MANUAL

PIPELINE REPAIRS
(SUPPLEMENTS TO ANSI/ASME B31.4 AND B31.8)

DEP 31.40.60.12-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
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The Hague, The Netherlands,

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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.

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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.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for responding to defects in carbon steel pipelines. Subjects addressed in this DEP are:

- essential defect information;
- safety requirements;
- inspection of defects;
- criteria for injurious defects;
- repair methods;
- selection of repair method.

This DEP is based on ANSI/ASME B31.4 and ANSI/ASME B31.8 and shall apply as a supplement to these documents.

The applicability of ANSI/ASME B31.4 and ANSI/ASME B31.8 is dictated by the fluid transported through the pipeline in accordance with the guidance provided in DEP 31.40.00.10-Gen.

This DEP is not applicable to defects in pipelines found during linepipe manufacturing or construction or to pipeline coatings.

NOTE: Acceptable defects during fabrication and construction are defined in the specifications used for fabrication and construction.

This DEP does not specify methods or requirements for performing fitness-for-purpose analyses.

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 Group company, and to Contractors nominated by them (i.e. the distribution code is "C" as described in DEP 00.00.05.0-Gen.).

This DEP is intended for use by those involved in the operation of pipelines.

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, 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 supplied 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 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

Defect	A flaw which may have a deleterious effect on the structural integrity of the pipeline.
Injurious defect	Defect which requires removal or repair, or derating of the pipeline.
Permanent repair	A repair that makes a pipeline safe for continuous service at its maximum allowable operating pressure.
Temporary repair	A repair that makes a pipeline safe for service during a limited period.

1.4 ABBREVIATIONS

ANSI	-	American National Standards Institute
ASME	-	American Society of Mechanical Engineers
HIC	-	Hydrogen Induced Cracking
MPI	-	Magnetic Particle Inspection
NPS	-	Nominal Pipe Size
SCC	-	Stress Corrosion Cracking
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 (9).

2. TYPES OF DEFECTS

Requirements for defect inspection, defect assessment methods and possible repair methods are to a large extent dictated by the type of defect. Table 1 contains a description and overview of possible causes of types of defects commonly encountered in pipelines in service. They are:

- pipe mill defects;
- girth weld defects;
- spalling;
- arc strikes;
- gouges;
- dents;
- cracks;
- metal losses due to internal or external corrosion.

It should be recognised that different types of defects can occur together and that it is essential that the combined occurrence of defects is also reported.

NOTE: The effect of a defect on the integrity of a pipeline can be more severe when occurring in combination with other types of defects. Dents combined with a gouge are an example of combined defects encountered in in-service pipelines.

3. ESSENTIAL INFORMATION

All parameters and factors essential for making the appropriate recommendation on the safety measures necessary following the reporting of a (possible) defect, for fitness-for-purpose analyses and for the selection of applicable repair methods must be known and considered.

Table 2 contains a checklist for the collection of essential parameters and factors, splitting these into the following five categories:

- pipe material;
- pipeline operating parameters;
- pipeline configuration;
- pipeline location;
- nature and extent of defect.

4. SAFETY REQUIREMENTS FOR WORK ON PIPELINES WITH DEFECTS

4.1 GENERAL

Pressures in pipelines with suspected defects should be reduced in accordance with the requirements of (4.2) and (4.3). Calculations for predicting the pressure at which a pipeline may fail at the location of a defect shall be based on "worst case" assumptions.

NOTE: Defects are likely to result in a lower pressure at which a line would fail. It is therefore prudent to lower the pressure to achieve a minimum safety margin between the pipeline operating pressure and the pressure at which failure may occur.

The period between reporting of a (possible) defect and its acceptance or repair shall be kept as short as practical.

Inspection and repair of pipelines under pressure shall be carried out by skilled personnel in accordance with approved procedures. Inspection and repair work shall be supervised by personnel who are familiar with the work to be performed and the associated hazards, and who have been trained to deal with emergencies.

Excavation of a damaged pipeline shall be carried out with due regard to trench stability and safe egress as approved by the Principal.

4.2 PRESSURE REDUCTION FOLLOWING REPORTING OF (SUSPECTED) DEFECTS

Isolated defects

Examples of isolated defects are a leak or damage reported by an outside party, e.g. a report of damage from an excavator hitting a pipeline. Another example is the discovery of defects when the pipeline is uncovered for other reasons.

The pipeline operating pressure shall be lowered to a pressure at which the defect can be shown by a fitness-for-purpose analysis to constitute no immediate potential threat to the pipeline integrity. In addition, this pressure should not exceed 80 percent of the pressure at which the defect was first discovered.

Defects discovered during pipeline patrolling

Leaks or damage may be discovered when a pipeline is patrolled and further information on their nature is lacking.

If the possible consequences of a leak are not acceptable then the pipeline shall be immediately depressurised.

