tests (ASTM F 606 Method 1) are required. Minimum frequency of tests is as specified in ASTM A 325, paragraph 9.5.

b. Wedge tests on full size bolts (ASTM F 606 paragraph 3.5) are required. Minimum frequency of tests is as specified in ASTM A 325, paragraph 9.5.

Nuts: Proof load tests (ASTM F 606 paragraph 4.2) are required. Minimum frequency of tests is as specified in ASTM A 563, paragraph 9.3.

Assemblies: Rotational-capacity (RC) tests are required and will be performed on all black or galvanized (after galvanizing) bolt, nut, and washer assemblies by the manufacturer or distributor prior to shipping. The Contractor is responsible for

assuring the rotational-capacity testing is performed by either the manufacturer or distributor prior to shipping. In addition, the Contractor should perform the rotational capacity tests at the project site.

The following applies:

a. Except as modified herein, the rotational-capacity test will be performed in accordance with the requirements of AASHTO HB-17. All lots, whether coated or plain, must be subjected to rotational capacity testing.

b. Each combination of bolt production lot, nut lot, and washer lot must be tested as an assembly. Where washers are not required by the installation procedures, they must not be included in the lot identification.

c. A rotational-capacity lot number will be assigned to each combination of lots tested.

d. The bolt, nut, and washer assembly must be assembled in a Skidmore-Wilhelm Calibrator or in an acceptable equivalent device for rotational capacity testing. Bolts that are too short to be tested in the Skidmore-Wilhelm Calibrator will be tested in a steel joint as described in AASHTO HB-17.

e. The minimum frequency of testing is three assemblies per rotational-capacity lot.

f. Three bolts of the same grade, size, and condition as those under inspection are placed individually in a device calibrated to measure bolt tension. This calibration operation will be done at least once each inspection day. There must be a washer under the part turned in torquing each bolt. In the calibrated device, each bolt will be tightened by any convenient means to the specified tension. The inspecting wrench will then be applied to the tensioned bolt to determine the torque required to turn the nut or head five degrees in the tightening direction. The average of the torque required for all three bolts will be taken as the job inspection torque.

g. Ten percent (at least two) of the tensioned bolts on the structure represented by the test bolts will be selected at random in each connection. The job inspection torque is then applied to each with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tensioned. However, if the torque turns one or more bolt heads or nuts, the job inspection torque will then be applied to all bolts in the connection. Any bolt whose head or nut turns at this stage must be retorqued and reinspected.

The Contractor may, however, retension all the bolts in the connection and resubmit it for inspection, so long as bolts are not over tensioned or damaged by this action.

Shipping and Storage of Bolt Assemblies - All bolts, nuts, and washers must be shipped in assemblies in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container must be permanently marked with the rotational capacity lot number such that identification will be possible at any stage prior to installation.

Verification of pre-tension after shipping of the structure should be performed for all connections on site after delivery to the project to ensure that shipping and handling have not loosened connections due to vibration and other imposed handling loads.

Documentation:

1. Mill Test Report(s) (MTR):
 - a. MTR must be furnished for all mill steel used in the manufacture of the bolts, nuts, and washers.
 - b. MTR will indicate the place where the material was melted and manufactured.
2. Manufacturer Certified Test Report(s) (MCTR):
 - a. The manufacturer of the bolts, nuts, and washers must furnish certified test reports (MCTR) for the items furnished.
 - b. Each MCTR should show the conformance to all applicable test requirements, the sites where tests were performed and the date of the tests.
 - c. In addition to the above requirements, the manufacturer performing the rotational capacity test must include on the MCTR:
 - 1) The lot number of each of the items tested.
 - 2) The rotational-capacity lot number as required above.
 - 3) The results of rotational capacity tests required.
 - 4) The location where the bolt assembly components were manufactured.
3. Distributor Certified Test Report(s) (DCTR):
 - a. The DCTR will include the MCTR data required above for the various bolt assembly components.
 - b. The rotational-capacity test performed by the distributor or manufacturer will be reported on the DCTR.

