

Shop Fabricated Induction Bends

STD.4505

Scope

This standard covers requirements for the purchaser to specify the Product Specification Level (PSL) for the design, material selection, manufacture, testing, coating, and inspection of carbon steel pipe bends produced by the induction bending process for oil and gas pipeline service.

TABLE OF CONTENTS

1.0	REFERENCES	3
1.1.	Pipeline and Hazardous Materials Safety Administration (PHMSA).....Error! Bookmark not defined.	
1.2.	American Petroleum Institute (API)	3
1.3.	American Society of Mechanical Engineers (ASME)	3
1.4.	American Society for Testing and Materials (ASTM)	3
1.5.	Tube and Pipe Association International (TPA)	3
1.6.	Company Specifications	3
2.0	DEFINITIONS	4
3.0	BASIS OF PURCHASE	4
4.0	DESIGN	5
5.0	PROCEDURE QUALIFICATION TESTING	6
6.0	FABRICATION	7
7.0	REPAIRS	7
8.0	POST-BENDING HEAT TREATMENT	8
9.0	MATERIALS	8
10.0	SURFACE PREPARATION AND PAINTING	8
11.0	MANUFACTURING AND INSPECTION PROCEDURE	9
12.0	INSPECTION	9
13.0	VISUAL INSPECTION	9
14.0	MAGNETIC PARTICLE INSPECTION	10
15.0	DIMENSIONAL CHECK	10
16.0	GAUGING PIG INSPECTION	10
17.0	TRACEABILITY	10
18.0	TESTING	11
19.0	MARKING	11
20.0	PACKING, CRATING, AND SHIPPING	11
21.0	DOCUMENTATION	12
Attachment	Revision Log	18

1.0 REFERENCES

- (1) Except as amended by this standard, the latest approved editions of the following codes, regulations, and industry standards shall form an integral part of this standard.
- (2) In case of conflict between documents, contact the Company Project Manager / Company Engineer for resolution. Any deviation from this standard by the Vendor shall be submitted in writing to the Company Project Manager / Company Engineer for approval. Vendor shall not deem such deviations to be accepted without written approval from the Company.

1.1. American Petroleum Institute (API)

API 5L	Specification for Line Pipe, 46th edition
API 1104	Welding of Pipelines and Related Facilities, 20th edition, October 2005, Errata/Addendum (July 2007), and Errata 2 (December 2008)

1.2. American Society of Mechanical Engineers (ASME)

B16.49-2012	Factory-Made, Wrought Steel, Buttwelding Induction Bends for Transportation and Distribution Systems
B16.9-2007	Factory-Made Wrought Buttwelding Fittings
B31.4-2006	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
B31.8-2007	Gas Transmission and Distribution Piping Systems
2007 BPVC	Boiler and Pressure Vessel Code Section V: Nondestructive Examination

1.3. American Society for Testing and Materials (ASTM)

ASTM E10	Standard Test Method for Brinell Hardness of Metallic Materials
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products

1.4. Pipeline and Hazardous Materials Safety Administration (PHMSA)

49 CFR 192	Transportation of Natural and Other Gas by Pipeline
49 CFR 195	Transportation of Hazardous Liquids by Pipeline

1.5. Tube and Pipe Association International (TPA)

TPA-IBS-98	Recommended Standards for Induction Bending of Pipe and Tube
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1.6. Company Specifications

STD.4500	Line Pipe Specification for Onshore Applications (API 5L) - for Pipe Purchased from Manufacturer
STD.4501	Line Pipe Specification for Onshore Applications (API 5L) - for Pipe Purchased from Supplier
STD.7003	Protective Coatings – Below Ground Steel Surfaces – Plant Applied Fusion-Bonded Epoxy and Abrasion-Resistant Overlay

2.0 DEFINITIONS

BHN – Brinnell Hardness Number

Company – Enterprise (if used in connection with a contract or other agreement, the actual Enterprise entity will be the specific Enterprise entity referenced in the contract).

Company Project Manager - An employee or contingent worker of Enterprise who has the overall responsibility for the project. For example, this can be someone in Capital Projects, Field Engineering, Maintenance or Operations.

Company Authorized Representative – Representative for company to visually inspect piping, welds, etc. (i.e. inspector).

