Specification for Pipe Bends
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1.0 SCOPE

This specification sets out requirements for prefabricated pipe bends for use on the PLEM and riser assemblies. It covers manufacturing, inspection, reporting, documentation and shipping.

2.0 DEFINITIONS

COMPANY:

MANUFACTURER: The company that contracts to provide services to this specification.

CONTRACT: The entire written procurement agreement between MANUFACTURER and COMPANY.

NONCONFORMITY: An instance of failure to meet contractual requirements, including physical, procedural or performance deficiencies.

STANDARDS: Industry codes, standards, and recommended practices referenced herein.

WORKS: The location(s) at which manufacturing, inspection and testing are performed.

2.1 Contractor Representative

MANUFACTURER shall designate in writing to Company an authorized representative to serve as liaison with COMPANY on matters associated with this Specification and on the CONTRACT or CONTRACT referencing this Specification. This representative shall be designated prior to the performance of services associated with this Specification and the CONTRACT referencing this Specification.

2.2 Document Precedence

In the event of conflict between documents, the priority shall be as follows:

a) CONTRACT
b) This Specification
c) Referenced Standards

However, conflicts shall be reviewed and resolved with COMPANY’s Representative prior to initiation or continuation of the services to be performed in association with the CONTRACT.

3.0 REFERENCE DOCUMENTS

The latest versions of the following codes, standards and guidelines are incorporated by reference, as applicable in the context of this specification.

a) American Petroleum Institute
   API SPEC 5L Specification for Line Pipe (40th edition)

b) American Society of Mechanical Engineers
   ASME BPV Code Section V Non-Destructive Examination

c) American National Standards Institute
   ANSI B31.4 Liquid Transportation Systems for Hydrocarbons, Liquid
Petroleum Gas, Anhydrous Ammonia, and Alcohols
ANSI B31.3 Chemical Plant and Petroleum Refinery Piping
ANSI B31.8 Gas Transmission and Distribution Piping Systems
d) American Society of Testing and Materials
ASTM E 18-89a Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
e) International Pipe Association
IPA-VIBS-86 Voluntary Standards for Induction Bending of Pipe (See Appendix C)
f) COMPANY Specifications
Specification for Seamless Line Pipe Specification for DSAW Line Pipe Specification for Pipe Handling and Storage

4.0 MANUFACTURER’S RESPONSIBILITIES

4.1 General
MANUFACTURER shall provide all labor, supervision, materials, tools and equipment, and shall undertake all manufacturing, inspection, testing, marking, reporting, storage and shipping necessary to do the work required in this specification and the CONTRACT. If MANUFACTURER believes that this specification conflicts with other terms of the CONTRACT, MANUFACTURER shall inform COMPANY and resolve the conflict by the terms of the CONTRACT. In case of conflict between this specification and referenced specifications, the more stringent shall apply.

4.2 Subcontractors
MANUFACTURER shall be responsible for the actions and performance of MANUFACTURER’s subcontractors, including those hired for handling and transportation.

4.3 Reporting and Approvals
4.3.1 Deviations and Disclaimers
Work done under this specification shall conform to all requirements herein, without deviations or disclaimers. If COMPANY approves changes, they will be incorporated into a revised specification, and this specification will be void.

4.3.2 Manufacturer Work Plan
Before work begins, MANUFACTURER shall submit and receive approval for a plan for carrying out the work required by this specification and the CONTRACT. The work plan shall include:
a) Production schedules;
b) Procedures for fabricating the pipe bend, including bending method, temperature, temperature measurement methods, bending speed, details of the cooling operation and heat treatment;
c) Production and factory acceptance test and inspection procedures with the projected dates they will be done;
d) Procedures for identifying, documenting, and segregating or disposing of nonconforming materials;
e) Procedures for transportation and storage.