If the consequences of a leak can be contained in an acceptable manner, then the pipeline operating pressure should be lowered to 80% of the level at the time of the survey and should not exceed this level until every leak or damage has been examined and repaired.

The pressure reduction should be achieved at all locations where leaks or damage have been discovered and also be maintained during pipeline shut-in.

Defects revealed with in-line inspection tools

In-line inspection surveys usually provide a list of defects and an estimate of the degree of severity. The accuracy of the estimated severity depends on many factors such as the tool used, the quality of the run, the skill of the interpreter of the survey results and experience with in-line inspection.

If the accuracy is high, then the required reduction in pressure may be based on the reported defect severity. If the accuracy is not high and the presence of injurious defects cannot be ruled out on the basis of the results of the inspection, then the pressure should be lowered to 80% of the highest level in the line at the time of the survey.

Other considerations

The above requirements for pressure reduction should be seen as the recommended minimum requirements to provide a minimum level of assurance that the defect will not grow.

The defect information shall be reviewed to establish whether conditions exist which require that the internal pressure is reduced further. Examples of conditions that require further reduction in the operation pressure are:

- additional risk of defect growth at locations with stresses other than due to internal pressure only; e.g. at locations of soil movement or settlement or inadequate pipe support conditions;
- presence of defect in a critical location;
- intolerable safety or environmental consequences in case of leaking defects.

4.3 PRESSURE REDUCTION DURING INSPECTION AND REPAIR

The pressure in the pipeline during uncovering and defect inspection shall not be higher than the maximum pressure permitted in (4.2).

Before commencement of a repair, the data obtained from the defect inspections shall be evaluated and the safe pressure at which the pipeline may be repaired shall be confirmed or adjusted. Possible inaccuracies in material and defect data and in modelling for calculating safe pressure levels for inspection and repairs shall be handled conservatively.

The pressure in the pipeline during repair shall not be higher than 80% of the calculated minimum pressure of failure of the pipeline. The pressure should be reduced further if required by the selected repair method.

5. DEFECT INSPECTION

5.1 GENERAL INSPECTION REQUIREMENTS

Inspection of pipeline defects shall be performed by experienced personnel qualified in accordance with the requirements of a recognised training and qualification scheme for the inspection technique(s) to be applied. Inspection shall be carried out in accordance with approved procedures.

NOTE: An overview of inspection techniques with training and qualification schemes for personnel is provided in EP 93-0750 Volume 2.8.

All loose wrapping shall be removed and the damaged area cleaned of all traces of mud and extraneous matter in the area of the defect and adjacent areas.

All defect inspections shall commence with:

- identification of surface anomalies and initial confirmation of the type of defect;
- wall thickness measurement with an instrument resolution of 0.1 mm. The wall thickness shall be measured on a grid with a mesh appropriate for the expected defect but with meshline distances not exceeding 25 mm. Measurements shall be taken over a square, centered around the defect, with a minimum side length of the largest dimension of the defect along the pipe surface plus 75 mm;
- check on the presence of cracks over the same area as specified for the wall thickness measurement.

Guidance on the information required for each type of defect and common inspection techniques are given in (5.2) and (5.3) respectively.

5.2 NECESSARY DEFECT INFORMATION

5.2.1 Spalling

The spalling shall be dressed, the depth and extent of the metal loss measured if more than superficial, and the dressed area shall be checked for the presence of cracks and hard spots.

NOTE: The energy used to form spalling can be of sufficient magnitude to cause hardening of the material beneath the spalling, which in the hard state is susceptible to cracking, and could remain undetected until the spalling is removed.

5.2.2 Arc strike

The extent of the possible hard spots (caused by surface melting) shall be determined and the depth estimated.

NOTE: The depth of a hard spot, normally 1-3 mm when caused by welding electrode arc strikes, cannot be measured. The estimated depth should be confirmed during the repair.

5.2.3 Gouge

The extent and depth of gouges shall be measured. Burrs on the surface of the gouge and hindering the measurements shall be filed off before measuring the gouge depth.

The extent of the possible hard subsurface layer shall be determined and the depth estimated.

5.2.4 Dent

The profile of the dent, indicated by the radial distance between the original pipe contour and deepest indentation, shall be measured and the presence of any associated damage shall be observed.

The dent shall be checked for the presence of gouges.

The extent of the possible hard subsurface layer shall be determined and the depth estimated.

5.2.5 Crack

The depth and length of the crack shall be determined. In case of environmental cracking, the possible occurrence of cracking at other locations shall be established.

NOTE: 1. Cracking caused by sensitivity to the fluid or the external environment is referred to as environmental cracking. HIC and SCC are examples of environmental cracking.

2. The advice of a corrosion engineer should be sought on the extent of the measurements necessary to conclude whether the environmental cracking is present at other locations.