DSAW – Double Submerged Arc Welded Pipe

ERW – Electric Resistance Welded Pipe

Extrados – Outer Curved Section of the Bend Arc

FBE – Fusion bonded epoxy

FOB – Free on board

Induction bend process – The induction process employs a heating coil to create a narrow, circumferential, heated band around the material to be bent. When the appropriate temperature is reached, the material is pushed forward through the coil at a consistent speed and temperature while a bending moment is applied. After the material passes through the coil, it may be cooled (quenched) by forced air or water spray, or it may be allowed to cool naturally at ambient temperature.

Injurious Defect – Defined as a defect having a depth in excess of 5 percent of the actual local wall thickness.

Intrados – Inner Curved Section of the Bend Arc

ksi – kip/square inch

MAOP – Maximum Allowable Operating Pressure

MOP – Maximum Operating Pressure

MPS – Manufacturing Procedure Specification

NDT – Nondestructive Testing

Ovality – Ovality is expressed as $2(a-b)/(a+b)$, where a is the length of the major axis and b is the length of the minor axis.

PO – Purchase Order

PSL – Product Specification Level

SAW – Submerged Arc Welded Pipe

SMYS – Specified Minimum Yield Strength

Transition Zone – The area, at the tangent points of a bend that covers the change (transition) from unheated to heated material.

Upset – A bump or dimensional change with a peak and valley that occurs at each tangent point (transition) of a bend. These are of a cosmetic nature and are not classified as injurious defects. B16.49-2012 (Section 13.1)

3.0 BASIS OF PURCHASE

- (1) The Request for Quotation and Purchase Order for pipe bends under this specification shall include a completed "Product Specification Level (PSL) for Induction Bending (to be provided by the Purchaser)" (Appendix A of this document), which specifies the following parameters:

- (a) Quantity
- (b) Pipe diameter (inside or outside)
- (c) Nominal wall thickness at the weld bevel
- (d) Material specification, material construction, and grade of pipe
- (e) Bend angle, (degrees)
- (f) Centerline bend radius
- (g) Straight tangent length on each end
- (h) Various other parameters

4.0 DESIGN

- (1) Vendor shall prepare and submit a "Manufacturing Procedure Specification" (Appendix B) and detailed shop drawings for approval prior to fabrication of each bend to be furnished indicating nominal dimensions, tolerances, location of weld seam, bend radii, minimum wall thickness in final configuration, tangential extensions, weld end preparations, and any heat treatment details.
- (2) For pipe other than seamless, the longitudinal axis of the weld seam shall be located near to the true neutral axis of the bend towards the inside of the bend.
- (3) Unless otherwise specified by the Company Project Manager / Company Engineer, post-bend dimensional tolerance requirements shall conform to TPA-IBS-98.
- (4) The outside diameter of the pipe bend shall not be reduced in any circumferential plane by more than 2.5 percent of the nominal pipe diameter and shall meet the requirements of API 5L for a length of at least 4 in from each end.
- (5) The maximum difference between any two outside diameter measurements in any circumferential plane shall not exceed 2.5 percent of the specified diameter and shall not exceed 1 percent of the specified diameter within 4 inches of the pipe end.
- (6) The wall thickness of the pipe bend in any location shall not be reduced to less than 92 percent of the specified nominal wall thickness of the original bend. This corresponds to approximately 5 R/D (centerline bend radius/outside pipe diameter) bend according to Table 1-1, TPA-IBS-98. Further wall reduction (lower R/D) requires Company Project Management / Company Engineering approval. Vendor shall select pipe of sufficient thickness such that post bend wall thickness is within the tolerances specified herein.
- (7) Unless otherwise stated ends of all pipe bends shall be machined beveled 30 degrees, +5 degrees / -0 degrees for butt-welding in accordance with API 5L end tolerances and shall meet ASME B16.9.
- (8) The radius of each bend shall be as specified in Appendix A -- Product Specification Level for Induction Bending.
- (9) Pipe bends manufactured from pipe with a wall thickness which exceeds the nominal wall thickness specified on the Request for Quotation and Purchase Order by 3/32 in or more shall have internally taper bored to match the specified nominal wall thickness. The taper bore shall be in accordance with ASME B31.4, Figure 434.8.6(a)-(2) Acceptable Butt Welded Joint Design for Unequal Wall Thicknesses or ASME B31.8, Appendix I, Figure 1-5 Acceptable Design for Unequal Wall Thickness.
- (10) Pipe bends shall be supplied as one-piece units with no circumferential fabrication welds unless pre-approved by the Company Welding Department. If bends cannot be produced from a single length of pipe, two or more bends from single length pipe shall be joined by welding with an approved and qualified welding procedure specification for the application after all processing required herein to produce the required length of bend.

