SECTION M4

QUALITY AND EXAMINATION REQUIREMENTS

1. GENERAL: The Seller, and all Seller's sub-suppliers, shall have a Quality Management System, approved by the Buyer, in accordance with ISO 9001. The Seller shall provide transparent supply chain integrity for the material sources.

1.1. All material markings and documentation provided by the Seller shall be in English.

1.2. All manufacturing, processing, testing and inspection operations affecting the equipment or material may be subject to surveillance by the Buyer, the Owner, and/or the Owner's Representative. The actual testing operations such as bend testing, tensile testing, radiography, or macroetching may be conducted by an independent laboratory on samples fabricated under the direction of the Buyer.

2. SELLER'S DELIVERABLE SCHEDULE (SDS): Shall be in accordance with the primary SDS described elsewhere in the design specification. It includes the Seller's supply chain. Prior to this submittal, the Seller shall review and approve the documents (including those of their supply chain) in accordance with the referenced code as modified by this specification. These documents shall be submitted in an organized manner that simplifies the Buyer's review thereof. The submittal process shall follow that prescribed via the primary SDS.

2.1. A Certificate of Compliance shall be submitted for each heat, lot or batch of filler metal.

3. QUALITY RECORDS: Records shall be maintained as appropriate for the currently qualified personnel, processes, and equipment of each special process. These records shall be submitted to the Buyer upon request. Examples of such records include:

a. Deviation request to the Welding Engineering Technical Specification, including resolution documentation
b. Quality records from the applicable Code of Construction, including but not limited to:
   - Material Test Reports (MTR) of base and welding materials
   - Welding Procedure Specification (WPS) and supporting Procedure Qualification Record (PQR)
   - Heat Treatment Records
   - Final Non Destructive Examination (NDE) Reports, including reader sheets or software for volumetric methods
   - Repair records
   - Personnel qualification records
   - Nonconformance reports
   - Manufacturer's Data Reports (MDR)

4. EXAMINATION REQUIREMENTS:

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4.1. In instances of extreme handling difficulties or inaccessibility issues, performing all the required hardness tests may not be practical. In those specific instances, the test reports must indicate the reason for not hardness testing those areas.

4.2. NONDESTRUCTIVE EXAMINATION (NDE): NDE shall be performed in accordance with detailed written procedures that are prepared in accordance with the referenced code or standard and as specified herein. NDE procedures shall be approved by a qualified and certified NDE Level III. NDE procedures shall be available for NDE personnel and shall be made available to the Buyer for review when requested. Records of demonstration of procedure capability shall be made available on request.

4.2.1. Persons performing or evaluating nondestructive examinations, except visual weld examination, shall be certified to a minimum Level II for the applicable method in accordance with SNT-TC-1A,2006 edition. NDE personnel qualification records shall be made available for review when requested.

4.2.2. The NDE results shall be documented in a report that is evaluated, interpreted, and accepted by an NDE Level II or Level III professional.

4.2.3. For visual examinations of welds, in lieu of the ASTN-SNT-TC-1A, personnel may be qualified as a Certified Welding Inspector (CWI) in accordance with the American Welding Society (AWS) QC 1 or previously approved equivalent program as determined by the Buyer. As a minimum, persons performing visual weld examinations shall be qualified and certified in accordance with the requirements of the applicable Code.

4.2.4. For coated piping systems that are fabricated in accordance with ASME B31.1, and where hydrostatic or pneumatic testing is to be performed in the field, all welds shall pass a radiographic, ultrasonic, dye/liquid penetrant, or magnetic particle examination performed by Seller prior to applying any coatings. Acceptance criteria shall be in accordance with the requirements of ASME B31.1. As an alternative to the additional examination prior to coating, Seller may pressure test finished piping spools in accordance with ASME B31.1 prior to coating. All test reports shall be submitted to the Buyer. For coated piping systems subject to initial service testing in the field, piping and welds shall be coated by Seller.

4.2.5. In addition to the above general requirements the following NDE guidance shall be applied to all Creep Strength-Enhanced Ferric Steel or P15E welds.

4.2.5.1. All welds shall receive a 100% final VT.

4.2.5.2. All welds shall receive a final surface examination (MT or PT), and it shall include any arc strikes and temporary attachment removal areas.

4.2.5.3. Any wet methods of NDE shall be performed after PWHT

4.2.5.4. PMI per the requirements of this document.

4.2.5.5. Hardness Testing per the requirements of this document.

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4.3. POSITIVE MATERIAL IDENTIFICATION (PMI)

4.3.1. When PMI is required for a material, it shall be performed in accordance with MSS SP-137. PMI shall not be considered as a substitute for required material test reports (MTRs) and material test reports shall not be considered as acceptable PMI.

4.3.2. PMI shall be conducted on all Creep Strength Enhanced Ferritic (CSEF) components and specialty stainless materials, including but not limited to Alloy 20, Inconel, and Hastelloy, as outlined below. All applicable material types shall undergo PMI for both base materials and welds that meet the following requirements.

4.3.2.1. Pressure containing and pressure retaining components, as well as key wetted mechanical components. The following list is not exhaustive; other components that meet the above definition shall also be included.

- Shells and Head Sections
- Circumferential and Longitudinal Weld Seams
- Piping
- Nozzle Necks, Flanges, Stub-ends
- Weld Overlay
- Cladded component surfaces
- Nozzle Weld Seams
- Reinforcing Pads
- Process Wetted Mechanical Parts (Impellers, Shafts, Wear Rings, etc.)
- Pipe Caps
- Valve Pressure Boundary and Pressure Retaining Parts
- Pump Casings
- Heat Exchanger Baffles, Tubesheets, Rods and Spacers
- Boiler Tubes, Tube hangers, and supports
- Piping Components (Expansion Joints, Bellows, Fittings, etc.)
- Load carrying CSEF integral attachments

4.3.3. PMI sampling shall be as follows:

- Pressure retaining fasteners for equipment items shall be 10% PMI tested. Where the same heat/lot can be documented to the satisfaction of the Buyer’s Inspector, 1% with a minimum of four (4) pieces shall be PMI tested.
- 100% of process wetted rotating components.
- For Heat Exchangers, Air Cooled Heat Exchangers, and Boilers a 10% random selection of tubes in each bundle shall be utilized.
- 100% of Head and Shell Sections
- Welds shall be sampled at a rate of once per seam. The process side of the weld shall be utilized. Internal and external seam review shall be performed where possible.
- 100% of Nozzle necks, Flanges, and stub-ends.
- T91 tube crates - 6 tubes per crate, each end.

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- Four (4) random T91 tubes to tube header per accessible tube rows (each end of harp assembly).
- 100% bundle CSEF material support lugs.
- 100% of any load carrying CSEF attachment.
- Unless otherwise stated sampling shall be 100%.

4.3.4. When a material is to be cut into multiple pieces, only the parent item needs to be checked provided that a method to assure material traceability (such as color coding per PFI-ES-22 or heat identification transfer) is utilized, documented, and verified by QC.

4.3.5. PMI PROCEDURE: A written PMI program and procedure that is in accordance with this specification and MSS SP-137 shall be provided to the Buyer for approval. Buyer's approval of procedure shall be provided before the start of fabrication.

4.3.6. PMI shall be performed prior to and during the fabrication of sub-assemblies that will be inaccessible after complete assembly.

4.3.7. PMI shall be performed during fabrication, including deposited weld material, on a basis agreed to by the Buyer and Seller.

4.3.8. PMI for field fabrication material provided by the Seller shall be performed before shipping the material to the facility location. Material at site may be subject to PMI verification at the Buyer's discretion.

4.3.9. Verification of the weld seam alloy shall be on the "wetted" (process) side of the fabrication. If this is not possible because of restricted access (e.g., small diameter piping) PMI shall be performed on the accessible weld surface.

