



# Materials System Specification

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01-SAMSS-039

13 December 2011

Induction Pipe Bends

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Document Responsibility: Materials and Corrosion Control Standards Committee

## Saudi Aramco DeskTop Standards

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## I Scope

- A. This specification covers shop fabricated pipe induction bends for pipelines under ASME B31.4 and ASME B31.8. These bends will be fabricated in accordance with ASME 16.49, as modified herein. Section VI gives requirements for process piping bends for ASME B31.3 applications.
- B. This specification covers pipe bends S-shapes and 3-dimensional pipe bends with a radius equal to or greater than 3 times the pipe diameter (3D),.
- C. Excluded from this specification are:
  - 1. Cold bends used in cross-country pipeline construction which are fabricated at the field or the yards.
  - 2. Standard elbows and process piping bends, 3D and lower, which are manufactured in accordance with ASME B16.9.

## II Conflicts and Deviations

- A. Any conflicts between this specification and other applicable Saudi Aramco Materials System Specifications (SAMSSs), Engineering Standards (SAESs), or industry standards, codes, and forms shall be resolved in writing by the Company or Purchaser Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- B. Direct all requests to deviate from this specification in writing to the Company or Purchaser Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

## III References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

- A. Saudi Aramco References

Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a  
Mandatory Saudi Aramco Engineering  
Requirement*

Saudi Aramco Engineering Standards

<a href="#"><u>SAES-L-101</u></a>	<i>Regulated Vendors List for Pipes and Fittings</i>
<a href="#"><u>SAES-L-136</u></a>	<i>Restrictions on the Use of Line Pipe</i>

Saudi Aramco Materials System Specifications

<a href="#"><u>01-SAMSS-035</u></a>	<i>API Line Pipe</i>
<a href="#"><u>01-SAMSS-038</u></a>	<i>Small Quantity Purchase of Pipe from Stockist</i>
<a href="#"><u>01-SAMSS-333</u></a>	<i>High Frequency Welded Line Pipe</i>
<a href="#"><u>01-SAMSS-043</u></a>	<i>Carbon Steel Pipes for On-Plot Piping</i>

Saudi Aramco Inspection Requirements

Form <a href="#"><u>175-013200</u></a>	<i>Induction Pipe Bends</i>
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B. Industry Codes and Standards

American Petroleum Institute

<a href="#"><u>API SPEC 5L/ISO 3183</u></a>	<i>Specification for Line Pipe</i>
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International Standardization Organization

<a href="#"><u>ISO 9000</u></a> - 9004	<i>Quality Management and Quality Assurance Standards</i>
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American Society of Mechanical Engineers

<i>ASME B16.9</i>	<i>Factory-Made Wrought Butt welding Fittings</i>
<i>ASME B16.49</i>	<i>Factory-Made Wrought Steel Butt welding Induction Bends for Transportation and Distribution Systems</i>
<i>ASME B31.4</i>	<i>Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids</i>
<i>ASME B31.8</i>	<i>Gas Transmission and Distribution Piping Systems</i>
<i>ASME B31.3</i>	<i>Process Piping</i>

American Society of Testing and Materials

<i>ASTM A671</i>	<i>Electric-Fusion – Welded Steel Pipe for Atmospheric and Lower Temperatures</i>
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National Association of Corrosion Engineers / International Standardization Organization

[NACE MR0175/ISO 15156](#) *Petroleum and Natural Gas Industries-  
Materials for use in H<sub>2</sub>S-Containing  
Environments in Oil and Gas Production*

## IV Modifications to ASME B16.49

The following paragraph numbers refer to [ASME B16.49](#), which is the basis of this specification. The text in each paragraph below is an **addition, commentary or modification** to [ASME B16.49](#), as noted. Paragraph numbers not appearing in [ASME B16.49](#) are new paragraphs to be inserted in numerical order.

### 1.2 Manufacturing Process

Seamless pipe shall have the thickest part of the wall oriented to the outside of the bend.