5.2.6 Metal loss corrosion defects

The depth and extent of internal and external metal loss corrosion defects should be determined.

Areas with external corrosion defects shall be blast-cleaned before inspection.

5.3 TECHNIQUES FOR INSPECTION

A summary of techniques available to assess the severity of damage to both onshore and subsea pipelines is presented in Table 3.

NOTE: Underwater inspection requires specialist equipment. "The Professional Diver's Handbook" contains information on underwater inspection equipment and techniques.

6. INJURIOUS DEFECTS

6.1 CRITERIA FOR INJURIOUS DEFECTS

6.1.1 ANSI/ASME B31.4 pipelines

All leaking defects shall be considered injurious.

Clause (a) Limits and Dispositions of Defects of ANSI/ASME B31.4 par. 451.6.2 on non-leaking injurious defects shall be replaced by the following:

The following non-leaking defects shall be considered injurious:

- **pipe mill defects** exceeding the defect criteria in DEP 31.40.20.30-Gen. for non-sour service conditions, in DEP 31.40.20.31-Gen. for sour service conditions or, if available, the specification applied for the linepipe fabrication;
- **girth weld defects** exceeding the defect criteria in DEP 61.40.20.30-Gen. or, if available, the specification applied for the girth welding;
- **spalling, gouges and grooves** in the pipe material with a depth greater than 12.5% of the nominal wall thickness and all gouges and grooves in seam and girth welds and their heat-affected zones;
- **dents** meeting any of the following conditions:
  a) dents which affect the curvature of the pipe at a longitudinal seam or girth weld;
  b) all dents containing a gouge or groove or arc burn;
  c) dents exceeding a depth of 6 mm in pipe NPS 4 and smaller or 6% of the nominal pipe diameter in sizes greater than NPS 4.
- **all arc burns;**
- **all cracks;**
- **general metal loss corrosion** if the wall thickness has been reduced to less than the thickness required in accordance with ANSI/ASME B31.4 par. 404.1.2, decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component;
- **localised metal loss corrosion** in the pipe body material not meeting the criteria of the SHELL92 (EP 94-0237) method and all localised metal loss corrosion in the girth welds and longitudinal seam or related heat-affected zones.

6.1.2 ANSI/ASME B31.8 pipelines

All leaking defects shall be considered injurious.

The criteria for non-leaking injurious defects in ANSI/ASME B31.8 par. 851.4 for pipelines in service shall be replaced by the following:

The following non-leaking defects shall be considered injurious:

- **pipe mill defects** exceeding the defect criteria in DEP 31.40.20.30-Gen. for non-sour service conditions, in DEP 31.40.20.31-Gen. for sour service conditions or, if available, the specification applied for the linepipe fabrication;
- **girth weld defects** exceeding the defect criteria in DEP 61.40.20.30-Gen. or, if available, the specification applied for the girth welding;
- **spalling, gouges and grooves** in the pipe material with a depth greater than 10% of the nominal wall thickness and all gouges and grooves in seam and girth welds and the heat-affected zones;
- **dents** meeting any of the following conditions:

  a) dents which affect the curvature of the pipe at the longitudinal seam or girth weld;
  b) all dents containing a gouge or groove or arc burn;
  c) dents in pipe material exceeding a depth of 6 mm in pipe NPS 12 and smaller or 2% of the nominal pipe diameter in all sizes greater than NPS 12.
- **all arc burns;**

- **all cracks;**
- **general metal loss corrosion** if the wall thickness has been reduced to less than the thickness required in accordance with ANSI/ASME B31.8 par. 841.11, decreased by an amount equal to the manufacturing tolerance applicable to the pipe or component;
- **localised metal loss corrosion** in the pipe body material not meeting the criteria of the SHELL92 (EP 94-0237) method and all localised metal loss corrosion in the girth welds and longitudinal seam or related heat-affected zones.

6.2 CORRECTION OF INJURIOUS DEFECTS

Injurious defects shall be corrected by replacement of the pipe section containing the defect, if acceptable (see 7), or repaired or the pipeline derated.

Replacement or repair is not required when it can be demonstrated with a fitness-for-purpose analysis that the safe operation of the pipeline is not impaired by the presence of an injurious defect. The pipeline shall be derated if this is indicated by the fitness-for-purpose analysis.

NOTES:
1. EP 94-0237 contains a method to assess defects of corroded pipelines; in EP 94-0237 this is called BRA92 but is now known as SHELL92. The SHELL92 method is a refinement of the procedures given in ANSI/ASME B31G providing guidance on acceptable metal loss defects as a function of the line pipe steel grade.
2. Limitations of fitness-for-purpose models should be recognised during application; e.g. the ANSI/ASME B31G and SHELL92 model have been derived for corrosion defects with their main axis in the longitudinal direction and not located in weld and heat-affected zone areas.
3. Local regulations may impose limitations on applying fitness-for-purpose analyses.

