TECHNICAL SPECIFICATION

LINEPIPE INDUCTION BENDS (AMENDMENTS/SUPPLEMENTS TO DEP 31.40.20.30-Gen. AND DEP 31.40.20.31-Gen.)

DEP 31.40.20.33-Gen.

October 1995

DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by SIOP, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.

3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, SIOP, SIEP and SIC disclaim any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof. The benefit of this disclaimer shall inure in all respects to SIOP, SIEP, SIC and/or any company affiliated to these companies that may issue DEPs or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of SIOP and SIEP, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of SIOP and SIEP. The copyright of DEPs vests in SIOP and SIEP. Users shall arrange for DEPs to be held in safe custody and SIOP or SIEP may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

TABLE OF CONTENTS

PART I INTRODUCTION

1.1 SCOPE

This new DEP gives minimum requirements for the purchase of induction bends for pipeline applications in oil and gas operations under both sour and non-sour service applications. Bends manufactured by other methods shall be supplied in accordance with DEP 31.40.21.30-Gen.

Part II of this DEP is written as amendments/supplements to DEP 31.40.20.30-Gen. and DEP 31.40.20.31-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is primarily intended to be used for oil and/or gas transmission pipelines and related facilities. It is intended for use by Exploration and Production, Manufacturing, Chemicals and Supply/Marketing companies which require pipeline bends.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Bevel - the total weld preparation machined on the end of a bend.

Defect (in NDT) - a discontinuity or group of discontinuities whose indication(s) do not meet specified acceptance criteria.

Flaw/discontinuity (in NDT) - an interruption, in the physical structure or configuration of a pipe.

Indication (in NDT) - evidence of a discontinuity that requires interpretation to determine its significance.

Linepipe DEP - term used to describe either DEP 31.40.20.30-Gen. or

DEP 31.40.20.31-Gen., whichever is appropriate.

Minimum operating temperature - the minimum temperature to which the pipeline or section of pipeline may be exposed during normal operational activities, including start-up and shut-down operations and controlled blowdown, but excluding abnormal situations such as pipeline ruptures.

Purchaser - term used in API Spec 5L which has the same meaning as Principal.

1.4 ABBREVIATIONS

DN	-	diameter nominal
HAZ	-	heat affected zone
HIC	-	hydrogen induced cracking
ID	-	internal diameter
MT	-	magnetic particle testing
NDT	-	non-destructive testing
OD	-	outside diameter
UT	-	ultrasonic testing

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (Part VI).

1.6 GUIDANCE FOR USE

The amendments to DEP 31.40.20.30-Gen. and DEP 31.40.20.31-Gen. given in Part II are directly related to equivalent sections in those DEPs (and to API Spec 5L). For clarity, the section and paragraph numbering of API Spec 5L has been used as far as possible.

Where clauses in the Linepipe DEP are referenced within this DEP, it shall mean those clauses as amended by this DEP. The requirements in this DEP shall **supplement** those in the Linepipe DEP unless it is clearly stated otherwise. Clauses in the Linepipe DEP that are not amended by this DEP shall apply as written.

1.7 INFORMATION TO BE SUPPLIED BY THE PRINCIPAL

There are a number of items within this DEP which require input from the Principal. Where these are mentioned within this DEP, they are identified by an annotation (A) in the left hand margin, indicating an action required by the Principal. The information which shall be supplied by the Principal to the Manufacturer includes:

1. The requirements for testing in the simulated heat treated condition (Part II, Section 4.2)
2. Minimum design temperature (Part II, Section 4.19 and Appendix E, SR5.1)
3. Type of service, i.e. non-sour or sour (Part II, Section 4.22 and Part IV, Section 4.1)
4. Tangent length (Part II, Section 6.5)
5. Bend radius (Part II, Section 6.8)
6. Bend angle (Part II, Section 6.9).

PART II AMENDMENTS/SUPPLEMENTS TO DEP 31.40.20.30-Gen. AND DEP 31.40.20.31-Gen.