4.3.10. If an item is rejected after PMI, all remaining pieces of the same item from the same Seller shall be verified. Rejected items shall be replaced with the specified material at no cost to the Buyer.

4.4. HARDNESS TESTING REQUIREMENTS FOR CSEF ALLOYS:

4.4.1. To verify that satisfactory PWHT and fabrication processes have been performed on base material and welds joining CSEF material to itself, the supplier/installer shall perform Brinell Hardness Tests or an acceptable equivalent hardness test on completed production piping pressure welds or welds to pressure-containing components as listed below.

4.4.2. Hardness testing shall be performed in accordance with a written procedure that meets the requirements of the applicable ASTM standard for the method of testing used. Hardness tests shall be performed using the Telebrinell or Ultrasonic Contact Impedance (UCI) method. Hardness testing equipment shall be capable of producing consistent results accurate to within ± 5 percent. The written procedure for performing the hardness testing shall be submitted for review and approval by Buyer prior to use. The test preparation and hardness tests shall not reduce the required weld size or section wall thickness below the minimum required by design. For areas where unacceptable low hardness readings are obtained, additional material removal is permitted provided that the material removal does not reduce the weld size or section wall thickness below

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the minimum required by design. Experience has shown that additional material removal of approximately 0.015 to 0.030 inch is sufficient to ensure a reliable hardness retest. The material removal may be necessary to ensure that hardness testing is performed below a possible decarburized surface layer.

4.4.3. After PWHT and prior to hardness testing, the piping shall be permitted to cool to ambient temperature. Unless otherwise directed by Buyer, the area to be hardness tested may be selected at random. Hardness tests for CSEF shall be judged acceptable if all the resulting hardness tests are in the Brinell Hardness Number (BHN) range as specified in the following:

4.4.3.1. For (9Cr-1Mo-V) Grade 91 or (9Cr-2W) Grade 92 base metal or unassigned base metals with the same nominal chemical analysis and mechanical property limits, the minimum hardness shall not be less than 200 BHN and the maximum BHN shall not exceed the maximum permitted by the applicable base metal material specification. In the absence of any base metal material specification hardness requirements, pressure-retaining components shall not exceed 250 BHN.

4.4.3.2. The hardness acceptance criteria for Grade 91 and 92 type weld deposits is 190 to 280 BHN.

4.4.3.3. For dissimilar joints produced using a lower alloy composition consumable than Grade 91 and 92, the acceptable hardness range is 168 to 280 BHN.

4.4.3.4. For Grade 91 and 92 field weld end preparation, the minimum acceptable hardness is 200 BHN after PWHT.

4.4.4. Evidence of components being intercritically heat treated (i.e., heated to a temperature at or above the material's lower critical temperature) during fabrication or stress relieving (e.g., from flame impingement) is cause for rejection.

4.4.5. The scope of welds and base material requiring hardness testing is defined as follows. Buyer shall be notified of any pressure-retaining welds or welds to pressure-retaining components not specifically defined in the remaining portion of Section **Error! Reference source not found.** When notified, Buyer will define the hardness testing requirements.

4.4.6. Hardness shall be verified on all P91 components to be welded, prior to the start of any welding procedures. A minimum of 4 locations, 90 degrees apart around each end of each component shall be verified. The locations shall be equally spaced around the weld end circumference, no more than 1 inch back from the outside surface of the weld end preparation. Grind the surface of the metal to create a flat surface to take the hardness reading. If the hardness values tested are found to be less than 200 BHN, the piece shall be ground or machined 0.020 inches in the low hardness areas and retested. If the piece still is found to be below 200 BHN after grinding 0.040 to 0.060 inches of material, the piece may have its microstructure examined by replica or other metallographic examination methods to determine if any ferrite is present in the material matrix. If any evidence of ferrite microstructures is found, the piece shall be rejected, and not used for construction. The piece may be sent back to the vendor for a full normalization and tempering heat treatment per the original ASTM specification document requirements for the component to try to restore the required microstructure.

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4.4.6.1. Hardness testing of the weld metal and adjacent base metal after completion of PWHT will be required to verify that the heat treatment was done properly. The total depth of grinding both pre weld and PWHT combined shall be kept to a maximum of 0.060 inches.

4.4.7. HARDNESS TESTING AND REPLICATION REQUIREMENTS FOR ASME SECTION I COMPONENTS:

4.4.7.1. Pipe/Tube-to-Header Welds (ASME Sect. I): Pipe/tube-to-header sections shall be hardness (H) tested and replicated (R) as follows: One series of tests shall be performed on at least four locations across the full length of each header section. Each series will consist of five tests (in a plane radial to the header): (1) One microstructure replication on the tube approximately 2 inches (50 mm) from the weld toe; (2) One weld metal (WM) hardness test; (3) One hardness test on the header approximately 1 inch (25 mm) from the weld toe; and (4 and 5) One hardness test on the header at 90 °s and also at 180 °s from the tube. The four locations for each series shall be selected as follows. First and second locations--Second tube from each end of header. Third and fourth locations--Approximate equal spacing between all test locations. All four series will result in the performance of 20 (total) hardness tests and 4 (total) replications on each header section. See the following Figure 1.

4.4.7.2. For dissimilar base material combinations of headers and pipe/tubes where one of the components is Grade 91 or 92 and the other is a lower grade alloy steel, the following testing is required: (1) Only the P/T 91 or 92 base materials require the specified test (hardness testing for P91 or 92 headers or microstructure replications for P/T 91 or 92, as applicable) and (2) Hardness testing of the weld deposit shall be performed regardless of the composition. The acceptable hardness value range for dissimilar weld deposits using Grade 91 composition filler metals is 190 to 280 BHN. For dissimilar joints produced using a lower alloy composition than Grade 91, the weld metal of dissimilar metal joints can have an allowable hardness of 168-280 BHN. Note: When the header contains more than one row of tubes, only a single row is required to be tested as defined above.

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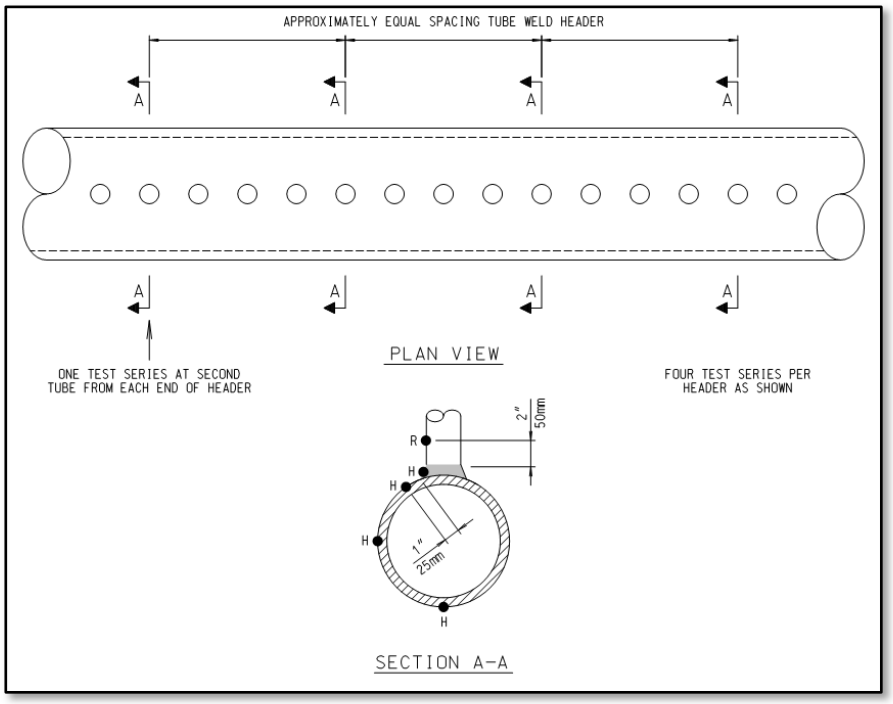


Figure 1: Header Welds (ASME Sec. I) Hardness Testing

4.4.7.3. Header End Plate Welds (ASME Sect. I): A minimum of 50 % of header end plates shall be tested per header section as follows: One series of hardness tests shall be performed on one end plate weld per header assembly. The hardness tests shall consist of five (total) hardness tests. The end plate weld metal shall be hardness tested in three circumferential locations approximately equally spaced around the weld. The end plate base metal shall be checked in one location at the approximate center. The header base metal shall be checked approximately 1 inch (25 mm) from the end plate weld on the header OD. Refer to the following Figure 2.