7. REPAIR METHODS

7.1 REPLACEMENT OF DEFECTIVE SEGMENT

After shutdown, depressurisation and isolation of the fluid from the defective area, the section containing the defect is removed as a cylinder and replaced.

The replacement pipe section shall have a strength of at least that of the pipe it replaces and shall meet the requirements of DEP 31.40.20.30-Gen. for non-sour service conditions, or DEP 31.40.20.31-Gen. for sour service conditions or, if available, the specification applied for the fabrication of the original pipe.

The replacement pipe section shall be hydrotested before being connected to the pipeline, in accordance with DEP 31.40.40.38-Gen.

The replacement pipe sections should be welded to the pipeline and inspected in accordance with DEP 61.40.20.30-Gen. The welds shall be examined ultrasonically in addition to radiography if not hydrotested before recommissioning of the pipeline.

Other tie-in methods, such as flanged connections or proprietary mechanical connectors, may be used for submerged parts in offshore pipelines.

NOTE: Tie-in methods for the replacement of sections in offshore pipelines should be selected on a case-by-case basis. Cost comparisons should not only consider the costs of the initial repair and interruption but also reflect, based on probability of failure of flanged connections and connectors, possible future costs.

If flanged connections are used, bolt tensioning shall be applied by using hydraulic bolt tensioning equipment.

Connectors shall be installed and tested in accordance with the procedures recommended by the Supplier of the connector.

7.2 GRINDING

Grinding is the removal of material by hand filing or power disk grinding. Appendix 3 specifies requirements applicable to power disk grinding.

Before removing material in excess of the criteria for injurious gouges and grooves (6.1), a fitness-for-purpose analysis shall be performed to identify the maximum extent and depth of material that may be removed, and the requirements for temporary or permanent pressure reductions. Grinding shall not be applied for the removal of material in excess of 40% of the nominal wall thickness.

If the defective material cannot be removed entirely by grinding within the limits stated above, the attempt to repair by grinding should be abandoned and another more suitable repair method used instead.

Areas of grinding shall always be verified for the presence of cracks by MPI. If present, cracks shall be removed and the surface reinspected.

The metallurgical structure of the pipe material at gouges, grooves and arc burns may have changed, resulting in hard spots, which shall be removed completely. The complete removal shall be verified by etching with a 10% ammonium persulfate or 5% nital solution.

7.3 FULL-ENCIRCLING REINFORCING SLEEVE

7.3.1 Tight-fit sleeve

Figure 1 shows a typical tight-fit reinforcing sleeve. This type of sleeve consists of two halves of a cylinder of pipe or appropriately curved plate material, made of weldable steel, placed around the pipe at the defective area and joined after positioning by welding of the side seams.

The side seams should be single-vee butt welds, with the depositing of weld metal on the pipeline prevented by the use of a mild steel backing strip. Seam welding shall be carried out in accordance with DEP 31.38.60.10-Gen.

NOTE: Overlapping side strips fillet-welded to the sleeve halves should not be used.

For short distance defects the sleeve should be designed to restrain bulging of the pipe at the area of the defects. The strength of sleeves for longer defects shall be designed to prevent rupture of the pipe.

Sleeves shall be designed to preventure rupture of the pipeline at the location of the defect.

Tight-fit sleeves shall be formed and positioned so that a firm contact between the pipe and the sleeve, especially at the area of the defect, is achieved. The effectiveness of the sleeve can be further enhanced by one or more of the following measures during sleeve installation:

- pressure reduction in the pipeline during the installation of the sleeve to two-thirds of the operating pressure;
- application of external loads to the sleeve to force a tight fit during the seam welding, see Figure 2 for examples of possible methods;
- use of semi-liquid filler material that will fill and harden in any gaps in the annular space between the pipeline and the sleeve.

NOTE: Hardenable fillers, such as epoxy or polyester compounds, are trowelled into depressions in the pipeline and the excess material "squeezed out" when the sleeves are placed before the filler has hardened.

A concern with the application of the tight-fit sleeve is the presence of the crown of seam welds. One of the following measures should be taken to ensure a tight fit also over seam welds:

- remove the crown by grinding flush with the surface of the pipe. The pressure in the pipeline should be reduced by at least one-third of the operating pressure;
- machine a compensating groove in the sleeve and use a thicker sleeve to compensate for the groove;
- use a hardenable filler material adjacent to the seam except when higher forces are applied for forcing the sleeve around the pipeline. High forces may be expected with the lug-and-bolt method and when using chain clamps, see Figure 2.

7.3.2 Epoxy-filled sleeve

With this type the sleeve is centred around the pipeline with a stand-off distance of several millimetres. The annular gap between the sleeve and the pipe is sealed at the ends using quick curing putty and then filled with a high-stiffness epoxy grout, see Figure 3.