5.0 PROCEDURE QUALIFICATION TESTING

- (1) All production pipe bends shall be made in accordance with pre-established written procedures provided by the Vendor in response to Appendix C.
- (2) Written procedures for Material Group 3 bends, pipe with a SMYS equal to, or greater than 60,000 psi shall be qualified in accordance with TPA-IBS-98.
- (3) If specified by the Company Project Manager / Company Engineer, Vendor shall re-qualify the Group 3 bend procedure or qualify a procedure for Group 2 bends for each heat. The qualification testing shall be performed by the Vendor and approved in writing by the Company Project Manager / Company Engineer before the fabrication of any production induction bends.
- (4) When a bend procedure qualification is required, the bend procedure qualification test and essential variables shall be as specified for the specific material group as defined in TPA-IBS-98; Table 2-1 Bend Procedure Qualification Test. Vendor shall produce one prototype bend for use in qualifying the written bending procedure. The prototype test bend shall be made using the same induction bend procedure and subjected to the same thermal and mechanical treatments as will be applied to the production bends. Testing shall be performed in accordance with Part 2 of TPA-IBS-98.
- (5) Following bending and heat treatment, tensile testing, Charpy impact testing, and hardness testing shall be performed on the procedure test bend as specified and at locations recommended by TPA-IBS-98 for the specific material group.
- (6) Acceptance criteria for the tensile tests shall be as indicated by API 5L, Table 7 Requirements for the results of tensile tests for PSL 2 pipe for the PSL 2 pipe grade used. The actual yield strength after bending shall not exceed the yield strength of the pipe prior to bending by more than 15 ksi or the specified minimum yield strength by more than 30 ksi minimum yield and the ultimate strength of the finished bend shall conform to API 5L, Table 7 Requirements for the results of tensile tests for PSL 2 pipe for the PSL 2 pipe grade used.
- (7) Notch toughness properties (i.e. Charpy impact testing) of the bend material shall be completed in the final heat-treated condition. The acceptance criteria at 0°F (-18°C) or the lowest expected metal temperature during pressure testing or during service, whichever is less for minimum test temperature for full-size and subsize specimens shall be in accordance with API 5L for PSL 2 pipe.
- (8) Hardness testing acceptance criteria are to be indicated by Company Project Manager / Company Engineer to the vendor based on service environment and shall be specified in the PO:
 - (a) For non-sour service applications the acceptance criteria for hardness testing performed on the pipe surfaces shall not exceed Brinell Hardness Number 235, and the allowable difference between minimum and maximum hardness readings for each location tested shall not exceed 30 BHN. Microhardness testing results for welds and heat-affected zones shall not exceed Vicker hardness 300 for non-sour service applications.
 - (b) For sour service applications acceptance criteria for both pipe, welds, and heat-affected zones shall be compliant with NACE MR0103 "Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments" or NACE MR0175 "Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment".
- (9) Grades X52 and Less: Manufacturing procedure qualification testing is not required on grades X52 and less providing the manufacturer has documentation on previous qualifications to the satisfaction of the Company Project Manager / Company Engineer.
- (10) Grades Higher than X52: At least one qualification test shall be performed for each combination of pipe diameter, wall thickness, grade, and pipe supplier. Qualification testing shall be conducted in accordance with qualification testing requirement that will be supplied by Company Project Manager / Company Engineer.

6.0 FABRICATION

- (1) Pipe to be used in the fabrication of the production and procedure qualification bends shall be furnished by the Company or by Vendor if noted on the Request for Quotation and Purchase Order. Pipe shall be of a grade and wall thickness suitable for the internal design pressure or MOP/MAOP and the field test pressures specified for the installation. The minimum required wall thickness and minimum required internal diameter will be specified by the Company Project Manager / Company Engineer when Vendor supplies the pipe. Vendor shall obtain written approval from the Company Project Manager / Company Engineer for the pipe to be used prior to the fabrication of any bends when Vendor supplies the pipe.
- (2) Induction bends made on cold worked or heat-treated pipe shall be designed based on the lower stress level.
- (3) The degree of bend to which each bend shall be formed, the bend centerline radius, and the tangent on each end shall be as specified on the Request for Quotation and Purchase Order. The longitudinal seam weld of the pipe shall be located at the neutral axis of the finished bend. Circumferential welds shall not be permitted in the finished bend except as noted in Section 4.0.
- (4) Bends shall be fabricated to minimize ovality, and shall be free of wrinkles, buckles, cracks, or other mechanical defects. The difference between the maximum and minimum diameter, measured on any radial cross section, shall not exceed 2.5 percent of the average measured outside diameter of the bend.
- (5) Pipe wall thickness thinning shall be controlled to accommodate production of bends suitable for the internal design pressure or MOP/MAOP, field test pressures, and minimum wall thicknesses specified.
- (6) Bend ends shall be machined and dimensionally sized to match the joining pipe in accordance with ASME B31.4 or ASME B31.8, Appendix I End Preparations For Buttwelding as appropriate. If necessary, internal diameters shall be taper-cut to avoid the need to backweld. Pipe ends shall be smoothly beveled to an angle of 30 degrees, +5 degrees / -0 degrees, measured from a line drawn perpendicular to the axis of the pipe. The root face dimension shall be 0.0625 inch, + 0.0156 inch for 95 percent of the circumference.