All high strength connections shall be tightened to a tension not less than that given below for A325 Bolts. Tightening shall be done by turn-of-nut, direct tension indicator, calibrated wrench, or alternative design bolt methods.

16 mm5/8 inch	80kN19 kips
19 mm3/4 inch	125 kN28 kips
22 mm7/8 inch	173 kN39 kips
25 mm1 inch	227 kN51 kips
29 mm1-1/8 inch	24956 kips
32 mm1-1/4 inch	31671 kips
35 mm1-3/8 inch	378 kN85 kips
38 mm1-1/2 inch	458 kN103 kips

All other connections shall be tightened to the snug-tight condition. The snug-tight condition is defined as the tightness attained by either a few impacts of an impact wrench or the full effort of a worker with an ordinary spud wrench that brings the plies into firm contact. Perform snugging in a systematic manner starting at the most rigid part of the joint and working to the outside of the connection or the free edges. Use thin metal feeler gages, such as a machinists 150 mm 6 inch metal rule, to ensure that gaps do not exist between the steel at the bolt holes. Install all bolts in a connection to a snug tight condition prior to pretensioning. Perform pretensioning in the same order as snug-tightening.

- a. Bolts, Nuts, and Washers. Provide bolts, nuts and washers of the type specified or indicated. All nuts to be used with high strength bolts shall be ASTM A 563. All nuts shall be equipped with washers. Where the use of high strength bolts is specified or indicated the materials, workmanship and installation shall conform to the applicable provisions of ASTM A 325 and RCSC Specifications for Structural Joints Using ASTM A 325 or A490 Bolts. Washers to be used with high strength bolts shall conform to ASTM F 436.
- b. Bolt Holes. Bolt holes shall be accurately located, smooth, perpendicular to the member and cylindrical.
 - (1) Holes for regular bolts shall be drilled or subdrilled and reamed in the shop and shall not be more than 2mm 1/16 inch larger than the diameter of the bolt.
 - (2) Holes for high strength fitted bolts shall be match-reamed or drilled. Remove burrs resulting from reaming. The threads of bolts shall be entirely outside of the holes. The body diameter of holes and bolts shall have tolerances as specified on the drawings.
 - (3) The provisions of AASHTO/AWS D1.5M/D1.5 Section 3.7.7 allowing misdrilled holes do not apply. All misdrilled holes shall be repaired as directed by the Engineer. Repair of mislocated or misdrilled holes shall be submitted for Government approval.

2.1.6 Miscellaneous Provisions

- a. Weldments. Portions of the structure include thick weldments where locked in thermal stresses may make final dimensions unstable. The Contractor is required to sequence the work and thermally stress relieve subassemblies of thick weldments such that final machining achieves stable specified dimensions and tolerances.
- b. Drain Holes. Locate drain holes as shown on the drawings, unless otherwise noted. Drain holes shall be drilled. Flame cutting of holes will not be permitted.
- c. Seal Welds. Seal welds are required to maintain water tightness. All seal welds shall be shown and made as indicated on the shop drawings. Seal welds, when called for on the drawings, shall be made the minimum size fillet weld as required in AASHTO/AWS D1.5M/D1.5. In addition, seal welds may require weld wrapping around reentrant corners that is specifically prohibited in AASHTO/AWS D1.5M/D1.5. All seal welds on fracture critical members shall be subjected to the minimum preheat requirements of AASHTO/AWS D1.5M/D1.5 Table 12.3 as applicable. All seal welds shall be subjected to the same testing requirements required for a fillet weld made to any fracture critical member according to AASHTO/AWS D1.5M/D1.5 Chapter 12.