Measures shall be taken to prevent seam weld metal being deposited on the pipe. Seam welding shall be carried out in accordance with DEP 31.38.60.10-Gen.

The grouting pressure shall be controlled to prevent damage to the pipeline.

NOTE: The principle of the epoxy-grouted sleeve is to prevent the damaged section of pipe from bulging radially at the location of the defect. Further information on this type of sleeve can be found in report EP 92-0854.

7.3.3 Composite reinforcement sleeve

This type of sleeve consists of multiple layers of glass-reinforced polyester to locally reinforce the pipe wall with a composite encirclement. Installation is by the winding of layers, see Figure 4.

Subsequent layers of the reinforcing polyester are wound around the pipe to a standard width of 300 mm. A multi-component adhesive is applied between the sleeve and the pipe and between the layers of the sleeve.

A major advantage of the method is the relative ease of application, using simple hand tools without any welding.

Composite reinforcement sleeves shall be installed in accordance with procedures recommended by the Supplier.

NOTES: 1. This method is applied primarily for local metal loss defects due to external corrosion.

2. Composite reinforcement sleeves have been used primarily for the temporary repair of non-leaking local metal loss due to external corrosion. Studies are ongoing to qualify this type of sleeve for permanent repairs.

7.4 FULL-ENCIRCLING PRESSURE-CONTAINING SLEEVE

This type of sleeve is like the tight-fit sleeve (7.3.1) except that the ends are fillet-welded to the pipeline, see Figure 5, and this type of sleeve can be designed to contain pressure (the tight-fit sleeve cannot).

Since the full-encircling pressure-containing sleeve may contain pressure, it shall be designed, fabricated and installed in accordance with the same requirements as specified for the pipeline.

The minimum required nominal wall thickness and steel grade of the sleeve shall be based on the wall thickness design factor and equation as required to be applied for the pipeline. The requirements for materials, welding and inspection specified in DEP 31.38.60.10-Gen. shall also be applied here.

NOTES:
1. The outside diameter of the sleeve shall be taken as the diameter in the equation for calculating the minimum wall thickness.
2. DEP 31.38.60.10-Gen. does not include requirements for sour service.

As for the tight-fit sleeve, the sleeve thickness shall be increased to compensate for the groove accommodating backing strips or seams of the pipeline.

The sleeve should extend to 0.1 m beyond the defect. Adjacent sleeves should not be placed closer then one-half pipe diameter from each other.

7.5 PRESSURE-CONTAINING CLAMP

A typical bolt-on clamp is shown in Figure 6. It consists of two halves bolted together with elastomer seals around the circumference of the pipe and where the two halves meet.

Bolt-on clamps are designed to contain full pressure. They are generally bulky and heavy to ensure an adequate clamping force.

This type of clamp shall not be welded to a pipeline.

7.6 LEAK CLAMP

This type of clamp consists of a relatively light-weight (when compared with the pressure-containing clamp), band of metal with a single draw bolt for securing to the pipeline, see Figure 7.

A threaded fitting is provided, located at 180 degrees from the draw bolt, and used to force a neoprene cone into a leaking pit.

7.7 HOT-TAPPING

This method is used to remove a defect from a pipeline in service. A hot-tap fitting is installed around the pipe and the defect is removed in the same way as removing a segment from the pipe wall for branch connections using the hot-tap method.

The requirements for hot-tapping are:

- the entire defect needs to be removed;
- all requirements of DEP 31.38.60.10-Gen. shall apply in addition to the requirements of this DEP.

The branch shall be sized such that the entire defect can be removed.

7.8 OTHER METHODS

Repairs should not be made by installing patches or depositing weld metal.

8. SELECTION OF REPAIR METHODS

8.1 REPLACEMENT OF DEFECTIVE PIPE

Shutdown and depressurisation of the pipeline followed by replacement of the line section containing an unacceptable defect is the preferred method for repairing pipelines (7.1). Temporary or permanent repairs with the line under pressure should be restricted to situations where shutdown would result in unacceptable interruption of the use of the pipeline or when the hazards created by removing fluid and/or cutting the pipe cannot be tolerated.

8.2 ALTERNATIVE REPAIR METHODS

Where depressurisation and replacement of a pipe section is not possible, alternative pipeline repair methods may need to be used. Table 4 provides an overview of common applications of these alternative repair methods as a function of location and type of defect. They may be used for other applications than indicated, provided the suitability is demonstrated.

As a general rule, a repair required to remain in the pipeline for a period longer than 2 years should not be considered as temporary. A temporary repair should be replaced within a period specified in the repair manual or re-evaluated to demonstrate that the period of the temporary repair may be extended with confidence.

Table 4 replaces ANSI/ASME B31.4 par. 451.6.2(b) and ANSI/ASME B31.8 par. 851.4.