SECTION 1 SCOPE

1.1 COVERAGE

Replace first paragraph by:

This specification covers bends made from seamless and seam welded steel linepipe. It includes bends made from standard-weight plain-end, regular-weight plain-end, special plain-end, extra-strong plain-end, and double-extra-strong plain-end pipe.

SECTION 2 PROCESS OF MANUFACTURE AND MATERIAL

2.1 PROCESS OF MANUFACTURE

Add to existing section:

All bends shall be produced by induction bending.

Induction bending shall be carried out in accordance with the qualified manufacturing procedure specification. The Manufacturer shall maintain continuous records of the forming conditions for each bend.

Bends manufactured from welded pipe shall have the longitudinal weld seam positioned on the neutral axis of bending. No girth weld shall be contained in the finished bend.

Any interruption to the bending process shall result in the rejection of the bend.

Cold or hot working of the bends to meet the dimensional requirements after bending or final heat treatment shall not be performed without the prior approval of the Principal.

2.4 HEAT TREATMENT

Delete existing section and replace with the following:

When a post-forming heat treatment is applied, the heat treating process shall be performed in accordance with a documented procedure which shall be supplied at the same time as the manufacturing procedure specification (Linepipe DEP Section 12.1).

SECTION 4 MECHANICAL PROPERTIES AND TESTS

4.2 TENSILE TESTS

Delete first paragraph of existing section and replace with the following:

(A) All mechanical properties, including tensile properties, shall be determined from specimens removed from test bends which have been subjected to all mechanical and heat treatment operations. If stress relieving of field girth welds will be performed, additional testing of parent metal, and weldments on bends containing seam welds, shall be performed on stress relieved specimens taken from the tangent section. The stress relieving temperature shall be 580 °C to 600 °C. The Principal shall specify whether this condition applies.

NOTE: All mechanical test acceptance criteria specified in the Linepipe DEP must be met by the bend after all mechanical and heat treatment operations. There is no requirement for the mother pipe to meet these criteria prior to bending.

4.3 TENSILE TESTING

a. Frequency

Delete existing clause and replace with the following:

Tensile tests shall be performed on samples taken from a finished test bend. Test bends shall be produced for each nominal pipe diameter per heat of steel using the smallest bend radius to be supplied. If there is more than one wall thickness involved after using this selection criterion, testing shall be done on the greatest wall thickness. Test specimens shall be taken from the following locations as indicated in Figures 1 and 2:

(a) The outside and inside of bend
(b) The neutral axis of bend (weld seam)
(c) The transition zone (start and finish)
(d) The tangent end of bend.

4.19 FRACTURE TOUGHNESS TESTS

Delete existing section and replace with the following:

(A) For each test bend, Charpy V-notch tests shall be performed on samples taken from the locations indicated in Figures 1 and 2. Test requirements shall be as specified in (Appendix E, Section SR5).

4.21 METALLOGRAPHIC EXAMINATION

Delete existing section and replace with the following:

For each test bend, specimens for metallographic examination shall be extracted from the locations shown in Figures 1 and 2.

4.22 HARDNESS TESTING

Delete existing section and replace with the following:

Hardness testing shall be performed on each metallographic specimen using the Vickers method. For parent metal specimens, a traverse shall be made across the thickness of the pipe wall beginning 1 mm from the internal surface and finishing 1 mm from the external surface. The spacing between impressions shall be 1 mm.

For weld specimens, a series of Vickers hardness tests (HV10) shall be made using three traverses, one 2 mm from the outer edge, the second across the centre and the third 2 mm from the inner edge. Each traverse shall extend from the unaffected base metal on one side of the weld to unaffected base metal on the other side. The spacing between the hardness impressions shall be 1 mm in the base metal and 0.75 mm in the HAZ and weld metal. The hardness impressions nearest the fusion line shall be within 0.5 mm of the fusion line.

(A) The hardness of weld, heat affected zone and base material shall not exceed 248 HV10 for bends in sour service and 325 HV10 for bends in non-sour service. The Principal shall inform the Manufacturer when sour service requirements apply.