### 1.11 Ordering Information

(Addition) The following must be included in the Purchase Order when applicable:

1. If the bends are intended for sour service.
  2. Bends shall be supplied with a straight tangent of not less than one and one-half nominal pipe diameter (1.5D) or two feet, whichever is less at each end unless otherwise specified in the purchase order.
  3. Detailed drawing for more complicated geometries such as an S-shape pipe bend.
  4. Minimum I.D. dimension, if required to permit passage of instrumented scraper or maintenance scraper.
  5. Pipe type (seamless, HFW (Class B or Class C) or DSAW straight seam)
  6. The applicable design code (ASME B31.4, B31.8 or other).
  7. Starting pipe material to be supplied by the Buyer or the manufacturer (see Section 5.1).
  8. Materials to be supplied by the manufacturer.
  9. Inspection requirements - Form [175-013200](#) plus any additional requirements.
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10. Non-material Requirements (NMR) form for fabricated pipe bend(s) if applicable.
11. Internal or external coating requirements.
12. The minimum design wall thickness and the grade of material must be specified in the Request for Quotation.
13. If bends are required to be suitable for segmentation it shall be specified along with ASME B16.49 SR15.3.

*(Commentary)*

*The purchaser must contact the benders to get technical requirements for the mother pipe to be used for bending prior to placing the pipe order.*

## **2.2 DESIGN OF BENDS**

(Addition) The manufacturer shall prepare detailed shop fabrication drawings based on the Purchase Order. The shop drawings shall be submitted to the Buyer for approval prior to fabrication when so specified in the Purchase Order.

Approval of Manufacturer's drawings by the Buyer does not relieve the Manufacturer of the responsibility for compliance with the code, this specification and the Purchase Order requirements.

## **4 MARKING**

### **4.1 Standard Marking**

(Addition) Pipe bends shall be marked by paint stenciling with information required in this section. In addition the following shall be marked:

- i) Points of tangency shall be indicated on both ends
- ii) Material grade per API SPEC 5L or ASTM
- iii) Sour service or non-sour service
- iv) Purchase order number and line item
- v) 01-SAMSS-039
- vi) Saudi Aramco

If the pipe is intended for external coating the marking will be on the inside.

## 5 MATERIAL

### 5.1 Starting Materials

(Modification) Unless otherwise specified in the Purchase Order, the allowable starting pipe materials are:

- Seamless or single straight seam submerged arc welded pipe, conforming to [01-SAMSS-035](#) or [01-SAMSS-038](#).
- HFW pipe meeting the requirements of [01-SAMSS-333](#) Class B or Class C, as appropriate, where the matching piping system is made of HFW line pipe. Prior to placing the order, approval shall be obtained from the Chairman of Materials & Corrosion Control Standards Committee.
- For sour service the starting pipe materials shall be procured as ‘Suitable for Sour Service’ in accordance to [01-SAMSS-035](#), [01-SAMSS-038](#) or [01-SAMSS-333](#). In-Process inspection per the applicable [175-013200](#) form is required for pipes procured in accordance with [01-SAMSS-035](#), [01-SAMSS-333](#) or [01-SAMSS-043](#).

(Commentary) HIC testing is required on all welded pipes (starting pipe materials) procured in accordance to [01-SAMSS-035](#), [01-SAMSS-038](#), [01-SAMSS-333](#) or [01-SAMSS-043](#) for sour service.

HIC testing is required on all seamless pipes (starting pipe materials) procured in accordance to [01-SAMSS-038](#) for sour service. The bender may conduct HIC testing at an approved laboratory on seamless pipe manufactured by an approved manufacturer.

HIC testing is not required on seamless pipes procured in accordance to [01-SAMSS-035](#) for sour service.