9. 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 or revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Hot-tapping on pipelines, piping and equipment	DEP 31.38.60.10-Gen.
Pipeline engineering	DEP 31.40.00.10-Gen.
Linepipe for use in oil and gas operations under non-sour service conditions (amendments/supplements to API Spec 5L)	DEP 31.40.20.30-Gen.
Linepipe for use in oil and gas operations under sour service conditions (Amendments/Supplements to API Spec 5L)	DEP 31.40.20.31-Gen.
Hydrostatic testing of new pipelines	DEP 31.40.40.38-Gen.
Welding of pipelines and related facilities (Amendments/Supplements to ANSI/API STD 1104)	DEP 61.40.20.30-Gen.
Maintenance management guidelines: inspection techniques	EP 93-0750 (Volume 2.8)
Defect assessment of corroded pipelines: evaluation of alternative methods	EP 94-0237

AMERICAN STANDARDS

Liquid transportation systems for hydrocarbons, liquid petroleum gas, anhydrous ammonia, and alcohols	ANSI/ASME B31.4 (1992 + addenda A, 1994)
Gas transmission and distribution piping systems	ANSI/ASME B31.8 (1992 + addenda A, 1993 + addenda B, 1994)
Manual for determining the remaining strength of corroded pipelines: a supplement to the ASME B31 code for pressure piping	ANSI/ASME B31G

Issued by:
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11 W 42nd street, 13th. floor
New York,
NY 10036, USA.

10. BIBLIOGRAPHY

NOTE: The documents listed in this bibliography are for information only and do not form an integral part of this DEP. The Shell Group document below cannot be made available without the approval of the Principal.

Cost-effective on-line repair of pipeline damage using epoxy-filled shells, British Gas 1991	EP 92-0854
The Professional Diver's Handbook	ISBN: 0 9508242 0 8

APPENDIX 1 TABLES

Table 1 Summary of common types of defects in pipelines in service

Type	Description	Possible Cause
pipe mill defect	Defect in the pipe body or seam introduced during pipe fabrication.	See technical specifications for the fabrication of linepipe. NOTE: Pipe mill defects are not normally encountered in pipelines in service if the pipe is fabricated in accordance with the requirements of DEP 31.40.20.30-Gen. or DEP 31.40.20.31-Gen. Examples of mill defects experienced in pipelines in service are laminations, slivers and cracks.
girth weld defect	Defect in the girth weld or heat-affected zone introduced during pipeline welding.	See technical specifications for pipeline welding. NOTE: Girth weld defects are not normally encountered in pipelines in service if the pipe is welded in accordance with the requirements of DEP 61.40.20.30-Gen.
spalling	Abrasion of the pipe surface resulting in shallow surface laps and possibly hardening of the material below.	- abrasion from wearing metal-to-metal contact such as from tracked vehicles penetrating the coating and wearing the pipe surface. NOTE: Spalling is recognised by its rough appearance similar to marks made on a work piece by an accumulation of material on the cutting edge of a lathe cutting tool.
arc burn	Localised points of surface melting caused by an electrical arc.	- welding electrode; - lightning; - spark during breaking of piping connection before installing lead for electrical continuity.
gouge	Elongated grooves or cavities caused by the mechanical removal of material.	- construction handling; - third party interference.
dent	Local change in surface contour of the pipeline but not accompanied by loss of metal.	- construction loads; - excessive operational loads; - third party loads; - geo-technical forces.
crack	Stress-induced separation of the pipe metal which, without any other influence, is insufficient in extent to cause complete rupture of the material.	- excessive straining during mechanical deformation of the pipe; - occurring as a result of a micro-structural sensitivity to certain environments, which are often high in hydrogen or sulphur content, in combination with tensile stresses. The tensile stresses may be applied or be residual.
metal loss corrosion	Isolated pitting, contiguous pitting or general corrosion on either the internal or external surfaces, resulting in localised or widespread thinning of the pipe wall.	- corrosive fluid; - damage or breakdown of coating without adequate coverage by cathodic protection.

Table 2 Checklist for essential information for pipeline repair decisions

Category	Parameter/factor
pipe material	- pipe diameter and wall thickness; - grade of pipe material; - chemical content ranges; - type of seam welds; - fracture propagation transition temperature; - Charpy V-notch upper-shelf impact energy; - information from previous repairs.
pipeline operating parameters	- maximum operating pressure; - extreme operating temperatures; - large or frequent fluctuations in pressure and/or temperature; - type of fluid present in the line at the time of repair; - flow rate at time of repair.
pipeline configuration	- bend radius and ovalisation of pipe if not straight at the location of the defect; - presence of appurtenances, seam or girth weld reinforcement in the vicinity of the repair; - presence of (mechanical) couplings which may necessitate special precautions with respect to pipe excavation and tolerance of pipe movement.
pipeline location	- onshore versus offshore; - above ground versus buried; - terrain; - accessibility; - proximity to populated or environmentally sensitive areas.
nature and extent of defect	- leaking or not; - possible presence of cracks; - internal or external corrosion metal loss; - seam or girth weld affected?