SECTION 5 HYDROSTATIC TESTS

Add to existing section:

Hydrostatic testing shall have been performed on the parent pipe prior to bending by the pipe supplier as per the Linepipe DEP.

SECTION 6 DIMENSIONS, WEIGHTS AND LENGTHS

6.2 DIAMETER

Add to existing section:

A gauging pig shall be passed freely through each bend. The gauging pig shall have two parallel 6 mm thick circular aluminium plates, each a minimum of 97% of the nominal pipe ID, separated rigidly by a bar of length twice the nominal pipe ID.

6.5 LENGTH

Delete existing section and replace with the following:

(A) Each bend shall be supplied with straight tangent ends at least 500 mm in length. If an alternative tangent length is required this shall be specified by the Principal.

Add new section:

6.8 BEND RADIUS

(A) The Principal shall specify the bend radius. The bend radius shall be within ± 1% of the specified value. The specified bend radius shall mean the radius of the arc described by the bend axis.

Add new section:

6.9 BEND ANGLE

(A) The Principal shall specify the required bend angle. The bend angle shall be within ± 1 degree of the specified value.

Add new section:

6.10 OUT OF PLANE

The out of plane measurement P as shown in Figure 4 shall be limited as follows:

$$P \leq 10 \times \left(\frac{\alpha}{90} \right) \text{mm}$$

where: P = out of plane measurement (mm)

α = bend angle (degrees)

SECTION 9 NON-DESTRUCTIVE INSPECTION

9.1 METHODS OF INSPECTION

Delete last paragraph of existing section and replace with the following:

NDT for acceptance of the bend (final inspection) shall take place after heat treatment of the bend. It may, however, take place before cropping, bevelling and end sizing.

All completed bends shall be subjected to manual UT over their entire surface to determine the minimum wall thickness. The survey shall be made along a grid with a maximum dimension of 150 mm.

The entire outside surface of all bends shall be subjected to MT to ensure freedom from surface defects that could be caused or revealed by the bending process.

For bends manufactured from welded pipe, the full length of the weld seam shall be inspected, for both longitudinal and transverse defects, using UT.

9.1.e. Bend Ends

Add to existing section:

MT shall be performed on the bevelled end of each finished bend.

SECTION 10 WORKMANSHIP, VISUAL INSPECTION AND REPAIR OF DEFECTS

10.1 VISUAL INSPECTION

Delete existing section and replace with the following:

The full body and welds (if applicable) of every bend shall be examined, internally and externally, for surface defects. For internal examination of bends DN 600 (24 inch OD) and larger, the inspector shall pass through the bore of the bend. Illumination greater than 500 lux shall be provided to enable proper inspection.

10.3 WORKMANSHIP AND DEFECTS

Add new section:

m. Bend Irregularities

Apart from the minor irregularities defined below, all bends shall be free from cracks, wrinkles, bulges, kinks and other serious defects.

Minor irregularities are buckles in the bend inside radius profile which will be acceptable if the height or depth of the buckle does not exceed 1% of the nominal internal diameter and the length to depth ratio is greater than 12:1. The distance between adjacent acceptable buckles in the bend inside radius profile shall be greater than one pipe OD, as shown in Figure 3.

SECTION 11 MARKING AND COATING

11.3 SEQUENCE OF MARKINGS

Add the following information to be marked on each bend:

- Purchase order number
- Bend identification number
- Bend angle
- Bend radius.

SECTION 12 MANUFACTURING PROCEDURE AND WELDING PROCEDURE

12.1 MANUFACTURING PROCEDURE SPECIFICATION

Delete existing section and replace with the following:

The Manufacturer shall prepare a manufacturing procedure specification which shall be submitted to the Principal for approval at least two weeks prior to the start of production. The manufacturing procedure specification shall include the following as a minimum:

Pipe Supply

- Pipe manufacturer
- Information relating to parent pipe as required by the Linepipe DEP Section 12.1.