7.0 REPAIRS

- (1) Surface defects such as laminations, cracks, slivers, sharp notches, gouges, arc burns, scores, or other injurious defects not deeper than 5 percent of the actual local wall thickness may be repaired by machining or sanding. The completeness of defect removal shall be checked with wet magnetic particle inspection (preferred) and/or dye penetrant inspection.
- (2) Final wall thickness conformance shall be checked and verified with ultrasonic inspection after all machining or sanding repairs are completed.
- (3) The bends shall be free of injurious defects and shall have a workmanlike finish. Injurious defects are defined as those having a depth in excess of 5 percent of the actual local wall thickness.
- (4) Machining or sanding repairs shall be performed in such a manner as not to gouge, groove, or reduce the base metal thickness.
- (5) All machining or sanding repairs shall be approved by the Company's Authorized Representative.
- (6) No repairs of any type are permitted to the existing longitudinal seam welds.
- (7) No welding repairs of base metal or weld metal are permitted, deviation to allow welding repairs shall be approved by Company Welding Department in addition to following Company Standard Wavier process, and will only occur on an extreme case-by-case basis.
 - (a) If weld repairs are approved a repair map with the final deposition of the repair shall be recorded and furnished with the final document package to the Company.

8.0 POST-BENDING HEAT TREATMENT

- (1) Post-bend heat treatment shall be in accordance with the Vendor's qualified bending procedure (to be submitted with proposal).
- (2) Induction bends shall be heat treated after bending in accordance with the approved pre-production bend qualification tests except as modified by this specification by one or more of the following methods:
 - (a) Stress Relieve or Temper: Heat treatment of carbon steel piping shall be at 1150°F, plus or minus 25°F, for one hour per inch of wall thickness with a one hour minimum soak time. Lower temperatures for longer times are not acceptable.
 - (b) Normalize: Heat treatment of carbon steel piping shall be above the transformation temperature range (the minimum austenitizing temperature shall be 1,650°F), for one hour per inch of wall thickness with a one hour minimum soak time, and allowed to cool in still air.
 - (c) Quench and Temper: Heat above the transformation temperature range and hold at temperature for a minimum time as indicated in (2.b) above, and direct quench in either water, oil, or a synthetic quenchant. Reheat to temper as defined in (2.a) above. Quench facilities shall be of sufficient size and shall be equipped to ensure proper and uniform cooling.
- (3) All heat treatment equipment shall have a recording device that is calibrated at least quarterly. Heat-treat furnaces shall be surveyed annually, or at a shorter interval, as necessary to maintain uniformity of heat treatment, or thermocouples shall be attached to each furnace load.
- (4) Thermocouples shall be calibrated at least quarterly.
- (5) The heat-treating temperatures (furnace and metal) shall be measured and recorded. A single thermocouple reading atmospheric temperature is not acceptable. Records shall be maintained by Vendor and the records shall be available for a minimum of two years from shipment of product.
- (6) Heat-treating procedures shall be submitted to the Company Welding Department for approval prior to fabrication.

9.0 MATERIALS

- (1) The chemical composition of the steel on heat analysis shall conform to the requirements given in API 5L, Table 5 Chemical Composition for PSL 2 Pipe with $t \leq 0.984$ in. unless otherwise noted on the drawing.
- (2) Line pipe to be used for the fabrication of induction bends shall be supplied by the fabricator. Fabricator supplied pipe shall be in accordance with the Manufacturing Procedure Specification (Appendix B). No material substitutions will be allowed without prior written approval by the Company Project Manager / Company Engineer.