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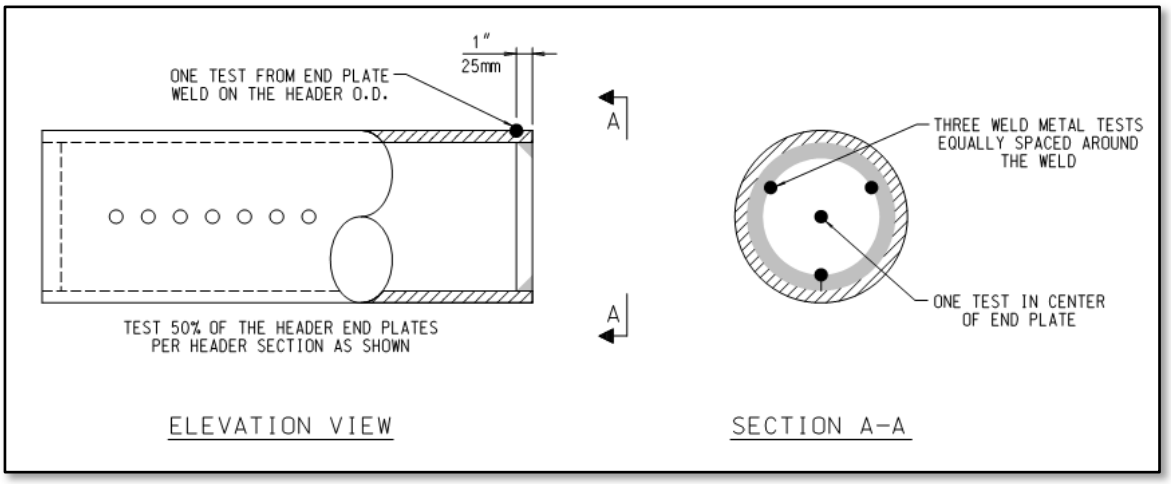


Figure 2: Header End Plate Welds (ASME Sec. I) - Hardness Testing

4.4.7.4. Headers with End Caps (ASME Sect. 1): A minimum of 50 % of header end caps shall be hardness tested per header section. See the following Figure 3.

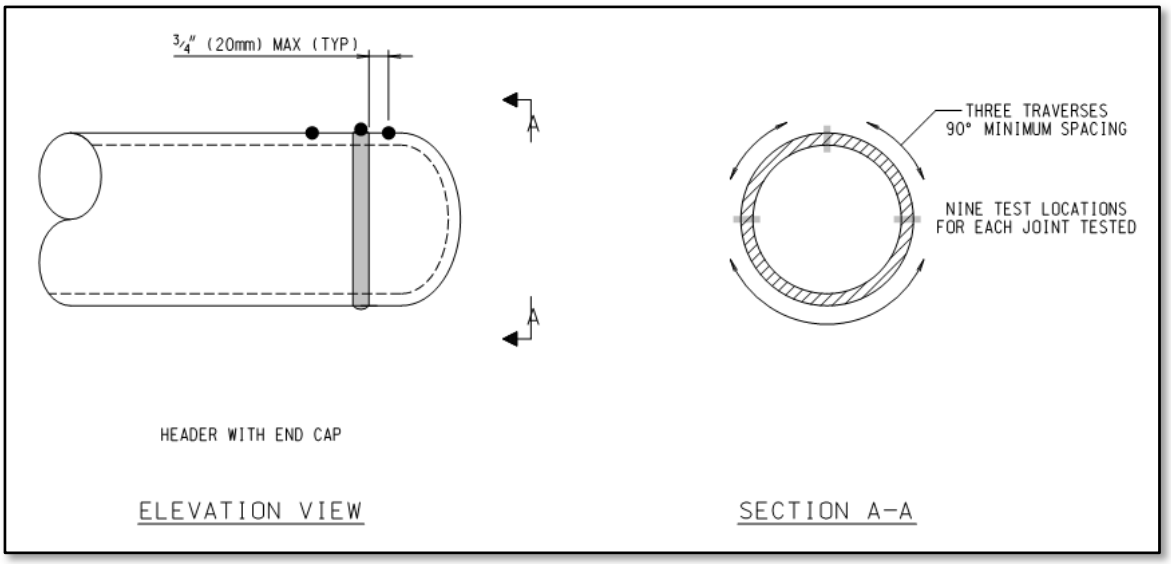


Figure 3: Header End Caps (ASME Sect. I) - Hardness Testing

4.4.7.5. Branch Connections (ASME Sect. I): A minimum of 25 % of branch connections shall be tested per header or pipe section as follows: (1) One test on the branch fitting; (2) One WM test; and (3) Three tests on the pipe or header, with each test spaced at least 90 °s around the branch fitting approximately 1 inch (25 mm) from the weld toe. Testing will result in the

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performance of five (total) hardness tests for each branch connection requiring testing. Reference the following Figure 4.

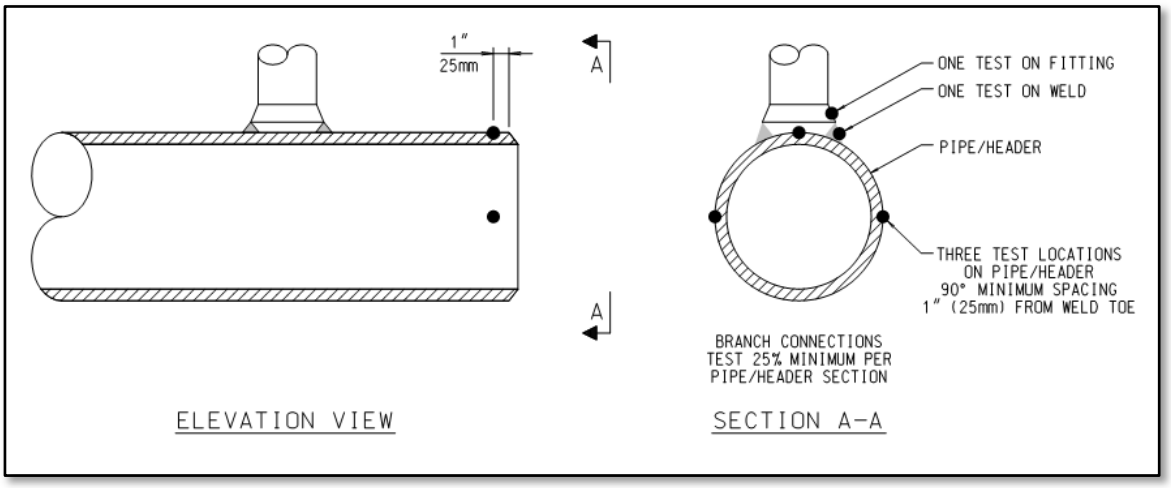


Figure 4: Branch Connection (ASME Sec. I) - Hardness Testing

4.4.7.6. Socket Welds (ASME Sect. I): A minimum of 10 % of socket welds per header or pipe section shall be tested as follows: (1) One test on the tube or pipe approximately 1 inch (25 mm) from the weld toe; (2) One WM test; and (3) One test on the socket weld fitting. Reference the following Figure 5.