Forming Procedure

- Operating sequence
- Forming process - machinery used, electrical characteristics, applied forces, etc.
- Production parameters - details of the following:
  - width of heated band
  - heating rate, bending temperature range, cooling rate
  - normal production bending speed
  - cooling method and coolant flowrate
  - rate of cool down at completion of bending
  - method of temperature measurement and recording
- Dimensions of finished bends - method of measurement, thinning of walls, out of roundness, tolerance on bend angle, etc.
- NDT procedures
- Post-forming heat treatment procedure, including details of furnace, number of thermocouples, method of support for bend and calibration of equipment.

SECTION 13 FIRST DAY PRODUCTION TESTS

Delete this section. First day production tests are not required for pipes used in bends.

APPENDIX E SUPPLEMENTARY REQUIREMENTS

SUPPLEMENTARY REQUIREMENT SR6

Delete this section. Drop Weight Tear tests are not required for bends.

PART IV HYDROGEN INDUCED CRACKING SENSITIVITY TESTS

4.1 SELECTION OF SAMPLES

(A) For bends in sour service only, HIC sensitivity tests shall be performed on samples removed from the test bend. All other requirements shall be in accordance with DEP 31.40.20.31-Gen. Part IV. The Principal shall inform the Manufacturer if HIC testing is required.

PART VI REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Linepipe for use in oil and gas operations under non-sour conditions (Amendments/Supplements to API Spec 5L)	DEP 31.40.20.30-Gen. December 1993
Linepipe for use in oil and gas operations under sour conditions (Amendments/Supplements to API Spec 5L)	DEP 31.40.20.31-Gen. December 1993

AMERICAN STANDARDS

Specification for Line Pipe	ANSI/API Spec 5L, 40th Edition, November 1992

Issued by:
American Petroleum Institute
1220 L Street, Northwest
Washington DC 20005
USA.