10.0 SURFACE PREPARATION AND PAINTING

- (1) All bends shall be furnished bare unless otherwise stated on the Request for Quotation and Purchase Order.
- (2) When specified, external coating with FBE shall be in accordance with Company STD.7003 *Protective Coatings – Below Ground Steel Surfaces – Plant-Applied Fusion Bonded Epoxy and Abrasion-Resistant Overlay*.
- (3) If specified, Fabricator shall apply external coating: 14 – 16 mils of FBE per Company STD.7003.

11.0 MANUFACTURING AND INSPECTION PROCEDURE

Before start of work, manufactures shall submit and obtain Company Project Management / Engineering approval on his manufacturing and inspection specification for each pipe diameter, wall thickness, grade, and type of pipe that the fabricator will bend under the Purchase Order. The manufacturing and inspection procedure shall contain the following as a minimum:

- (1) The forming procedure: including bending temperature, width of heated band temperature control methods, starting and stopping procedures and parameter ranges and tolerance.
- (2) Cooling method, cooling rate, water flow rate, controls, parameter ranges, and tolerances.
- (3) Post forming heat treatment procedures.
- (4) Test data on past projects to support the forming and heat treatment procedure.
- (5) Complete testing and inspection procedures, which shall include visual, dimensional, NDT, and hardness testing/inspection.

12.0 INSPECTION

- (1) The Company Project Manager or designee reserves the right to inspect materials, manufacturing, fabrication, and to witness tests at any time.
- (2) Vendor shall provide the required access for such inspections and test witnessing.
- (3) Vendor shall notify the Company Project Manager or designee at least seven working days prior to scheduled test dates to permit the Company Project Manager or designee to witness tests.
- (4) Vendor shall not deliver the specified item until it is inspected by the Company Project Manager or designee.
- (5) The Company Project Manager reserves the right to waive witnessing of inspection.

13.0 VISUAL INSPECTION

- (1) Every bend shall be examined 100% for imperfections and defects, as well as for arc burns or copper deposits.
 - (a) An upset or "start/stop" bump may be present in the transition zones of the bend arc, as long as these upsets have a dimensional measurement from peak to valley not exceeding 1/16 inch (1.6 mm) and all other dimensional requirements specified within this standard are met.
 - (b) Wrinkles, buckles, or other mechanical defects present anywhere within the induction bend are not permitted.
 - (c) Inspect the internal surfaces to the extent possible.
- (2) Ample fluorescent lighting both overhead and at component ends (for internal inspection) shall be provided for Company Authorized Representatives. The minimum illumination level shall be 15 foot candles (165 lumen per sqm) for general examination and 50 foot candles (550 lumen per sqm) for study of small anomalies.
- (3) The component surface condition shall be such that meaningful examination can be performed. If required, scale shall be removed where this interferes with examination. The possibility of rolling each component for inspection shall be provided. Company Authorized Representative shall have reasonable access to inspection aids to assist with Company inspection.
- (4) The work shall be subject to visual inspection, throughout the manufacturing phase, for surface finish, freedom from defects, dimensional checks, marking checks, etc., as required by this specification.

14.0 MAGNETIC PARTICLE INSPECTION

- (1) Bends shall be examined by wet magnetic particle inspection using the A.C. yoke and thinly applied background paint technique in accordance with ASME BPVC Section V. Nondestructive Examination shall cover external surfaces two inches each side of the extrados and each welding bevel. All scale and other pipe surface contaminants shall be removed by wire buffing or other appropriate methods before wet magnetic particle inspection is performed.
- (2) Examinations shall be performed after final head treatment and machining. The lifting power of the yoke shall be checked prior to examination and shall meet ASME BPVC Section V requirements. Burma Castrol Type 2 flaw indicators shall be used to check the adequacy of the magnetizing field.

15.0 DIMENSIONAL CHECK

The following measurements and specifications shall apply during the bending process:

- (1) Each bend shall be dimensionally checked for compliance with TPA-IBS-98. Each bend shall be measured for conformance to centerline radius, degree of bend, and center-to-end dimensions.
- (2) The wall thickness of the steel pipe for each bend shall be measured ultrasonically before bending at approximately 14 to 18 inches intervals along both the inner (intrados) and outer (extrados) radii of the bend (between and including the start and stop points of the bend arc angle).
- (3) The wall thickness of the steel pipe for each finished bend shall be measured ultrasonically after bending at the same locations measured before bending. In addition the walls thickness of the tangents shall be measured mechanically. These measurements shall be taken at four equally spaced locations around the pipe circumference at both welding ends of the bend.
- (4) Diameter measurements shall be made by means of mechanical calipers to check for conformance with ovality requirements.
- (5) The wall thickness at any location in the finished bend shall not be reduced to less than 92.0 percent of the specified nominal wall thickness of the original bend (Section 4.0 Design, Item 6).
- (6) The ovality in any plane along a finished bend shall not exceed 2.5 percent.
- (7) The post-bend dimension tolerance for the radius of the bend shall be ± 1 percent.
- (8) The post-bend dimension tolerance for the degree of bend shall be $\pm 1/2$ degree.
- (9) The post-bend dimension tolerance for the plane of bend shall be ± 1 degree.

16.0 GAUGING PIG INSPECTION

- (1) All bends shall be tested for ovality with a gauging pig having two sizing plates separated by a rigid bar of a length equal to the pipe ID. The diameter of the sizing plates shall not be less than 97.5 percent of the nominal inside diameter of the pipe.
- (2) The sizing plates shall be fabricated from material that will avoid gouging or scratching of the inside surface of the bends with exception that copper or copper alloyed (brass, bronze) shall not be used. The Company Project Manager / Company Engineer prior to the commencement of inspection shall approve the design of the gauging pig.

17.0 TRACEABILITY

- (1) Throughout the manufacturing process, a means of identification shall be utilized to maintain a strict accountability of all bends. The manufacturer shall develop a procedure for identification and submit it to the Company Project Manager / Company Engineer for approval.

18.0 TESTING

- (1) All tests required by this specification and all inspection shall be made in Vendor's plant prior to shipment and at Vendor's expense unless otherwise specified.
- (2) The following testing and inspection shall be performed on each finished bend before application of coating. Test and inspection results shall be recorded and furnished to the Company's representative on a daily basis. Details of the manufacturer's testing and inspection procedures shall be furnished to the Company Project Manager / Company Engineer:
- (3) Bends shall be internally and externally cleaned by mechanical means to remove any scale, rust, oil, grease, dirt, or other foreign matter from the bend. The bend shall be clean and dry for inspection.
- (4) Each bend shall be checked for surface hardness at the locations prescribed by TPA-IBS-98. Acceptance shall be the same as for Section 5.0. The bend will be rejected if any hardness reading exceeds 235 BHN or if the allowable difference between minimum and maximum hardness readings for each location tested exceeds 30 BHN.
- (5) The weld seam of bends made from ERW, SAW, or DSAW pipe shall be inspected in the bend section with ultrasonic flaw detection in accordance with API 5L after forming and heat-treating.
- (6) Welding procedures and acceptance criteria for pressure-containing parts shall be in accordance with the requirements of API 1104 and/or ASME BPVC Section IX, when necessary and shall be reviewed and approved by Company Welding Department.
- (7) The entire surface area of each finished weld bevel shall be examined after beveling using a dye penetrant technique to detect surface defects. Vendor shall record on test certificates the elapsed time period allowed for absorption on each weld bevel. Surface imperfections may be relieved by grinding as permitted by API 5L. The area to be examined shall be prepared to allow satisfactory examination. Cracks are unacceptable, as are laminations greater than 0.25 inch at the bevel face. Dye penetrant absorption shall be in accordance with the manufacturer's recommendations for the prevailing temperature at the testing facility. Details of the Vendor's wet magnetic particle inspection, dye penetrant inspection, and ultrasonic inspection procedures shall be furnished to the Company.
- (8) The external surface of each bend shall be visually inspected for arc burn or copper deposits. Any bend showing evidence of arc burn or copper deposits shall be rejected and replaced.
- (9) Pipe bends shall have a workmanlike finish with smooth contours and shall be free of mechanical damage and injurious defects.

19.0 MARKING

All bends shall be marked to include the Company's Purchase Order number, Vendor's name or trademark, the pipe nominal size (inches), nominal wall thickness of matching pipe (inches), material specification, bend angle (degrees), and centerline radius (inches). Markings shall be paint stenciled on the outside near the end of each bend and shall not damage the pipe.

20.0 PACKING, CRATING, AND SHIPPING

- (1) The handling may be performed only with a padded forklift or by lifting with nylon slings or bevel hooks. No chains shall be used.
- (2) For shipping, all dunnage used to support the bends shall be suitably padded to prevent damage. Nails shall be kept out of the contact area of the pad. When multiple bends are shipped in one load, suitable padding shall be allowed to prevent the bends from damaging each other. Nylon straps shall be used to tie down the bends. No chains shall be used.