4.3.3 Disposition of Nonconforming Materials
MANUFACTURER must submit a summary report of all nonconformities and their disposition. Dispositions of nonconforming...
materials should be categorized as "scrap," "rework," or "use as is". The report also should include a full description. If a nonconformity cannot be eliminated by replacement or by a procedure set out herein, then immediately upon its occurrence or discovery, MANUFACTURER shall inform COMPANY and propose a disposition. Dispositions must be approved in writing by a COMPANY representative whose authority MANUFACTURER has established by the terms of the CONTRACT. COMPANY may reject bends that do not conform to these specifications and the cost of pipe lost to such rejections shall be charged to the MANUFACTURER. MANUFACTURER shall not let repairs or replacements delay the delivery schedule or increase costs to COMPANY.

4.3.4 Certification
MANUFACTURER shall furnish one original and seven copies of a certificate of conformity for each lot of pipe bends. The certificates shall include the following:

a) MANUFACTURER’s name;
b) A unique reference to the pipe material certificate (furnished by COMPANY);
c) A description of the heat treatment;
d) Evidence of satisfactory performance test results, as specifically required elsewhere in this specification.

4.4 Records
MANUFACTURER shall keep up-to-date records adequate to confirm that the work, including all required tests, inspections and reviews, has been carried out to this specification. These records shall be indexed and legibly recorded in enough detail that they can be accessed and understood by a qualified, independent third party. In absence of other instructions, MANUFACTURER shall keep these records available to COMPANY for inspection or photocopying for five years after the work is complete. The records should include:

a) A description of each test or inspection and its results, with a reference to the paragraph number of the requirement in this specification or MANUFACTURER’s work plan;
b) The date of the test or inspection;
c) The name and qualifications or authority of the inspector or reviewer and his employer;
d) Evidence of calibrations;
e) MANUFACTURER shall record pertinent information about nonconformities or test failures, including:
   - Material or condition that caused rejection,
   - Method of detection,
   - Number of items involved, if more than one,
   - Proposed and actual disposition,
   - Preventive action taken.

4.5 Interactions between Manufacturer and Company
MANUFACTURER shall give COMPANY free access to his facilities and processes where work is being done under this specification for monitoring, surveillance and inspection, including but not limited to:

a) Review of adequacy of facilities and equipment;
b) Review of personnel qualifications;
Performing or witnessing inspections tests and analyses COMPANY deems necessary to confirm compliance with requirements.
MANUFACTURER shall give COMPANY notice of the production start up and all tests and inspections required herein. The number of days notice shall be according to the requirements of the CONTRACT. MANUFACTURER shall provide all reasonable facilities to COMPANY for the above purposes while the work is being done. Such facilities shall include office equipment, telecommunications equipment and office work space.

5.0 GENERAL SPECIFICATIONS

5.1 General
Pipe bends shall conform to this specification, COMPANY drawings provided, and the applicable requirements of ANSI B31.4 and ANSI B31.3 and ANSI B31.8.

5.2 Mechanical Properties
The mechanical properties of the finished pipe bend shall be the same as the COMPANY-supplied seamless and DSAW line pipes which meet API 5L and the following:
- Seamless: Grade X-60 and SP-002
- DSAW: Grade X-65 and SP-011

5.3 Surface of the Finished Bends
The finished pipe bend shall be free of significant surface damage, including cracks, dents, gouges, wrinkles, waves, or bulges. Discontinuities less than 1/16th of an inch between their highest and lowest points may be corrected by grinding, provided that the wall thickness is not reduced below the specified minimum.

5.4 Dimensions and Tolerances
5.4.1 Bend Radius
The bend radius shall be within one percent of the values specified in COMPANY drawings provided.

5.4.2 Bend Angle
The bend angle shall be within ±0.5 degree of the values specified in COMPANY drawings provided.

5.4.3 Outside Diameter
The difference between the maximum and minimum outside diameter shall not exceed 3 percent of the nominal outside diameter of the pipe.