- a) Spirally welded pipes shall not be used as starting pipe materials.
  - b) Induction bend starting pipe materials need not be suitable for offshore service per API SPEC 5L even if it is intended for offshore application. (Annex J and K need not apply unless required for sour service)
  - c) Induction bend starting pipe materials need not be suitable for Class IV service per [01-SAMSS-035](#) even if the pipeline is Class IV service. (Annex G need not apply)
  - d) Pipe containing circumferential butt welds shall not be used to make bends. However, circumferential butt welds are permitted to join
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compound bends which were specified without a sufficient tangent between the two bends.

- e) The starting pipe materials may be supplied by the manufacturer or Saudi Aramco. This shall be declared in the purchase order or in the bid qualification submitted by the manufacturer. If the starting pipe materials are to be supplied by Saudi Aramco to the manufacturer then the manufacturer must present to Saudi Aramco the starting pipe materials requirements at the time of price quotation.

These requirements must include both of the following options:

1. The bend will be furnished to the stated pipe strength grade and wall thickness of the pipeline. For this case the manufacturer will indicate any special chemical, mechanical or thickness requirements for the starting pipe material and weld.
2. The bend will be furnished to a lower strength grade with a higher wall thickness. In this case, the manufacturer must state the starting pipe material grade, wall thickness and any special chemical or mechanical properties. The manufacturer must also give the targeted minimum strength grade and thickness of the finished bend. In this case, the bend must have a matching ID with that of the pipeline. (See ASME B16.49 Section 8.1).

(Commentary) The plates used in LSAW pipe obtain their properties by a combination of controlled rolling and cooling in the plate mill.

These properties are lost during the heating of the induction bending process and stress relief heat treatment. It may not be possible to achieve the desired mechanical and sour service properties if the selection of the starting pipe materials is not correct. Materials with chemistry deviating from the material specifications may be proposed for non-sour applications with CSD approval. It is also acceptable to use lower strength bends of corresponding higher wall thickness (see ASME B16.49 Section 8.1 and Section 5 f) of this specification).

- 5.3 (Addition) The starting pipe materials shall be traceable to mill certificates. Used or reclaimed pipes or of unknown specification are not acceptable.
- 5.4 (Addition) All starting pipe material shall be procured from a manufacturer approved by Saudi Aramco.

## **8 Material Properties**

### **Table 3**

(Commentary) Materials of similar chemistry have been added to the essential variables in Table 3 in accordance with SR15.8.2 to minimize the amount of testing required. A new qualification bend shall be made and tested for each change in the essential variables listed in Table 3.

(Addition) The type of pipe is an essential variable (i.e., LSAW, Seamless, or ERW).

The pipe mill that produced the pipe is an essential variable.

The steel mill that produced the starting billet or slab is an essential variable

The Product analysis for C-Mn steels outside the range of  $\pm 0.02\%$  carbon value,  $\pm 0.02\%$  carbon equivalent value and  $\pm 0.03\%$  in PCM value shall be an essential variable. The formula for PCM is as given in API SPEC 5L.

The final heat treatment of the starting pipe (or plate used to make the pipe) is an essential variable (i.e., normalized, Quench and tempered, or TMCP).

The maximum heating and cooling rates above  $425^{\circ}\text{C}$  for heat treatment shall not exceed those of the qualification bend.

A change in the welding procedure, consumable classification or manufacturer of consumable of welded pipe is an essential variable.

### **8.2 Fracture Toughness Properties**

(Addition) For DSAW pipe Charpy impact testing must be conducted on the weld centerline and fusion line. The required temperature shall be  $0^{\circ}\text{C}$  and the acceptance values shall be as shown for the weld metal in ASME B16.49.

For HFW Pipe the Charpy impact testing must be conducted on the weld fusion line. Full size specimens (10 mm x 10 mm) shall be used whenever possible and the pipe sample may be flattened before machining to obtain as close as possible to a full size specimen. Subsize specimens shall only be allowed when the pipe wall thickness is insufficient to provide full size specimens. In these cases, the largest possible subsize specimens, obtainable by flattening or use of tapered ends, shall be used. The axis of the notch shall be within  $\pm 0.25$  mm from the weld line. Each test piece shall be etched prior to notching in order to ensure proper placement of the notch.