2.1.7 Shop Assembly

Perform fabrication and assembly in an indoor, climate controlled shop. Each item shall be closely checked to ensure that all necessary clearances have been provided and that binding does not occur in any moving part. All shop testing for assembly shall be witnessed by the Government Representative. Errors or defects disclosed shall be immediately remedied without cost to the Government.

2.1.8 Seals

NOTE: Define seal requirements in the following paragraph recognizing that seal bars and keeper bars welded to fracture critical members are fracture critical welds.

Each [structure] [_____] shall be provided with bulb seals, rubber bearing blocks, and bearing seals as shown on the drawings. Bulb seals, rubber bearing blocks, and bearing seals shall be compounded of ethylene propylene dimonomer (EPDM) or neoprene (CR) as specified in Section [_____]. The surfaces of finished splices shall be smooth and free of irregularities. Bolt holes in the rubber seals shall be match-drilled with the seal support and clamping bars, as applicable; to insure proper fit and spacing between holes of the completed seal assembly. Seal support and clamping bars shall conform to the configurations shown on the drawings and shall be machine finished. The seals and blocks shall be installed after painting has been completed.

2.2 CERTIFIED TEST REPORTS

Submit reports of tests, inspections, and verifications of all materials used under this contract approved by the Government before incorporation into the structure. All steel used in this contract shall be tested by an

approved U.S. laboratory to ensure that it meets the required standards.

2.2.1 General

Have required material tests and analyses performed and certified by an approved laboratory, at the Contractor's expense, to demonstrate that materials are in conformity with the specifications. Tests, inspections, and verifications shall conform to the requirements of the particular sections of these specifications for the respective items of work unless otherwise specified or authorized. Tests shall be conducted in the presence of the Contracting Officer. Furnish specimens and samples for additional independent tests and analyses upon request by the Contracting Officer.

2.2.2 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, magnetic particle, 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 and rejected parts shall be replaced and retested by the same test method that located the defect at the Contractor's expense.

2.2.3 Inspection of Structural Steel Welding

Maintain an approved inspection system and perform required inspections. Welding shall be subject to inspection to determine conformance with the requirements of [AASHTO/AWS D1.5M/D1.5](#) and the approved welding procedures and provisions stated in other sections of these specifications. All completed welds shall be cleaned and carefully visually examined for insufficient throat or leg sizes, cracks, undercutting, overlap, excessive convexity or reinforcement and other surface defects to ensure compliance with the requirements of [AASHTO/AWS D1.5M/D1.5](#), subsection 6.26 and the additional requirements of chapter 12 for the Fracture Control Plan. In addition, the Government may choose to hire a third party inspector to perform verification of this work. The Government's third party inspection will occur at various times throughout the duration of fabrication. The Contractor will be advised that third party inspection shall be coordinated with the GQAR and the Contractor for all verification inspections selected by the Government.

- a. Visual Examination. Prior to any welding, a certified weld inspector (CWI) supplied by the Contractor shall visually inspect and document on the weld tracking log the preparation of material for welding at each weld or joint in order to assure compliance with [AASHTO/AWS D1.5M/D1.5](#) and approved WPS. The CWI shall also perform VT inspection on all completed welds throughout the welding process to assure compliance with [AASHTO/AWS D1.5M/D1.5](#) and approved WPS. All completed welds shall be cleaned free of oxide, flux, scale, paint spatter, or other foreign matter before inspection.
- b. Nondestructive Examination. The nondestructive examination of welds shall be performed as specified or described on the drawings or as listed in the following paragraphs.

- (1) 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 shall be subject to the approval of, and all records shall become the property of, the Government. Certified Weld Inspectors (CWI) shall be qualified and certified in accordance with the provisions of AWS QC1 and shall be familiar with AASHTO/AWS D1.5M/D1.5 fracture critical member inspection as required in AASHTO/AWS D1.5M/D1.5 Section 12.16. The laboratory and all personnel performing nondestructive testing shall be qualified as specified. Only individuals qualified for NDT Level II or Level III may perform nondestructive testing. The Level III NDT inspector who supervises all NDT shall possess a currently valid American Society for Nondestructive Testing (ASNT) Level III certificate for each of the processes for which they are qualified. Copies of the certifications, including the ASNT certificate of Level III NDT Technician that certified the Level II Technicians shall be included in the submittals.