- (3) Vendor shall provide and securely attach a metal, heavy plastic, or plywood bevel protector to each beveled end and other machined surfaces.
- (4) Vendor shall prepare the equipment for shipment after all testing, inspection, and coating have been accomplished and approved by the Company Project Manager / Company Engineer.

21.0 DOCUMENTATION

- (1) Vendor's quotation shall include as a minimum the following:
 - (a) Material description
 - (b) Unit Price FOB Vendor's plant
 - (c) Delivery schedule
 - (d) Exception(s) to Company's specification and Request for Quotation
 - (e) Other information as specified in the Request for Quotation
- (2) Vendor shall submit fabrication drawings for the Company Project Manager / Company Engineer approval prior to start of fabrication.
- (3) Vendor shall submit a record copy of each bending procedure along with a record copy of each applicable procedure qualification test prior to start of fabrication.
- (4) Vendor shall submit a record copy of Vendor's inspection procedures.
- (5) Vendor shall submit certified mill test reports for each joint of fabricator furnished line pipe to be supplied by Vendor and for the Company Project Manager / Company Engineer approval prior to start of fabrication. Each mill test report shall give pipe specifications, grade, diameter, wall thickness, process manufacturer, ladle analysis, chemical check analysis, mechanical properties, and mill hydrostatic test pressure.
- (6) Vendor shall furnish to the Company Project Manager / Company Engineer the complete inspection reports including hardness values.
- (7) Immediately following shipment, Vendor shall submit three certified copies of each bend drawing and three copies of all nondestructive examinations identified by bend.
- (8) Vendor shall also furnish the Company Project Manager / Company Engineer with the location copies of shipment tally reports.

Appendix A Product Specification Level for Induction Bending (To Be Provided by the Purchaser)

Standard Information	
Bend designation of each bend	
Quantity of bends	
Supply of mother pipe by the purchaser or the manufacturer	
Required bend dimensions, including	
- Diameter (inside or outside)	
- Minimum wall thickness	
- Bend radius	
- Bend angle	
- Tangent lengths	
End preparation if different from square ends	

Supplemental Information	
Minimum design temperature	
Maximum design temperature (and any requirement for high temperature tensile testing)	
Special dimensional requirements	
Requirements for supplementary inspection and testing	
Maximum wall thickness	
Requirements for gauging and other measurements of dimensions	
Pipeline design standard or design factors	
Pipeline operating conditions	
Whether post-bending heat treatment is to be applied	
Mechanical property requirements at the maximum design temperature	
Charpy impact test temperature	
Requirements for proof, burst, or hydrostatic testing	
Hold-points for witness and approval by purchaser	

Supplemental Information	
Surface condition	
Coating or painting requirements	
Marking requirements	
Packaging and shipping instructions	
Third-party inspection organization	
Standard designation of inspection document required	
Requirements for format and additional content of the inspection document	
Requirements for hardness testing	
Other special requirements	

Mother Pipe Information (If the mother pipe is supplied by the purchaser, the following information on the mother pipe shall be provided to the manufacturer)	
Pipe diameter (inside or outside)	
Pipe wall thickness (nominal or minimum)	
Pipe lengths	
Pipe manufacturer	
Pipe material specification and pipe material certificates if available, (to include chemical composition, heat treatment, mechanical properties, dimensions and results of NDT)	
Welding procedure specification and weld metal chemical composition for welded pipe	
Weld seam repair welding procedure specification for welded pipe	

Appendix B Manufacturing Procedure Specification

A Manufacturing Procedure Specification (MPS) shall be produced for all bends. Test bends shall be manufactured in accordance with a preliminary MPS documented before commencement of test bending. The preliminary MPS shall be modified as necessary, based on the parameters recorded during test bending, prior to commencing production bending. If specified by the purchaser, manufacturing shall not proceed until the MPS has been accepted by the purchaser.