Table 3 Summary of techniques for defect inspection

Defect type	Objective of inspection	Techniques for onshore pipelines
all	confirmation of type of defect	visual
	check for presence of surface anomalies	visual
	wall thickness measurement	UT
	check for presence of cracks	MPI
spalling	measurement of extent and depth of metal loss	ruler/tape and depth gauge
	check for presence of possible hard spots	etching
arc strike	determination of extent of possible hard spots	etching
gouge	measurement of extent and depth of metal loss	ruler/tape and depth gauge; and/or mould
	check for presence of possible hard spots	etching
dent	measurement of extent and depth	ruler/tape and depth gauge; and/or mould; or caliper pig
crack	length, depth and location	MPI and UT
metal loss corrosion	extent and depth	UT, preferably using automated scanning equipment, for internal and external metal loss; or ruler and depth gauge for external corrosion if UT is not feasible.

Table 4 Alternative repair methods

Factors and defect	Grinding [1] (7.2)	Tight-fit sleeve [1] (7.3.1)	Epoxy-filled sleeve [1] (7.3.2)	Composite reinforcing sleeve [1] (7.3.3)	Pressure containing sleeve (7.4)	Pressure containing clamp (7.5)	Leak clamp [2] (7.6)	Hot-tapping (7.7)
pipelines on land	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
offshore pipeline	Yes	No	No	No	No	Yes	No	No
straight pipe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
gradual bend	Yes	Yes[3]	Yes	Yes	Yes[3]	Yes	Yes	Yes
fabricated bend	Yes	Yes[3]	Yes[3]	Yes	No	No	Yes	No
spalling, arc strikes and gouges in pipe material	P	P	P	No	P	No	No	P
dent without stress concentrators in pipe material	No	P[4]	P[4]	No	P[5]	No	No	P
spalling, arc strikes, gouges and dents in submerged arc welded seams or circumferential welds	No	P[4]	No	No	P[6]	No	No	No
spalling, arc strikes, gouges and dents in electric resistant weld seams	No	No	No	No	P[6]	No	No	P
crack in pipe material	No	No	No	No	P[6]	No	No	P
crack in girth weld/HAZ	No	No	No	No	P[6]	No	No	No
local metal loss due to internal corrosion	No	T[7]	T[7]	T	P	T	T	P
general metal loss due to internal corrosion	No	T[7]	T[7]	T	P	No	No	No
local metal loss due to external corrosion	No	P	P	T	P	T	T	P
general metal loss due to external corrosion	No	P	P	T	P	No	No	No

LEGEND: P= permanent repair T = temporary repair

NOTES:
1. Suitable for non-leaking defects only.
2. Suitable for leaking defects only.
3. Require special configuration to fit the pipe.
4. Dent to be filled with hardenable material.
5. Sleeve to be pressurised by hot-tapping the pipeline when applied for repair of dent.
6. Sleeve to be pressurised by hot-tapping the pipeline.
7. May be considered as permanent only if further internal corrosion can be prevented.