The required temperature shall be 0°C and the acceptance values shall be as shown for the weld metal in ASME B16.49.

**8.3 Hardness Testing (Correction) Section 8.3 line 9 should reference Table 1 instead of Table 3.**

**(Addition) No hardness reading will exceed 237 BHN**

**8.3.1 Hardness Testing for Qualification**

(Addition) For sour service bends, in addition to the hardness testing required in this section, hardness tests shall be conducted per API SPEC 5L / ISO 3183 Section H.7.3.3. One set of hardness tests shall be conducted on both the intrados and extrados. In the case of welded pipe, one set of hardness tests shall be conducted on the weld from the bent portion of the bend. Only Vickers hardness testers shall be used. The maximum hardness measured shall not exceed 250 HV using 5 or 10 kg load. Dimension “b” in Figure H.1 b) shall be 0.2 mm maximum from the fusion line on the HAZ instead of 0.75 mm. The indentation on the weld metal shall be separated from the indentation on the HAZ by at least 0.75 mm.

**9 Heat Treatment**

**Table 3**

(Clarification) The Heat treatment soaking time Essential Variable will be -0 +15 Minutes.

**10 Qualification Bend**

**10.2 Records**

(Addition) The limits on ranges of the essential variables in a Procedure may not be expanded by individual testing. Each Procedure may only reference and use the parameters from one qualification test.

(Addition) The bend qualification shall include the following:

- i) The General Bending procedure reference
  - ii) The bending equipment being used
  - iii) The mill test certificate for the starting material pipe
  - iv) A summary sheet that shows all of the essential variables, the actual values used for the qualification, the tolerances for the variable and the resulting ranges to be used in production.
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v) All mechanical testing, non-destructive testing and inspection results.

(Addition) Multiple bends may be made at the time of qualification provided that all of the essential variables are within the required ranges. The qualification testing will determine the acceptance of all bends made with the procedure being qualified.

## **11 TEST REQUIREMENTS**

(Addition) Hydrotesting is not required unless it is specified in the purchase order.

## **12 DIMENSIONAL REQUIREMENTS**

### **12.1 Ovality**

(Addition) Ovality may be corrected by local cold deformation provided that the induced permanent strain does not exceed 1,5 %. The correction must be in accordance with a written procedure and must be performed prior to the stress relief heat treatment.

### **12.4.2 (Clarification)**

If no minimum internal diameter is specified in the purchase order then the gauging scraper will be 97% of the minimum permitted ID for the mating pipe and the length shall be at least one-half of the diameter. This will take into consideration the minimum average diameter, maximum wall thickness and maximum out of roundness.

(Addition) When a minimum I.D. dimension is specified by the Purchase Order, the bend shall be checked by the Manufacturer by passing a gauging scraper through the finished spool. The diameter of the gauging scraper shall be equal to the specified minimum I.D. dimension and the length shall be at least one-half of the diameter.