5.4.4 Wall Thickness
The minimum wall thickness shall not be less than the following:
- 24 inch diameter: 0.750 inch
- 18 inch diameter: 1.0 inch
- 16 inch diameter: 0.812 inch
- 14 inch diameter: 0.688 inch
- 12.75 inch diameter: 0.562 inch
Pipe joints with the largest wall thicknesses shall be selected for the pipe bends.

5.4.5 Bend Plane
Bends shall be flat within .005 inches per degree of bend angle.

5.4.6 Pipe Ends
Ends of pipe bends shall be beveled to thirty degrees with a 1/16 inch face. Ends shall be square with the axis of the pipe within two percent of the specified diameter, where the squareness measurement is taken as the maximum difference in the distances along the axis of the pipe end from any two points on the pipe end to a plane normal to the axis of the pipe end.

5.4.7 Linear Dimensions
All linear dimensions shall be within 1/8 of an inch of the specified dimensions.

5.5 Coating
The pipe shall be clean and free of oil when the varnish or COMPANY approved equivalent is applied. Outside surfaces of the bends shall be coated with mill varnish
5.6 Marking
The following information shall be white paint stenciled on the finished pipe bend:

a) Boomvang/Nansen Export Pipeline;

b) Nominal outside diameter and wall thickness of the pipe bend;

c) Material grade and heat number;

d) Radius and included angle of the bend;

e) The "mark number" shown on the drawing.

6.0 MANUFACTURING AND IN-PROCESS TESTING

6.1 General
Pipes shall be bent in a single continuous motion after they have been heated. The bending procedure and temperature shall be according to the following paragraphs and MANUFACTURER's work plan as described in Section 4.3.2.

6.2 Heating Methods
Acceptable methods of pipe heating include enclosed furnace, electric induction and electric resistance.

6.3 Bending Methods

6.3.1 Thick Side Out
Before bending, MANUFACTURER shall use an ultrasonic device to measure the wall thickness of the pipe at four points ninety degrees apart, around its circumference at approximately half way along the length of the section to be bent. MANUFACTURER shall mark the measurements on the pipe, at the points where they were taken, and use them to install the pipe in the bending machine so that the thickest quadrant is on the outside of the bend.

6.3.2 Hot Bending
Hot bending shall include the following steps:

a) Pack the pipe with dry low silica sand. Packing shall be done mechanically or by hand tamping. Hammers shall not be used.

b) Heat the pipe to the temperature given in MANUFACTURER's work plan, between 1550 and 1750°F.

c) Bend the pipe in a continuous motion at the specified temperature.

d) Cool to 600°F before further handling. Water shall not be used to cool the pipe.

6.3.3 Induction Bending
Induction bending shall include the following steps:

a) Clamp one end of the pipe in a pivoted bending arm.

b) Use an induction ring to heat a narrow band of the pipe to the temperature specified in MANUFACTURER's work plan.

c) Push the unclamped end of the pipe in a continuous motion not to exceed three inches per minute while the pipe is at a specified temperature, not to exceed 1900°F.

d) Before further handling, lower the temperature to 600°F using the method described in MANUFACTURER's approved work plan. If water quenching is used it shall be continuous and in full contact with the pipe surface in the area extending to a distance three times the pipe wall thickness from each end of the induction ring.

6.3.4 Heat Treating
After forming, pipe bends may require heat treatment necessary to restore the
mechanical properties of the pipe to the requirements of API 5L X-52, X-60 or X-65 as the case maybe. The heat treatment procedures shall be according to MANUFACTURER's approved work plan of Section 4.3.2.

6.4 Handling, Storage and Shipping
MANUFACTURER shall handle and transport pipe and finished pipe bends with due care according to COMPANY Specification SP 016 and to MANUFACTURER's approved work plan of Section 4.3.2. MANUFACTURER shall furnish and install pipe bevel protectors or end caps.