- (2) Examination Procedure and Extent. All nondestructive testing shall comply with AASHTO/AWS D1.5M/D1.5, Section 6 or section 12, as applicable. Testing shall be required as defined in the following paragraph.
- (3) Acceptability of Welds. Welds will be unacceptable if shown to have defects prohibited by AASHTO/AWS D1.5M/D1.5.
- (4) Examination Procedures. Examination procedures shall conform to the following requirements:

NOTE: List here the type, location and extent of welds to be subject 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".

Note that AWS Section 6.7.1.2 gives the Contractor considerable leeway regarding what percentage of welds are tested unless they are labeled fracture critical. As a result, if a weld is to be fully tested as fracture critical it must be labeled fracture critical and if testing on any other critical welds is needed, designate the weld testing by item, both on the drawing and on the specifications. While the standard specifications may require a percentage of welds to be tested, if specific welds are to be subjected to MT, PT, or UT, ensure that these welds are specified on the drawings. Consider specifying test requirements in the tail of each weld needing NDT on.

AWS C-2.1.5 indicates that all requirements for special inspections not covered by this code need to be specified in the contract documents. This

ensures that required inspections and tests will be performed, avoiding disagreement over minimum weld quality and additional costs as described in 6.6.5. AWS D1.5 6.6.5 says that if NDT other than originally specified in the contract is requested by the Engineer, the Contractor shall perform the requested inspection. The costs will be negotiated by the owner and the Contractor. The cost of extra work will be the responsibility of the owner, unless the testing reveals an attempt to defraud the owner. Ensure that all testing requirements are defined on the drawings or listed in these specifications. Do not assume that testing requirements can be amended after award without increased cost. Identifying all testing requirements is defined as the responsibility of the Engineer as referenced above. Specifying testing according to AWS D1.5 without specifically identifying what the Engineer wants tested will not produce a permanent record of the structure in accordance with ER-1110-2-8157.

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

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

Both UT and RT should be used for fracture critical tension splices.

Magnetic particle inspection may be used for the detection of cracks and other discontinuities at or near the root and for the 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 and for non ferrous material.

- (5) Ultrasonic Testing (UT) - Ultrasonic testing of welds shall conform to the provisions of AASHTO/AWS D1.5M/D1.5. The ultrasonic equipment shall be capable of making a permanent record of the test indications. A record shall be made of each weld tested.
- (6) Radiographic Testing (RT) - Making, evaluating and reporting radiographic testing of welds shall conform to the applicable requirements of AASHTO/AWS D1.5M/D1.5.
- (7) Magnetic Particle Inspection (MT) - Magnetic particle inspection of welds shall conform to the provisions of ASTM E 709 and AASHTO/AWS D1.5M/D1.5, Section 6 and Subsection 12.16 where applicable. Requirements of AASHTO/AWS D1.5M/D1.5 section 6.7.2.3 shall not apply to these specifications, such that secondary members shall be subjected to MT sampling as required. MT by the prod method is prohibited.

(8) Dye Penetrant Inspection (PT) - Dye penetrant inspection(PT) of welds shall conform to the applicable provisions of ASTM E 165.