## **13 INSPECTION OF PRODUCTION BENDS**

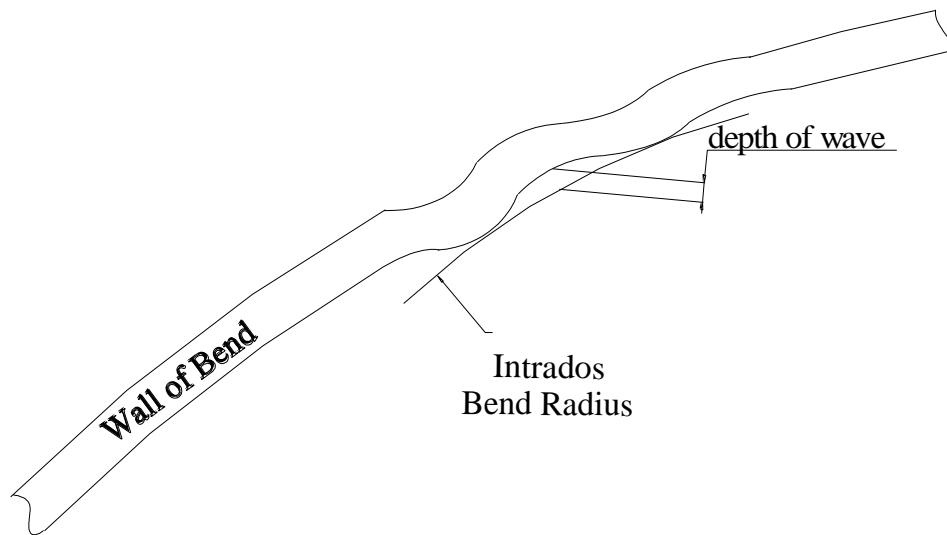
### **13.1 Workmanship and Finish**

(Modification) Weld repairs are not permitted on bends.

(Addition) Welding is permitted to attach a push tangent (a straight pipe segment attached temporarily to push the pipe through the entire bending arc if the specified tangent is not long enough). In such case, at least 6.5 mm of the welded end shall be subsequently machined off.

(Addition) Bends shall be free of indentations caused by the grips of the bending machine.

(Addition) Bends shall be smooth and conform to the contour of the bend. Waving, as shown in Figure 1, is acceptable provided that the wave shape blends into the pipe surface in a gradual manner with a maximum depth, of 1% of the actual outside diameter.



**Figure 1 – Measurement of Wave Depth on Intrados of Bend**

(Addition) Bends shall be free of any flat spots exceeding the value given by the following formula:

$$d = \sqrt{(2tD)} \quad (1)$$

where:

d: largest dimension of the flat spot

t: nominal wall thickness

D: nominal pipe diameter

(Addition) Bends that are suitable for coating inside or out.

For bends that are intended to be subsequently coated (See [Section I](#)), the surfaces to be coated shall be essentially free of scabs, slivers, cold laps, burrs or other surface defects that would impair the coating.

**(Clarification) The upset in the tangent area described in 13.1 shall not exceed 1 % of the nominal OD from the theoretical profile.**

### **13.3 Outside Inspection**

(Addition) All inspection and testing shall be performed as per Saudi Aramco Inspection Requirements Form [175-013100](#).

The Vendor shall give two week advance notice in writing to the Buyer regarding the dates that fabrication qualification will start and tests will be made.

All materials, certificates, fabrication, testing and examinations shall be subject to verification by Buyer's Inspector in accordance with the applicable ASME Code specified in the purchase order for full compliance with this Specification and the Purchase Order drawings.

Inspection shall be carried out at the place of manufacture. All NDT tests shall be conducted in accordance with ASME SEC V.

## **14 CERTIFICATION**

(Addition) The bend certification documentation shall clearly indicate the identification of the bends represented by each qualification test.

### **SR15 Supplementary Requirements**

#### SR 15.5

If sour service (liquid or gas service) is indicated in the purchase order then Supplementary Requirement SR 15.5 shall apply. Only hardness testing per ANSI/NACE MR0175/ISO 15156 is required. No SSC testing is required unless specifically addressed in the purchase order.

#### SR15.6

The weld seam of the qualification bend shall be RT or UT examined.  
The acceptance criteria shall be in accordance with the starting pipe material.

## **V Preparation for Shipment**

All loose foreign material shall be removed from the inside and outside of the bend.  
The bend shall be clean and dry.

Unless otherwise specified in the Purchase Order the pipe bend shall not be painted or coated.

Welding ends shall be protected against damage during handling and shipment by means of a securely fastened bevel protector.

## **VI Bends for Process Piping Application**

Induction bends for process piping applications will meet the design requirements of ASME B31.3. These bends shall be fabricated in accordance with ASTM 234 or other fitting manufacturing standard

The starting pipe material for process piping applications will be in [01-SAMSS-043](#). In-Process inspection per the applicable 175 form is required for pipes procured in accordance with [01-SAMSS-043](#).

### **Revision Summary**

13 December 2011      Major revision after value engineering session.