FIGURES

FIGURE 1 LOCATIONS FOR EXTRACTION OF TEST SPECIMENS FROM A TEST BEND

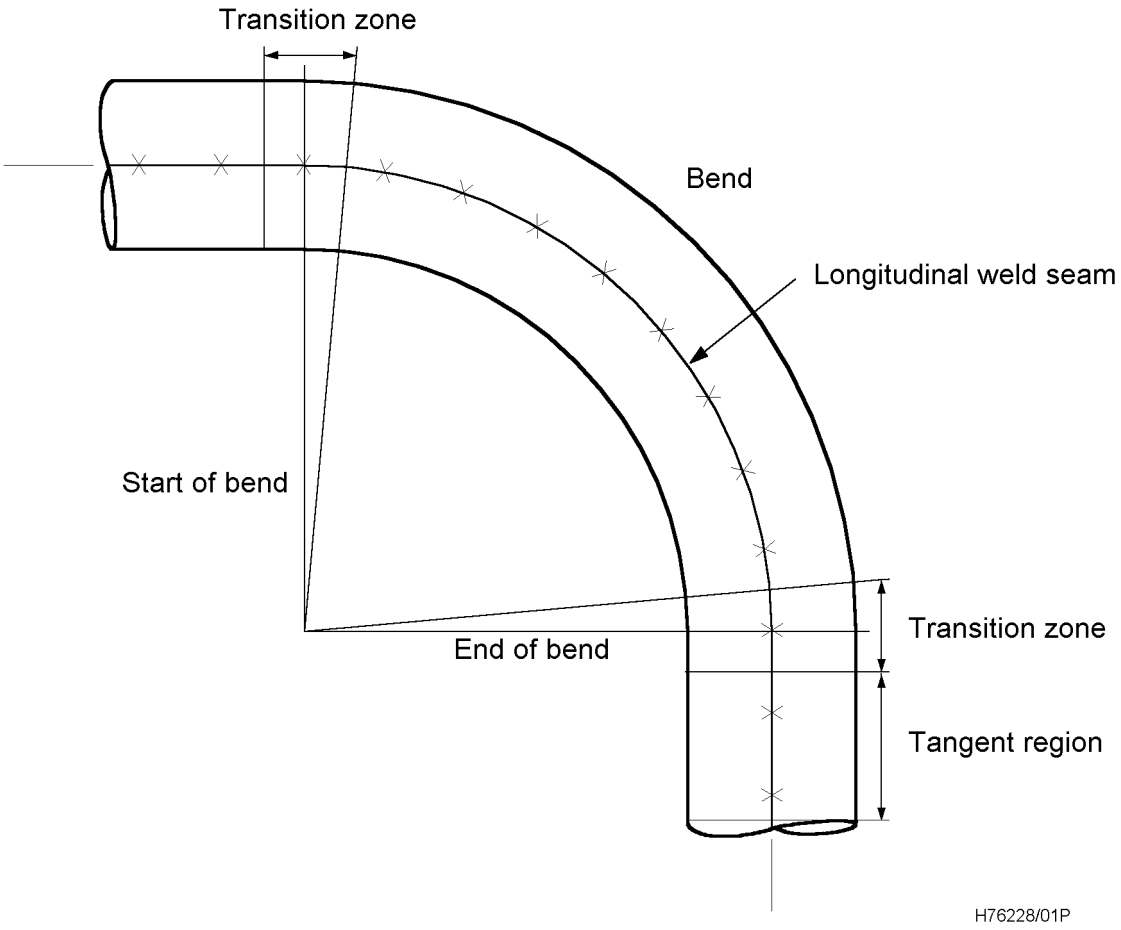
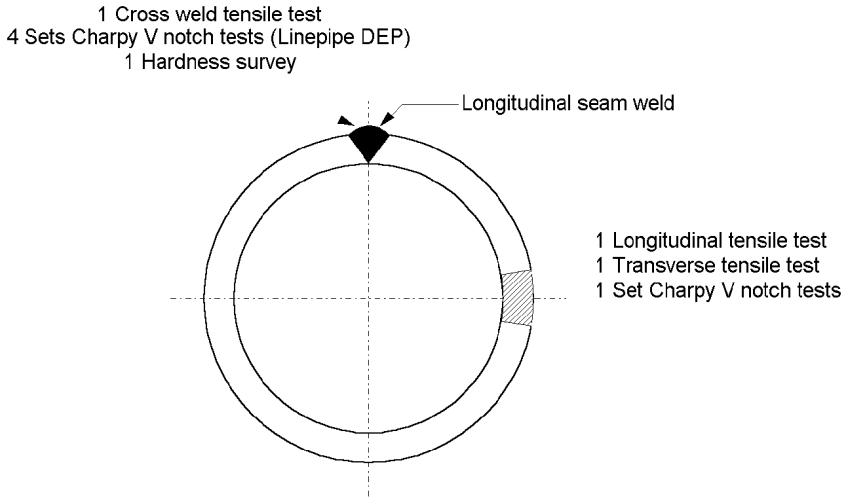
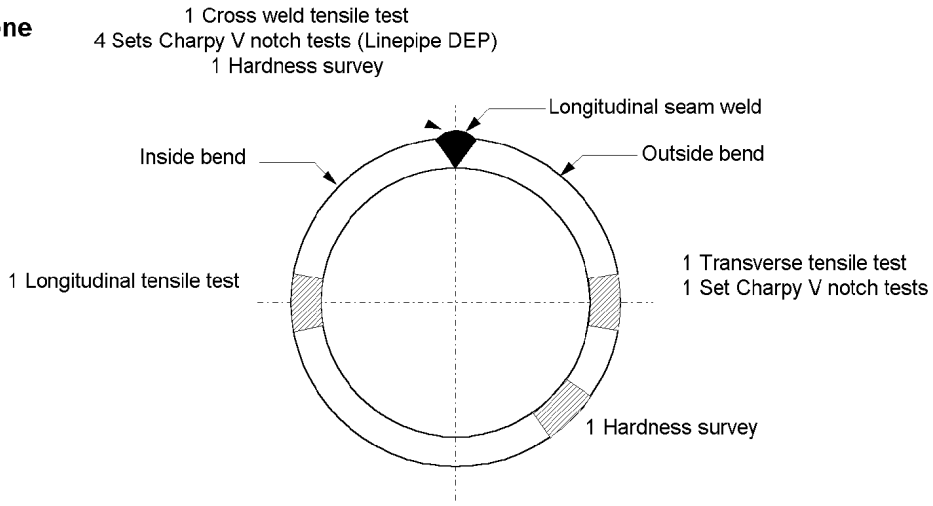