2.2.4 Welds to be Subject to Nondestructive Examination

- a. Structural Steel Non-Fracture Critical Members - Full Penetration Welds. Welds shall be inspected in conformance with AASHTO/AWS D1.5M/D1.5, Section 6.7. Testing shall include a representative sample of welds and weld types from all welders and each of the processes each welder used. Testing shall be spread throughout the project. [100] [_____] per cent of all Full Penetration welds on non-fracture critical members shall be tested.
- b. Structural Steel Non-Fracture Critical Member Fillet Welds and Partial Penetration Welds. A minimum of [50] [_____] per cent of all fillet welds and partial penetration welds shall be randomly selected for examination by magnetic particle and or dye penetrant testing procedures described previously. The random testing shall include a representative sample of welds and weld types from all welders and each of the processes each welder used. The random testing shall be spread throughout the project. A schedule for implementing the random testing shall be developed and submitted for approval prior to fabrication.
- c. Structural Steel Fracture Critical Member Welds. All welds on FCM shall be tested in accordance with AASHTO/AWS D1.5M/D1.5, Subsection 12.16. 100 per cent of all fracture critical full-penetration welds on fracture critical members shall be subjected to ultrasonic testing. Butt joints in tension shall be inspected by both RT and UT. The testing shall be done as early in the project as possible to ensure the quality of the procedure and process. Weld backing shall be removed from all fracture critical welds prior to all NDE unless the weld backing member is permanent. The UT report for all butt welds shall include non-rejectable indications with defect severity ratings within 5 db of being rejectable and shall be fully recorded as to indication, rating, size, and location. In accordance with AASHTO/AWS D1.5M/D1.5 Section 12.16.5.3, all discontinuities found by UT must be recorded.

2.2.5 Test Coupons

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 shall be removed from the work. When coupons are removed from any part of a structure, the members cut shall be repaired in an appropriate manner with joints of the proper type to develop the full strength of the members. Repaired joints shall be heated or 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 will be borne by the Government. If the coupons fail testing, repair costs as well as sampling costs, will be borne by the Contractor.

2.2.6 Supplemental Examination

NOTE: Consider adding Third Party testing in this

section in lieu of "allowing" the Government to perform testing at our discretion. Consider stipulating that Third Party testing, either hired by the Contractor or hired by the Corps, will be required to confirm inspection findings. Third party inspection can be used to check additional welds when indications are found or to confirm UT findings when questions arise regarding the evaluation of UT findings etc. Consider including both of these requirements in this specification. The problem with the statement "third party" is defining the impartiality of this testing agency. CENWP has had a recent experience where the fabrication shop was extremely busy so they hired an outside testing agency as a subcontractor to work in their fabrication shop. The fabricator then claimed that the testing agency was both the primary and third party testing agency. For this reason, it is recommended that each district hire an independent testing agency for a day to confirm the findings of the fabricators inspector. This is accomplished in USACE with a Visa purchase for services. A typical day of UT inspection costs on the order of \$1000. Each district should have a working relationship with the local testing agency from HSS inspections. Decide ahead of time how to handle independent evaluation of testing results. Having the ability to hire a testing agency ensures that the fabricator is aware of the potential to have an outside testing firm on site and allows a neutral party to evaluate inspection findings when a disagreement arises. These requirements for QA are discussed above under witness point but do not address the potential for bringing in outside assistance for conflict resolution. By bringing in an independent testing firm, anonymity can be maintained.

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. If welds are found to be defective, repair the defective work and bear the cost of the inspection.

2.2.7 Structural Steel Welding Repairs

Defective welds in the structural steel should be defined as critical repairs or non-critical repairs and shall be repaired in accordance with [AASHTO/AWS D1.5M/D1.5](#), Subsection 3.7 for non-FCM and section 12 for FCM. Make separate submittals for [Welding Repairs - Non-Fracture Critical Members](#) and [Welding Repairs - Fracture Critical Members](#). Submit welding repair plans for steel and for fracture critical welds, approved prior to making repairs. Welding repair plans shall address weld repairs within the weld as well as weld repairs for base metal discontinuities. All weld repairs to fracture critical members shall be considered critical welds in accordance with [AASHTO/AWS D1.5M/D1.5](#) Section 12.17.3 and shall be approved by the Engineer of Record. Approval by the Government shall be obtained for weld repairs to mill defects in the base metal, repair of cracks, or a