6.5 In-Process Testing

6.5.1 Magnetic Particle Inspection
MANUFACTURER shall remove surface scale from each pipe bend, and then carry out magnetic particle examinations of the entire external surface. The inspection shall be done according to ASME Section V, Article 7.

6.5.2 Ultrasonic Examination
MANUFACTURER shall carry out an ultrasonic examination over a two inch wide band around each end of each bend. Pipe bends shall be rejected if these examinations indicate points where lamination exceeds the limits specified in API SPEC 5L. MANUFACTURER shall also measure the pipe wall thickness on the outer circumference of the bend to be sure that it exceeds the minimum specified in Paragraph 5.4.4.

6.5.3 Inside Diameter Measurement
MANUFACTURER shall test each bend in the presence of a COMPANY representative with a gauging pig consisting of two aluminum plates, with a diameter of 95% of the specified interval line pipe diameter 1/8-inch thick rigidly separated by a distance of 5 inches. MANUFACTURER shall submit a sketch/drawing of the gauging pig for COMPANY approval.

6.5.4 Hardness Tests
MANUFACTURER shall carry out hardness tests at four points, 90 degrees apart around the circumference of the pipe, beginning on the outer radius of the bend. This shall be done on circumferences at each end of the bent section (where it becomes straight) and at a third circumference half way between the first two. The hardness tests shall be done according to ASTM E 18-89a and shall show the pipe hardness to be less than Rockwell C-22.

7.0 QUALIFICATION TESTING

7.1 General
Before production of the bends begin, one bend shall be fabricated and heat treated according to MANUFACTURER's work plan and tested as described in this Section to demonstrate that the procedures achieve the required result. The testing matrix from Table 2-1 Category I in IPA-VIBS-86 shall be used to qualify bends.

7.2 NonDestructive Examinations
MANUFACTURER shall measure the test bend to confirm that it meets all dimensional requirements, and shall successfully perform the production tests of Section 6.5.

7.3 Mechanical Properties

7.3.1 Tensile Tests
MANUFACTURER shall carry out tensile tests on longitudinal test specimens taken from the inner and outer radii of each test bend. If the bend is heat treated a pair of tests shall also done on longitudinal specimens from the inner and outer radii. Tests shall be done according to the
applicable methods and acceptance criteria of API 5L for the Grade of line pipe.

7.3.2 Charpy Impact Tests

MANUFACTURER shall carry out Charpy V-Notch tests according to the requirements of Appendix A for inside and outside radius.
APPENDIX A

MANUFACTURER'S DATA REQUIREMENTS LIST (MDRL)
APPENDIX A
MANUFACTURES DATA REQUIREMENTS LIST (MDRL)

CLIENT: ___________________________ P.O./S.C. NO.: _______________________
LOCATION: ___________________ SELLER/SUBCONTRACTOR: _______________________

EQUIPMENT TAG NO.(S): _______________________________________________________

DESCRIPTION(S): PIPE BENDS ________________________________________________

The seller's/subcontractor's quotation shall state his intended compliance with this listing, as regards to the type of data required and schedule for data submittal, as well as the quantity and data form (reproducible, prints, etc.) indicated in the inquiry and purchase order/subcontract standard clauses. The seller/subcontractor shall confirm responsibility for similar compliance by his subvendors and/or subcontractors.

As a part of the seller's/subcontractor's quotation, any deviation(s) from the data submittal schedule shall be shown in the comments column.

All data submitted shall be identified with equipment tag number, equipment description, buyer's job number, and purchase order/subcontract number.

AFTER ORDER IS PLACED, UNLESS OTHERWISE NOTED IN THE COMMENTS COLUMN, the following data submittal schedule shall apply:

FOR APPROVAL DATA DUE 3 WEEKS AFTER PURCHASE ORDER/SUBCONTRACT IS PLACED,
CERTIFIED CORRECT DATA DUE 4 WEEKS AFTER BUYER'S APPROVAL, RECORD DATA DUE 8 WEEKS AFTER PURCHASE ORDER/SUBCONTRACT IS PLACED.