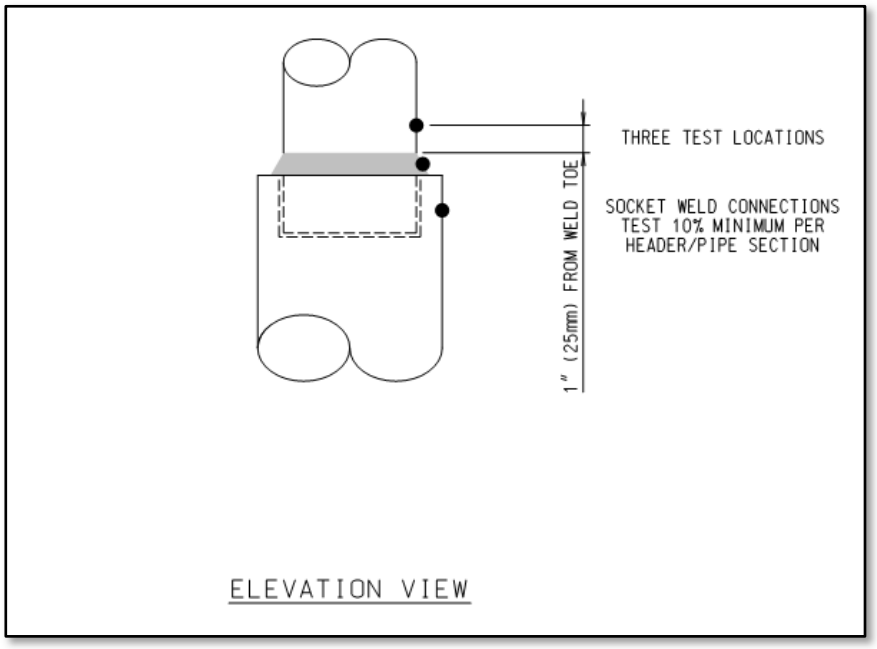


Figure 5: Socket Welds (ASME Sec. I) - Hardness Testing

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4.4.7.7. Circumferential Butt Welds (ASME Sect. I, pipe or tube NPS 6 [DN 150] or less): A minimum of 5 % of butt joints for each pipe or tube size, per each header or pipe section, shall be tested. One traverse consisting of three (total) hardness tests in a line shall be tested as follows: (1) One test on each side of the weld approximately 1 inch (25 mm) from the weld toe; and (2) One WM test. Reference the following Figure 6.

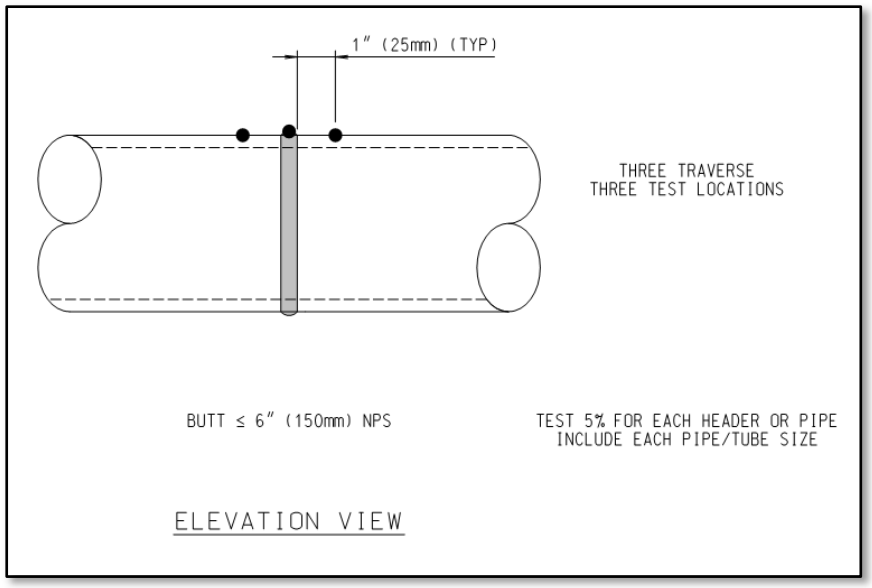


Figure 6: Circumferential Butt Weld <= 6 in (ASME Sec. I) - Hardness Testing

4.4.7.8. Circumferential Butt Welds (ASME Sect. I, pipe >NPS 6 [DN 150]): A minimum of 50 % of butt joints per header or pipe section shall be tested as follows: Three traverses consisting of three readings per traverse are required (nine readings total). Each traverse shall be comprised of the following: (1) One test on each side of the weld approximately 1 inch (25 mm) from the weld toe; and (2) One WM test. Each traverse shall be spaced at least 90 °s from each of the other traverses. Reference the following Figure 7.

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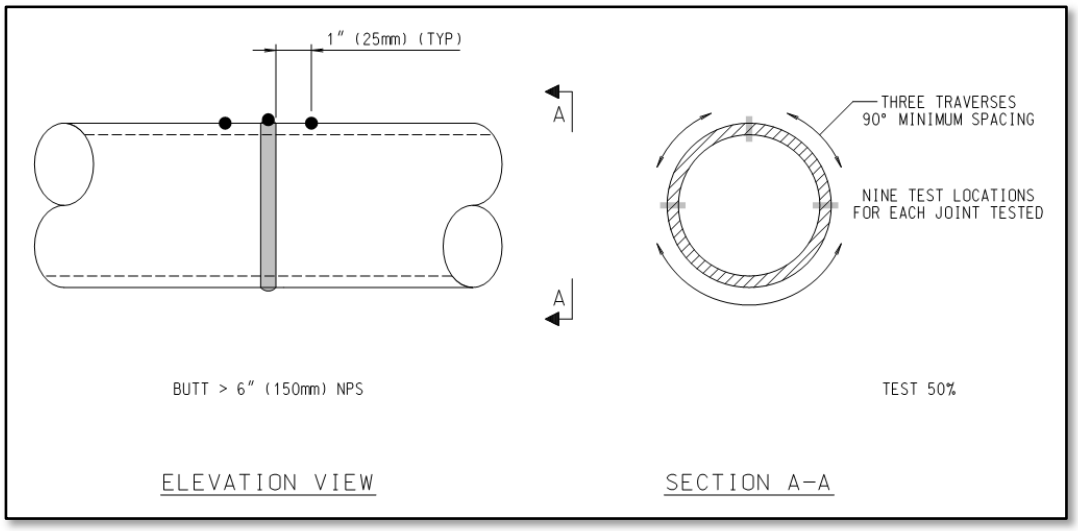


Figure 7: Circumferential Butt Welds > 6 in (ASME Sec. I) Hardness Testing

4.4.7.9. Hardness Test for Hot Bends (ASME Sect. I): 100% of hot bends shall be tested. Hardness tests shall be performed at both tangent areas at the end of the bend and at the mid-bend area. A total of four locations, one test at each 90° increment around the pipe bend, shall be hardness tested and shall include the intrados and extrados at each test area. A total of four hardness tests shall be performed at each of the three different areas (12 tests total). Reference the following Figure 8.

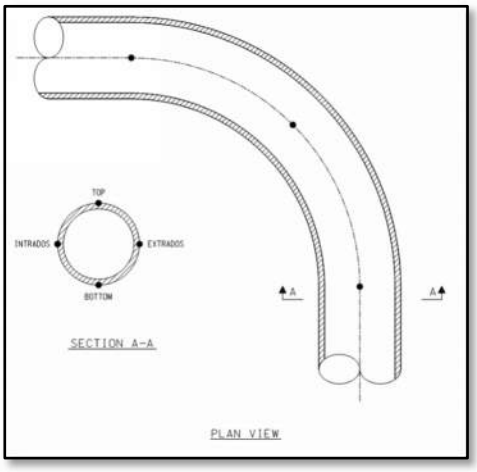


Figure 8: Hot Bends (ASME Sect. I) - Hardness Testing

4.4.7.10. Hardness Test for Cold Bends (ASME Sect. I): Surface hardness measurements of cold bends are only required if external heat is applied at any time during bending or if bends have been post bend heat treated (100% for applicable bends). Hardness tests shall be performed

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completed bends at each of the following three locations: at the midpoint of the intrados, the extrados, and the neutral axis on either the top or bottom of the bend (3 tests total). Reference the following Figure 9.