FIGURE 2 TEST REQUIREMENTS AT EACH TESTING LOCATION

2a Tangent end



2b Transition zone



2c Bend region

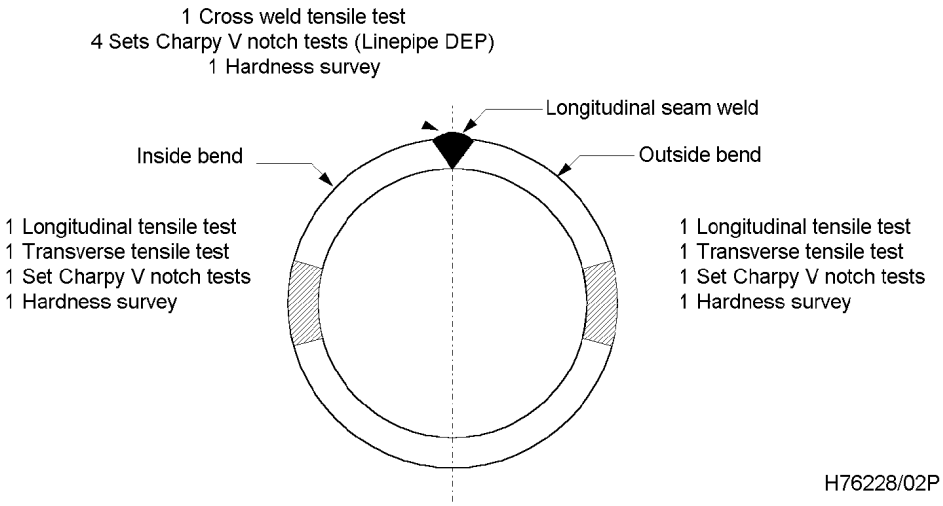
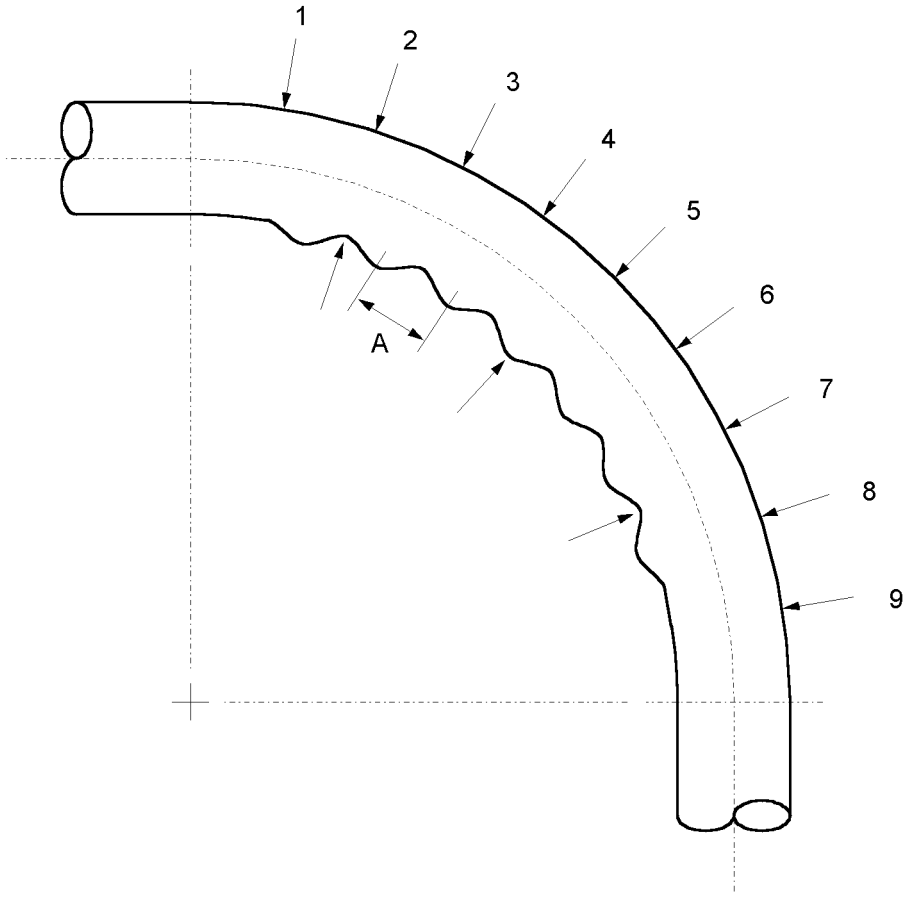