revised design to compensate for deficiencies. The Contractor may prepare procedures and specifications for the repair of anticipated routine problems and submit them for approval before fabrication begins. Critical weld repairs require a WPS specific to the weld repair. Defective weld metal shall be removed to sound metal by use of air carbon-arc gouging. Oxygen gouging for purposes of weld repair shall not be permitted. The surfaces shall be thoroughly cleaned before welding. Inadequate removal of welds that damages the base metal shall be subject to replacement of the base metal, or compensation for the deficiency in a manner approved by the Contracting Officer. Welds that have been repaired shall be retested 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 shall be borne by the Contractor.

2.2.8 Control Dimensions

After fabrication of each structure, but prior to painting, record and submit on the "control dimensions" chart provided, the actual dimensions indicated on drawing [SXX]. Control dimensions shall be verified prior to witness points defined under the schedule of witness points so that they may be verified during inspection and prior to either final assembly, painting, or installation of the structure. All control dimensions shall be verified and documented prior to shipping the structure.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Cleaning

All parts to be installed shall be thoroughly cleaned. Packing compounds, rust, dirt, grit and other foreign matter shall be removed. Holes and grooves for lubrication shall be cleaned. Enclosed chambers or passages shall be examined 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. Pipe wrenches, cold chisels or other tools likely to cause damage to the surfaces of rods, nuts or other parts shall not be used for assembling and tightening parts. Non-Structural bolts and screws shall be tightened firmly and uniformly but care shall be taken not to overstress the threads. When a half nut is used for locking a full nut the half nut shall be placed first and followed by the full nut. Threads of all bolts except high strength bolts, nuts and screws shall be lubricated with an approved lubricant before assembly. Threads of corrosion-resisting steel bolts and nuts shall be coated with an approved antigalling compound. Driving and drifting bolts or keys will not be permitted.

3.1.2 Alignment and Setting

Each machinery component or structural unit attached to structurals fabricated according to this specification shall be accurately aligned 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. Shims are to remain with the final installation where called for on the drawings. Where parts are press-fit, anti seize compound shall be applied to laying surfaces.

3.2 PROTECTION OF FINISHED WORK

Machined surfaces shall be thoroughly cleaned of foreign matter. All finished surfaces shall be protected by suitable means. Unassembled pins and bolts shall be oiled and wrapped with moisture resistant paper or protected by other approved means. Finished surfaces of ferrous metals to be in bolted contact shall be washed with an approved rust inhibitor and coated with an approved rust resisting compound for temporary protection during fabrication, shipping and storage periods. Finished surfaces of metals shall be painted as specified in specification SECTION 09 97 02: PAINTING - HYDRAULIC STRUCTURES.

3.3 PAINTING

NOTE: Paint preparation is defined in the paint specifications. Consider that the level of preparation required is directly related to the quality of paint application as well as the cost of the project. Industry standards governing the description of surface preparation categories are published by the Society for Protective Coatings SSPC. For most HSS applications the preparation level should be SSPC-SP5 - White Metal Blast Cleaning. This level of preparation removes all contaminants from the surface of the steel. This preparation has limited exposure time (8 hours or less depending on relative humidity) and is therefore not included in this section. Grinding of plate edges and corners is recommended to remove hardness due to flame cutting. Hardness on the edges of plates (flanges of girder etc.) will result in insufficient roughness to permit proper paint adhesion. Grinding these areas to remove the oxygen cut area will produce proper adhesion and will also reduce the potential for hydrogen embrittlement.

All exposed surfaces of the structure shall be painted as specified in Section 09 97 02: PAINTING - HYDRAULIC STRUCTURES. All edges of plate shall be ground prior to coating. Grinding plate edges shall be accomplished before paint preparation in order to remove hardness as a result of flame cutting. All square edges and holes other than bolt holes shall be broken and ground to a 2 mm 1/16 inch radius prior to painting.

-- End of Section --