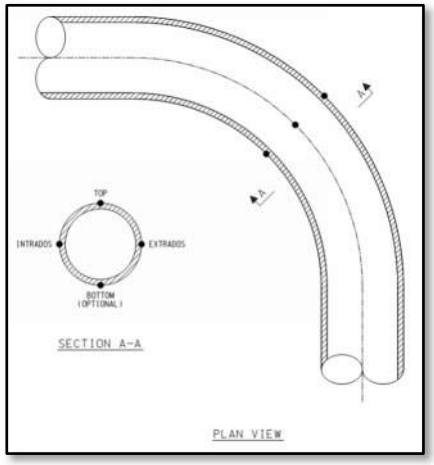


Figure 9: Cold Bends (ASME Sect. I) - Hardness Testing

4.4.7.11. Round Nonpressure Attachments, e.g. stanchions and trunnions (ASME Sect. I): One attachment per header or pipe section shall be tested as follows: Three tests on the pipe or header, with each test spaced at least 90 °s around the attachment approximately 1 inch (25 mm) from the weld toe. Reference the following Figure 10.

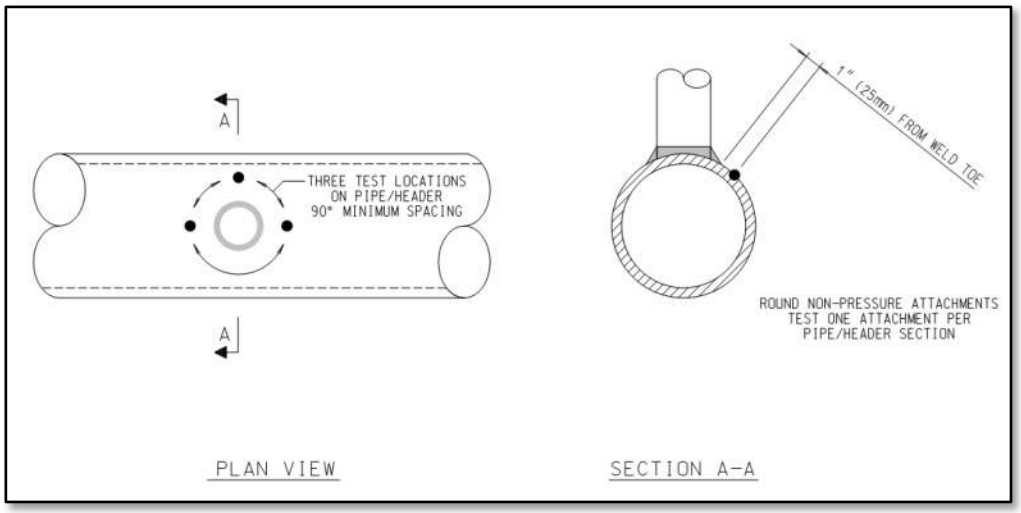


Figure 10: Non-pressure Attachments (ASME Sec. I) - Hardness Testing

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4.4.7.12. Rectangular Nonpressure Attachments, e.g., support lugs (ASME Sect. I): A minimum of 25 % of rectangular nonpressure attachments shall be tested per header section or pipe as follows: One test shall be performed on the header or pipe (on each of the major sides of the lug), with the hardness test located approximately centered and approximately 1 inch (25 mm) from the weld toe. Reference the following Figure 11.

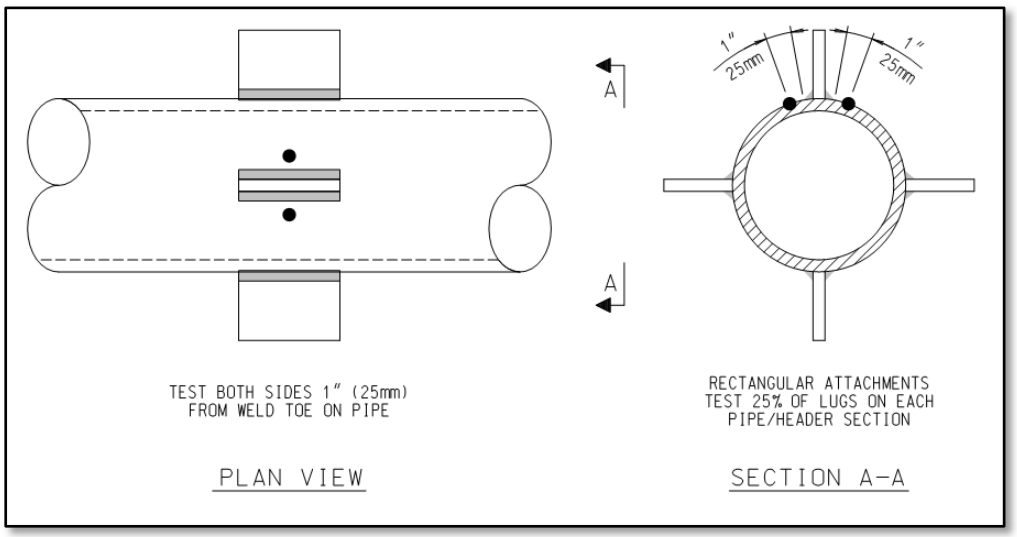


Figure 11: Rectangular Non-pressure Attachments (ASME Sec. I) - Hardness Testing

4.4.8. HARDNESS TESTING REQUIREMENTS FOR ASME B31.1 COMPONENTS: The requirements in this section include where ASME Section I invokes the requirements of B31.1 including Boiler External Piping (BEP) and Non-Boiler External Piping (NBEP).

4.4.8.1. Circumferential Butt Welds (B31.1, NPS 4 [DN 100] and less): One hardness traverse shall be completed on 100 % of the circumferential butt welds. The traverse consists of five (total) hardness tests in a line. One hardness test shall be performed on the WM. One hardness test shall be performed on the base material on each side of the weld toe as close as practical to the weld toe. One hardness test shall be performed on the base metal (BM) approximately 4 inches (100 mm) from the weld toe on each side of the weld. Five (total) hardness tests are required. Reference the following Figure 12.

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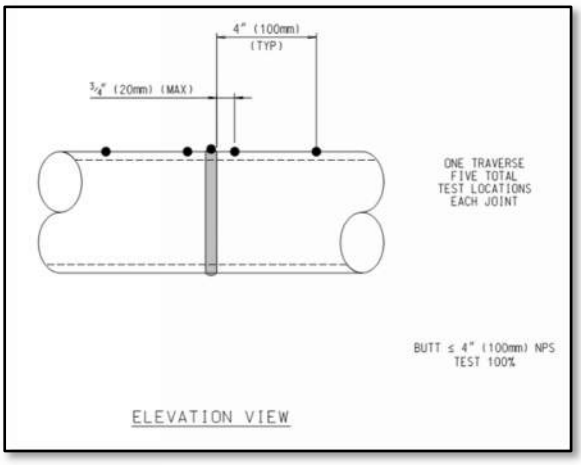


Figure 12: Circumferential Butt Welds <= 4 in (B31.1) - Hardness Testing

4.4.8.2. Circumferential Butt Welds (B31.1, >NPS 4 [DN 100] through NPS 10 [DN 250]): Two hardness traverses shall be completed on 100 % of the circumferential butt welds. The two traverses shall be located diametrically opposite each other. Each traverse will consist of five (total) hardness tests in a line. One hardness test shall be performed on the WM. One hardness test shall be performed on the base material on each side of the weld toe as close as practical to the weld toe. One hardness test shall be performed on the BM, approximately 4 inches (100 mm) from the weld toe on each side of the weld. Both traverses will result in the performance of 10 (total) hardness tests. Reference the following Figure 13.