The MPS shall specify the following details:

Information on the mother pipe	
Name of manufacturer	
Pipe grade	
Type of pipe	
Pipe forming process	
Pipe dimensions	
Chemical composition	
Mechanical properties	

Welding procedure and weld metal chemical composition for welded pipe	
Inspection technique and reports for weld seam	
Weld seam repair procedures	
Heat treatment conditions	

Testing and inspection requirements for	
Qualification test bend	
Production bends	

Bending process details	
Pipe cleaning method prior to bending;	
Identification of the bending machine	
Method of temperature measurement and control during bending	
Heating and quenching of tangent ends	

Details of post-bending heat treatment	
Type of post-bending heat treatment	
Heating rate, soaking time and temperature	
Cooling rate	
Type and location of thermocouples	

Additional purchaser requirements (such as end preparation, coating and marking)	
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Appendix C Shop Fabricated Shop Bends Procedure Qualification Testing

C-1. General

- (1) Unless otherwise stated in the Purchase Order, the manufacturer shall perform procedure qualification testing on each size and grade combination. Procedure qualification testing ensures manufacturer's procedure specification will produce bends having required mechanical properties. Procedure qualification testing shall be conducted prior to starting each production run. Company Project Manager / Company Engineer shall select or approve selection of one pipe from the same heat or a representative heat of steel from which pipes for bending were manufactured. This selected pipe shall be bent using the same induction bending procedure and subjected to the same thermal and mechanical treatments to be applied to the production bends.
- (2) Procedure qualification testing shall be included in the Manufacturing Procedure Specification. Therefore, details of procedure qualification testing shall be approved by Company Project Manager prior to production.
- (3) Properties of the test bend shall meet the requirements of the specification and the Purchase Order.

C-2. Mechanical Properties Tests

- (1) Test specimens shall be obtained from the pipe body and weld metal in the as-received condition and after bending from the inside and outside radius areas and the top and bottom neutral axis.
- (2) Mechanical properties testing shall be performed in accordance with API 5L.

C-3. Tensile Tests

- (1) Two transverse tensile specimens shall be taken from each of the following locations: the point of maximum bending on the inside and outside radius and the top and bottom neutral axis.
- (2) Yield strength shall not exceed the yield strength of the original pipe by more than 22 KSI and shall not be less than the minimum grade requirement as specified by the Purchase Order.
- (3) The ratio of yield to tensile strength shall not exceed 0.90.

C-4. Charpy V-Notch Impact Tests

Charpy Impact Test will be conducted in accordance with API 5L, 10.2.4.3 - Charpy Impact Tests for PSL 2.

Attachment Revision Log

Revision 0.0			Publish Date: 27 Jun 11
Location of Change	Type of Change	Reason for Change	
N/A	N/A		
Revision 1.0			Publish Date: 04 Apr 12
Location of Change	Type of Change	Reason for Change	
Section 2.0	Update	Updated references	
Section 4.0	Deletion	Deleted conflicting requirement regarding circumferential welds	
Section 4.0(8)	Addition	Added reference to Enterprise STD.7003	
Section 5.0(8)	Revision	Revised hardness testing requirements to be consistent with ASME B16.49	
Section 7.0(1)	Deletion	Deleted "arc burns" from the list of surface defects that may be repaired, to be consistent with section 18.0(8) which states that bends with arc burns shall be rejected and replaced.	
Section 18.0(4)	Revision	Revised hardness testing requirements to be consistent with section 5.0(8) and ASME B16.49	
Section 20.0(2)	Clarification	Clarified padding requirements	
Revision 1.1			Publish Date: 03 Mar 15
Location of Change	Type of Change	Reason for Change	
Section 2.2	Update	Updated references to API 5L and API 1104	
Revision 2.0			Publish Date: 21 Aug 19
Location of Change	Type of Change	Reason for Change	
Section 1.0	Revision	Updated and revised References	
Section 2.0	Addition/ Revision	Revised and updated Definition Section	
Section 5.0 (7)	Revision	Revised the notch toughness acceptance test criteria to 0°F (-18°C).	
Section 5.0 (8)	Revision	Revised to state Hardness testing acceptance criteria are to be indicated by Company Project Manager / Company Engineer to the vendor based on service environment and shall be specified in the PO. The acceptance criteria for sour and non-sour applications were defined.	

Section 7.0	Revision	Added clarity on the requirements of any repairs made to the bends
Section 13.0	Revision	Added clarity on visual inspection
Section 18.0(6)	Addition	Added "Welding procedures and acceptance criteria for pressure-containing parts shall be in accordance with the requirements of API 1104 and/or ASME BPVC Section IX, when necessary and shall be reviewed and approved by Company Welding Department"
Section 18.0(7)	Revision	Added clarity to what resting the vendor shall supply- "Details of the Vendor's wet magnetic particle inspection, dye penetrant inspection, and ultrasonic inspection procedure."
Various Locations	Revision/ Additions/ Deletions	Clarified who at the "Company" is responsible. Minor corrections and updates throughout document for clarity.