FIGURE 3 MEASUREMENT OF LOCAL BUCKLING



The average crest-to-valley depth is the sum of the OD of the two adjoining crests divided by two, minus the OD of the valley.

$$\text{Average depth} = \frac{OD_2 + OD_4}{2} - OD_3$$

$$\text{Distance between crests} = A$$

$$\text{Ratio} = \frac{A}{\text{average depth}} \geq 12 : 1$$

Note : A shall be greater than OD

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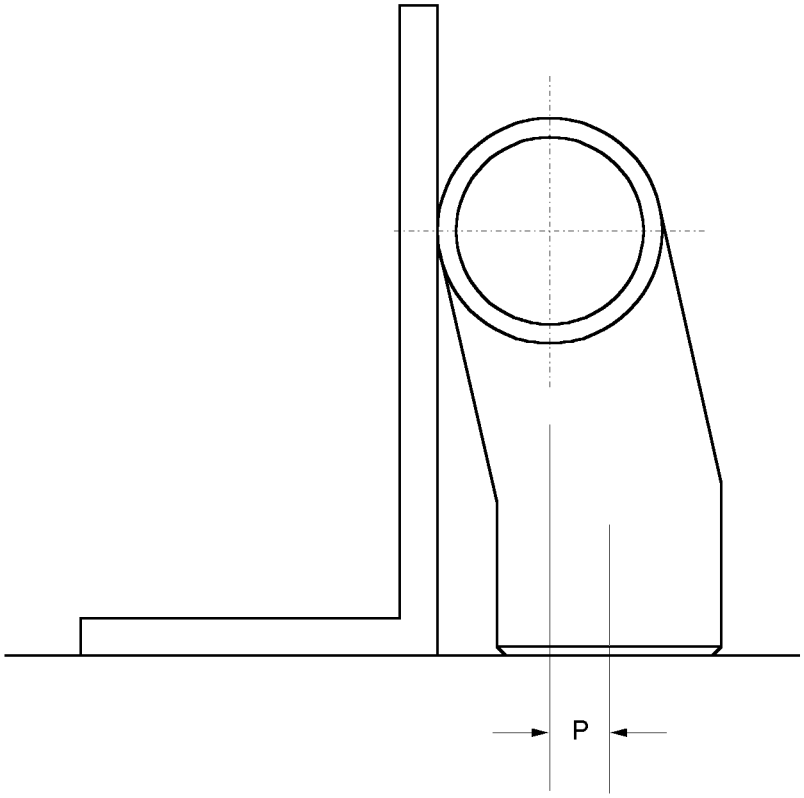
FIGURE 4 OUT OF PLANE MEASUREMENTS



Out of plane (P) shall not exceed $\frac{\alpha}{90}$ x 10 mm

where α is required bend angle, in degrees

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