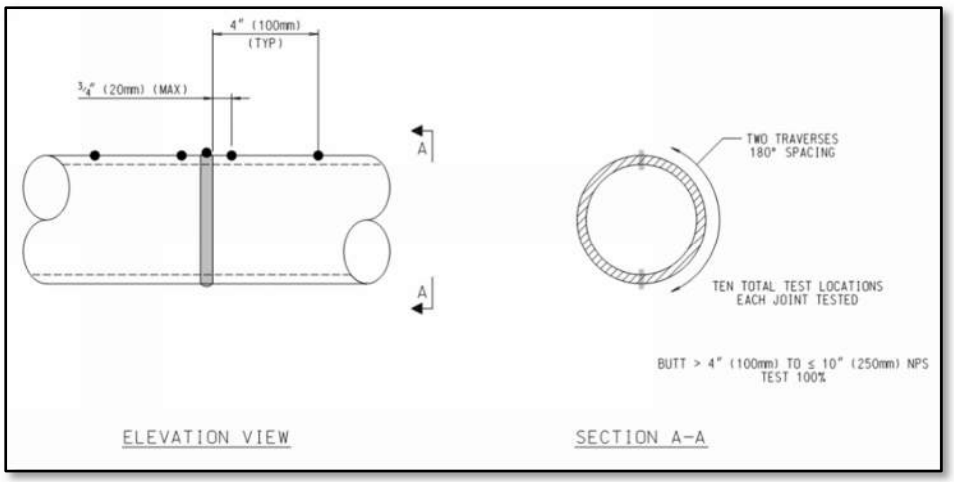


Figure 13: Circumferential Butt Welds > 4 in <=10 in (B31.1) - Hardness Testing

4.4.8.3. Circumferential Butt Welds (B31.1, >NPS 10 [DN 250]): Four hardness traverses shall be completed on 100 % of the circumferential butt welds, at four locations around the weld

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at 90 ° increments. Each series of hardness tests consists of five (total) hardness tests in a transverse line. One hardness test shall be performed on the WM. One hardness test shall be performed on the base material on each side of the weld toe as close as practical to the weld toe. One hardness test shall be performed on the BM approximately 4 inches (100 mm) from the weld toe on each side of the weld. All four traverses will result in the performance of 20 (total) hardness tests. Reference the following Figure 14.

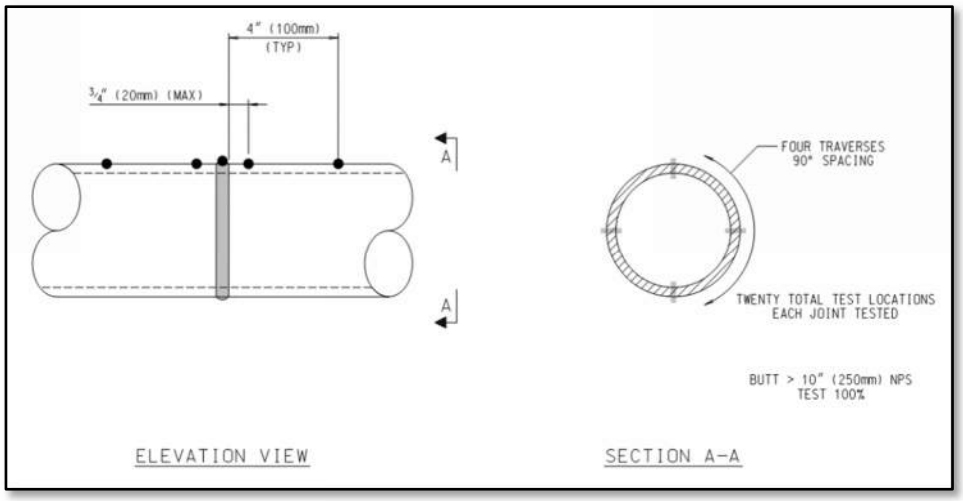


Figure 14: Circumferential Butt Weld > 10 in (B31.1) - Hardness Testing

4.4.8.4. Branch Connection and Thermowell Connection (Stub-In) Welds (B31.1): One series of hardness tests shall be completed on 100 % of the branch connection welds. One hardness test shall be performed on the WM. One hardness test shall be performed at each 90 ° increment approximately 1 inch (25 mm) from the toe of the weld on the header around the branch connection (four total). Additionally, one hardness test shall be performed (in the same radial plane as the branch connection around the header) at each 90 ° increment (three total) from the branch connection. All series of hardness tests will result in the performance of eight (total) hardness tests. Reference the following Figure 15.

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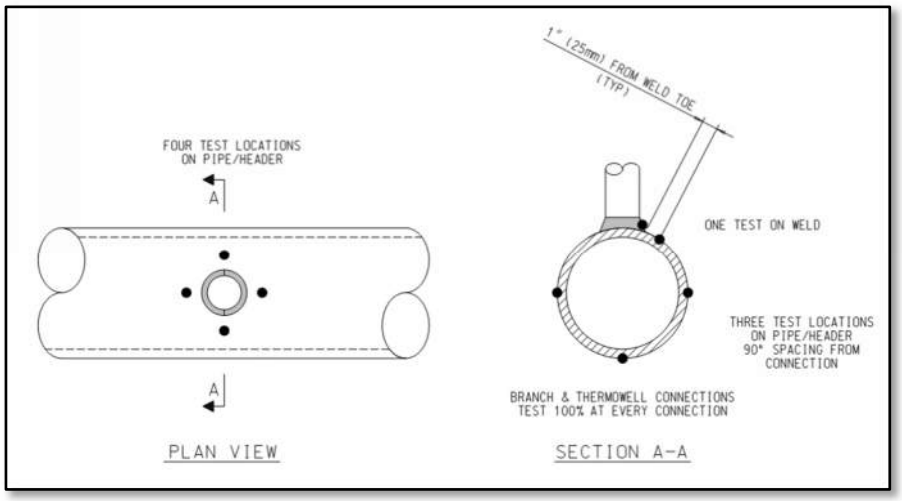


Figure 15: Stub-In Weld (B31.1) - Hardness Testing

4.4.8.5. Socket Welds (B31.1): One series of hardness tests shall be completed on 100 % of the socket welds. One hardness test shall be performed on the WM, and one hardness test shall be taken adjacent to the socket weld on the pipe BM and the fitting BM within approximately 1 inch (25 mm) from the toe of the weld (three total). Reference the following Figure 16.

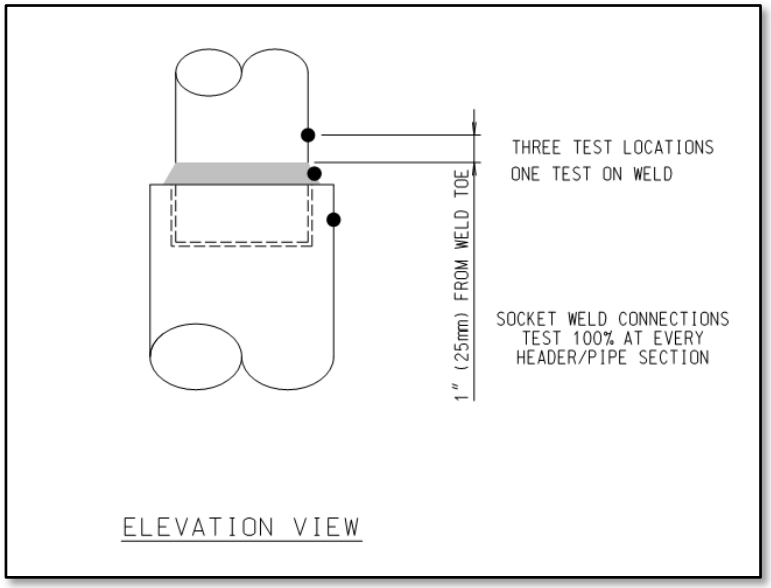


Figure 16: Socket Welds (B31.1) - Hardness Testing

4.4.8.6. Round Nonpressure Attachment Welds (such as stanchions and trunnions [B31.1]): One series of hardness tests shall be completed on 100 % of the attachment welds as described.