ABBREVIATIONS:
Q = With Quotation, A = Approval, C = Certified,
R = Record, P = Prints, RP = Reproducible,
M = Microfilm, S = Shotdown
APPENDIX A
MANUFACTURES DATA REQUIREMENTS LIST (VDRL)

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APPENDIX B

INSPECTION MATRIX
APPENDIX B
INSPECTION MATRIX

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<td>OTHER SECTIONS/PARAGRAPHS LISTED BELOW ARE REFERENCES TO INFORMATION WITH THIS SPECIFICATION</td>
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<td>B = One or More In-Process Insp., Witness Tests, Final Inspection, Doc. Review</td>
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<td>C = Witness Tests, Final Insp., Doc. Review</td>
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<td>D = No Inspection, Review Vendor Submitted Documentation (if applicable)</td>
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<td>2 = Review of Documentation</td>
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<tr>
<td>3 = Obtain Certification/Test Documents</td>
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### APPENDIX B
### INSPECTION MATRIX

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**LEGEND:** X = Required, O = Observe, V = Verify, W = Witness (Hold Point)
APPENDIX C

FRACTURE TOUGHNESS TESTS
CHARPY V-NOTCH IMPACT TESTS
APPENDIX C
FRACTURE TOUGHNESS TESTS
CHARPY V-NOTCH IMPACT TESTS

A.1 Charpy V-Notch test samples shall be taken from one length of pipe from one completely finished bend. Three specimens shall be machined and tested in accordance with API 5L Supplementary Requirement SR5 and ASTM A 370.

A.2 One set of three specimens shall be taken from the pipe body and oriented so that the longitudinal (major) axis of the specimen is parallel to the longitudinal axis of the pipe. Test temperature shall be 32°F, and the minimum energy requirement shall be 35 ft-lbs average for three specimens, with a 30 ft-lbs minimum for any single specimen with an average 80% shear and 60% for any single heat.

The energy values herein are for full size (10 mm x 10 mm) specimens. If the wall thickness does not permit the use of full size specimens, 10 mm x 7.5 mm, 10 mm x 6.7 mm, or 10 mm x 5.0 mm specimens may be used and the minimum energy values shall be 83%, 75% or 67% of those tabulated respectively. Percentage shear area values shall be in accordance with API 5L SR5 for all specimen sizes. The largest sub-size specimen which can be obtained from the pipe shall be used for testing.

A.3 COMPANY’s Inspector is authorized to permit a retest if there is a reason to believe that the failure of a specimen is due to some fault in its preparation or testing, and that it is has not provided a true indication of the toughness of the material.

A.4 If any sample fails to pass the test, that length of pipe shall be rejected and two further samples (two sets of specimens from each bend), shall be taken from two other finished bends and tested. If both further tests pass, then bend production shall be allowed to commence. If one, or both, of the further tests fail, then modifications to the pipe bending procedure shall be implemented to produce acceptable bends.
APPENDIX D

MANUFACTURER’S QA/QC PLAN REQUIREMENTS
APPENDIX D
MANUFACTURER’S QA/QC PLAN REQUIREMENTS

B.1 Before work begins, MANUFACTURER shall submit to COMPANY and receive written approval for, a Quality plan and QA/QC procedures for carrying out the work according to this specification and the purchase order, including but not limited to the following:

a) Organization description;

b) Quality control and inspection procedures, including procedures for identifying, documenting, and segregating or disposing of non-conforming materials;

c) Description of personnel qualification for performing the verification activities;

d) A description of the format and information to be included on the required reports, described in this specification;

Method of checking pipe dimensions
APPENDIX E

IPA-VIBS-86

VOLUNTARY STANDARDS FOR INDUCTION BENDING OF PIPE