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One hardness test shall be performed at each 90 ° increment approximately 1 inch (25 mm) from the toe of the weld on the header around the attachment (four total). Additionally, one hardness test shall be performed (in the same radial plane as the attachment around the header) at each 90 ° increment (three total) from the attachment. All series of hardness tests will result in the performance of seven (total) hardness tests. Reference the following Figure 17.

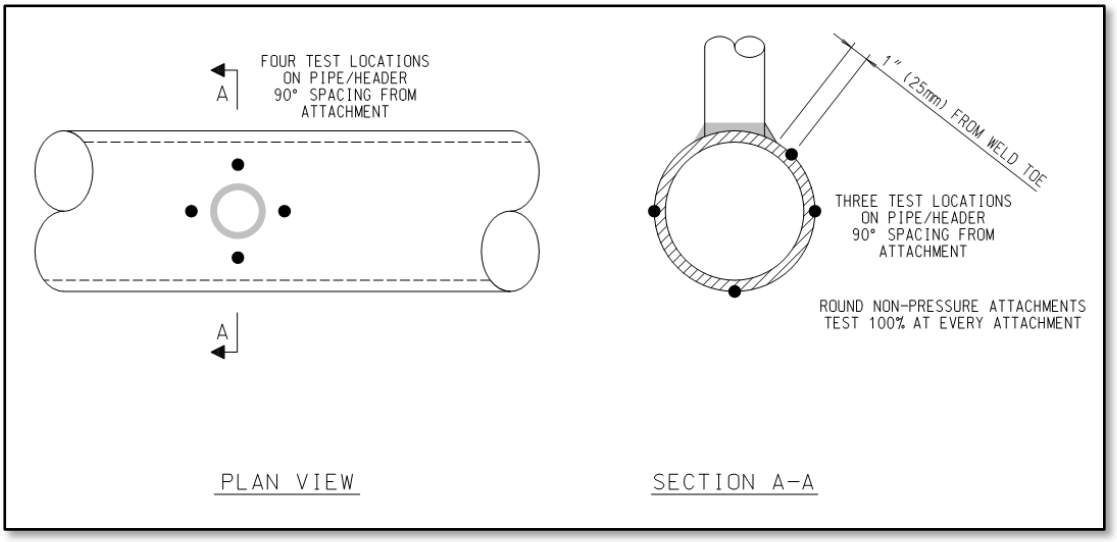


Figure 17: Round Non-pressure Attachment Welds (B31.1) - Hardness Testing

4.4.8.7. Rectangular Nonpressure Attachment Welds (such as support lugs [B31.1]): One series of hardness tests shall be completed on 100 % of the lugs/attachments. When testing lugs/attachments, one hardness test shall be performed on each of the major sides of the lug, with the hardness test located approximately centered and approximately 1 inch (25 mm) from the toe of the weld on the pipe. Reference the following Figure 18.

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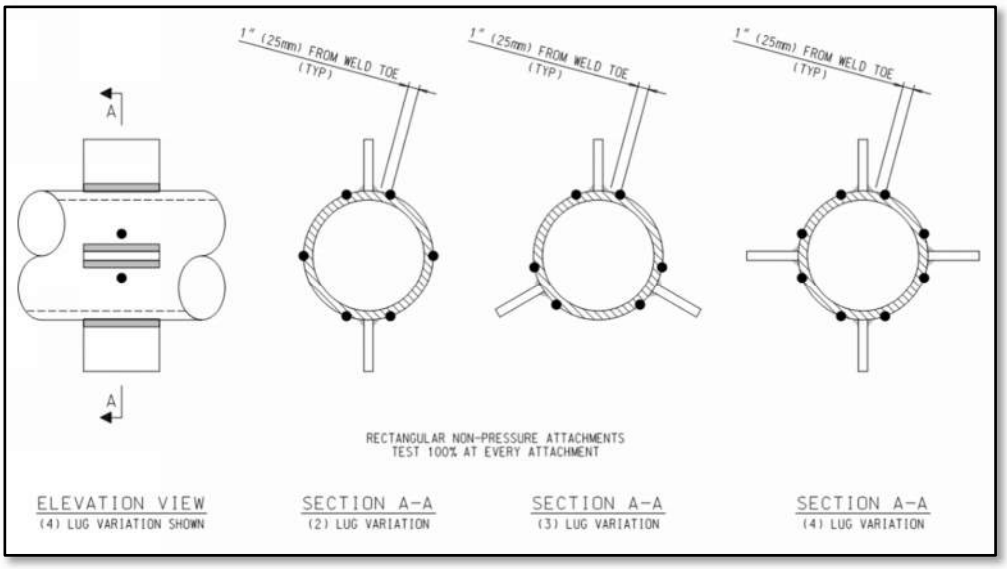
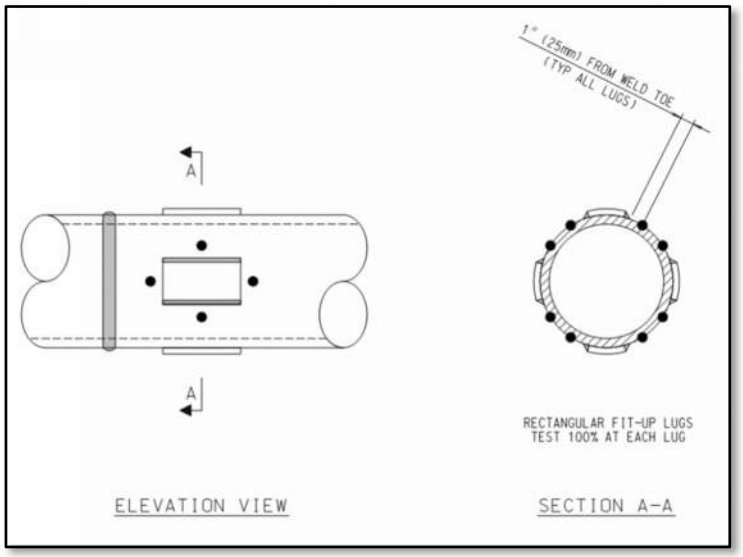


Figure 18: Rectangular Non-pressure Attachment Welds (B31.1) - Hardness Testing

4.4.8.8. Rectangular Non-pressure Attachment Welds Designed for Alignment/Fit-up (B31.1): Alignment attachments are used to aid fit-up of the piping and are associated with an adjacent circumferential butt weld. Temporary attachments are exempt from this testing. One series of hardness tests shall be completed on 100 % of this attachment type. The attachment welds shall be hardness tested at four locations on each of the four alignment attachments. One hardness test shall be performed on each of the four sides of the attachment (four total), approximately centered and 1 inch (25 mm) from the toe of the weld or attachment on the pipe. All series of hardness tests will result in the performance of 16 (total) hardness tests. Reference the following Figure 19.



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Figure 19: Rectangular Non-pressure Attachments (B31.1) - Hardness Testing

4.4.8.9. Seal/Partial Penetration Welds for Gamma Ray Plugs (B31.1): One series of hardness tests shall be completed on 100 % of the gamma ray plug seal/partial penetration welds. One hardness test shall be performed on the WM, and one hardness test shall be taken adjacent to the seal weld on the pipe BM within approximately 1 inch (25 mm) from the toe of the weld. Additionally, one hardness test shall be performed (in the same radial plane as the gamma ray plug seal/partial penetration weld around the pipe) at each 90 ° increment (three total) from the gamma ray plug seal/partial penetration weld. All series of hardness tests will result in the performance of five (total) hardness tests. Reference the following Figure 20.

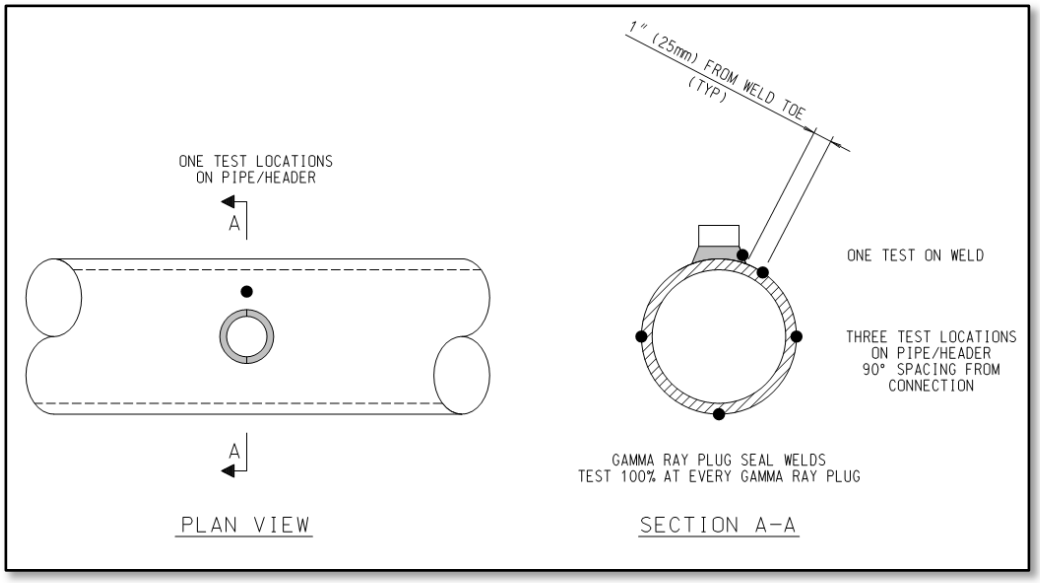


Figure 20: Partial Penetration Welds (ASME B31.1) - Hardness Testing

4.4.8.10. Hardness Testing Requirements for Field Weld End Preparation(s) (B31.1): Hardness tests shall be performed on the piping field weld end preparation for all end preparations that are required to be field welded. At a location approximately 1" (25 mm) from the face of the weld end preparation, a total of four locations shall be tested at each 90° increment around the pipe (4 tests total). Reference the following Figure 21.

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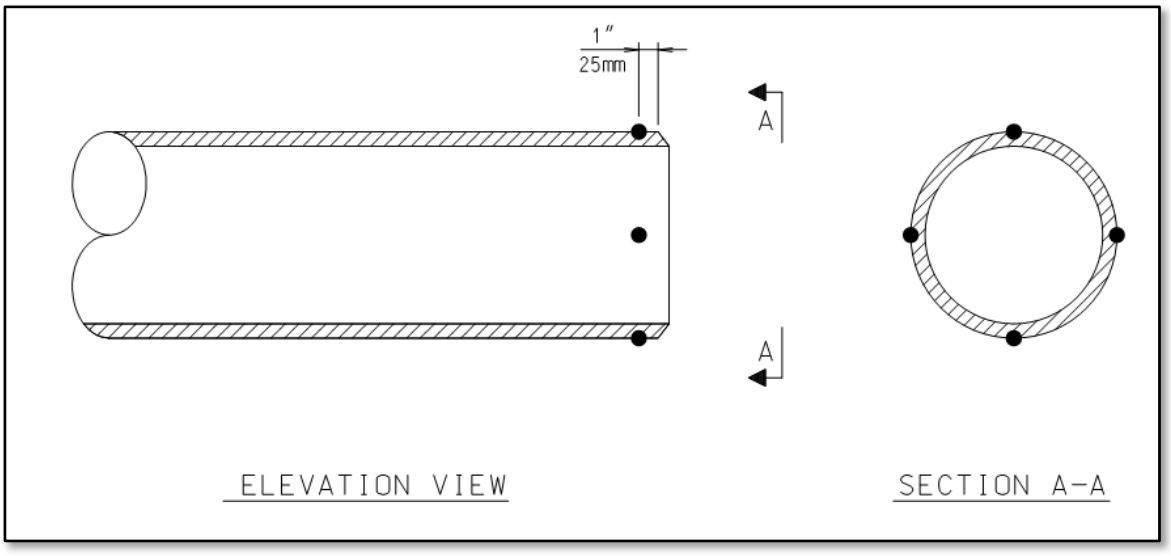


Figure 21: Field Weld End Preparation (B31.1) - Hardness Testing

4.4.8.11. Hardness Test for Hot Bends (B31.1): Hardness tests shall be performed at both tangent areas at the end of the bend and at the mid-bend area. A total of four locations, one test at each 90° increment around the pipe bend, shall be hardness tested and shall include the intrados and extrados at each test area. A total of four hardness tests shall be performed at each of the three different areas (12 tests total). Reference the following Figure 22.

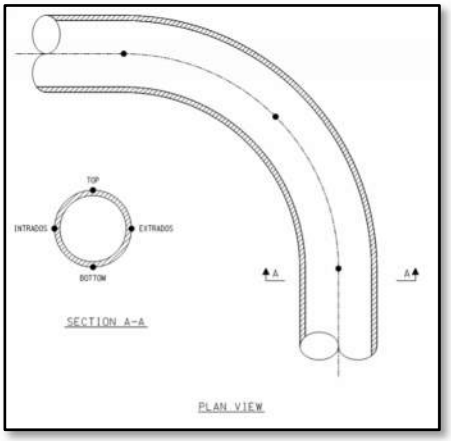


Figure 22: Hot Bends (B31.1) - Hardness Testing

4.4.8.12. Hardness Test for Cold Bends (B31.1): Surface hardness measurements of cold bends are only required if external heat is applied at any time during bending or if bends have been post bend heat treated. Hardness tests shall be performed completed bends at each of the following

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three locations: at the midpoint of the intrados, the extrados, and the neutral axis on either the top or bottom of the bend (3 tests total). Reference the following Figure 23.

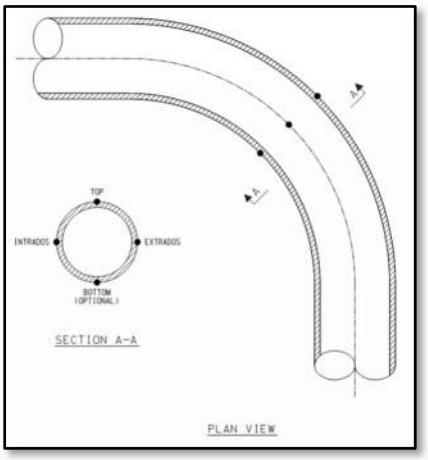


Figure 23: Cold Bends (B31.1) - Hardness Testing

4.4.9. HARDNESS TEST RETESTS - Hardness test retests shall be performed as follows:

4.4.10. If any hardness test is unacceptable, three retests are required and shall be performed in the same area as close as practical to the failed test. If the average of the retests is within the allowable hardness test range, no additional testing is required.

4.4.11. If the results of the hardness tests are unacceptable, a nonconformance report documenting the BM, filler metal, location, weld configuration, test results, and proposed disposition shall be submitted to Buyer for review.

4.5. WALL THICKNESS MEASUREMENTS:

4.5.1. Where pipe wall thickness measurements are required, they shall be determined by recording measurements at four equidistant points along the pipe's circumference; 0°, 90°, 180°, and 270°. For each pipe, sets of 4 equidistant point measurements shall be recorded along the longitudinal axis according to following criteria:

- Pipe length less than or equal to 5 feet: 1 pipe diameter in length from each pipe end.
- Pipe length greater than 5 feet: 1 pipe diameter in length from each pipe end, and within the middlemost 5-foot section of the pipe.

END OF SECTION

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