APPENDIX 2 FIGURES

FIGURE 1 FULL-ENCIRCLING TIGHT-FIT SLEEVE

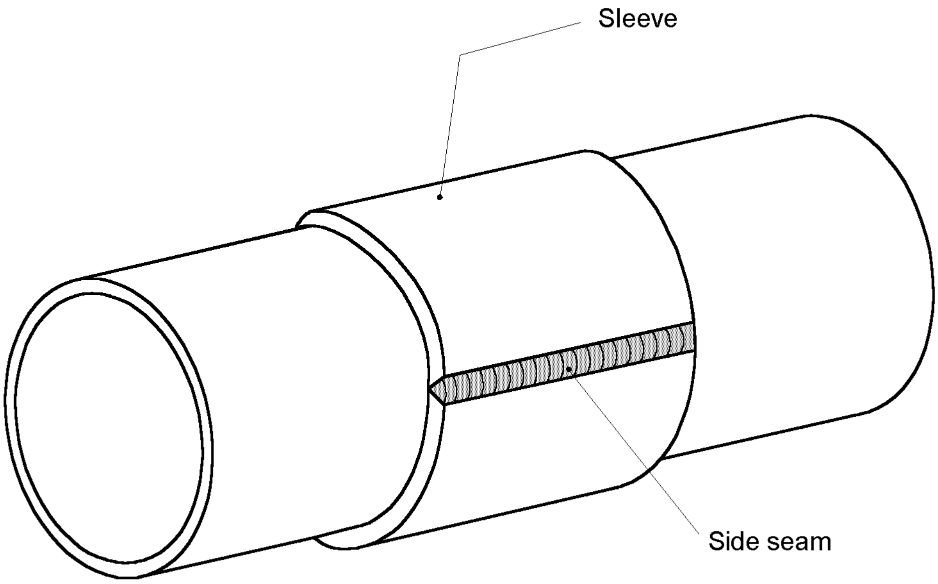

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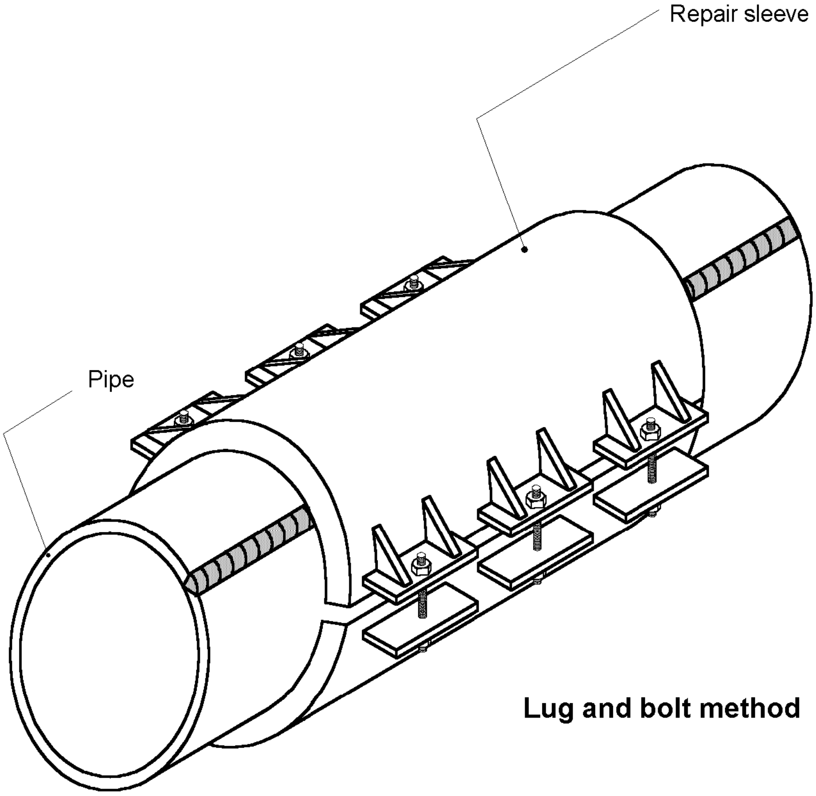
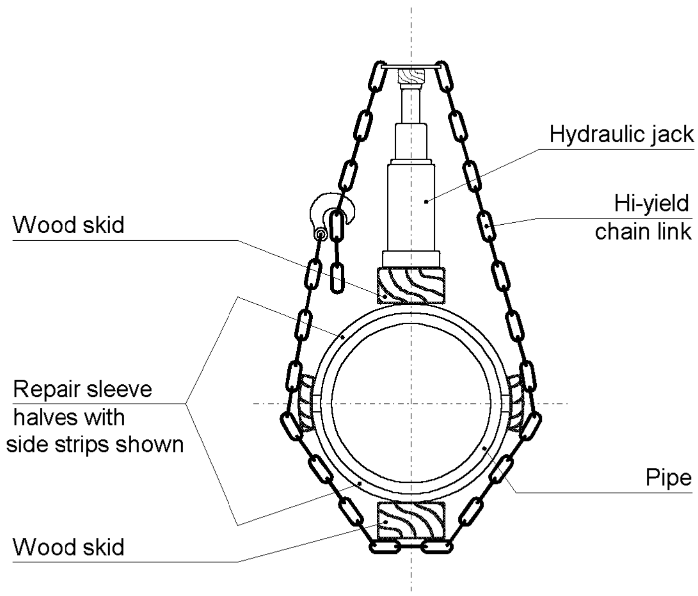
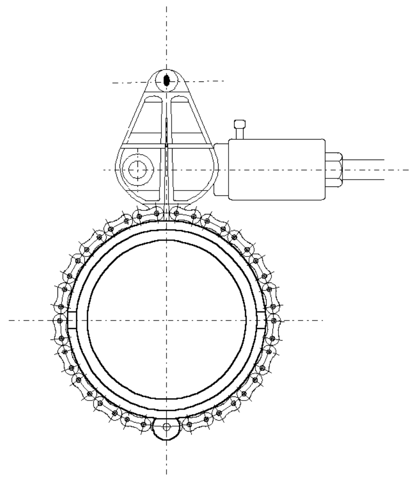
FIGURE 2 MECHANICAL METHODS TO ASSIST TIGHT-FITTING SLEEVES



Lug and bolt method



Standard method



Chain clamp method

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FIGURE 3 EPOXY - GROUTED SLEEVE

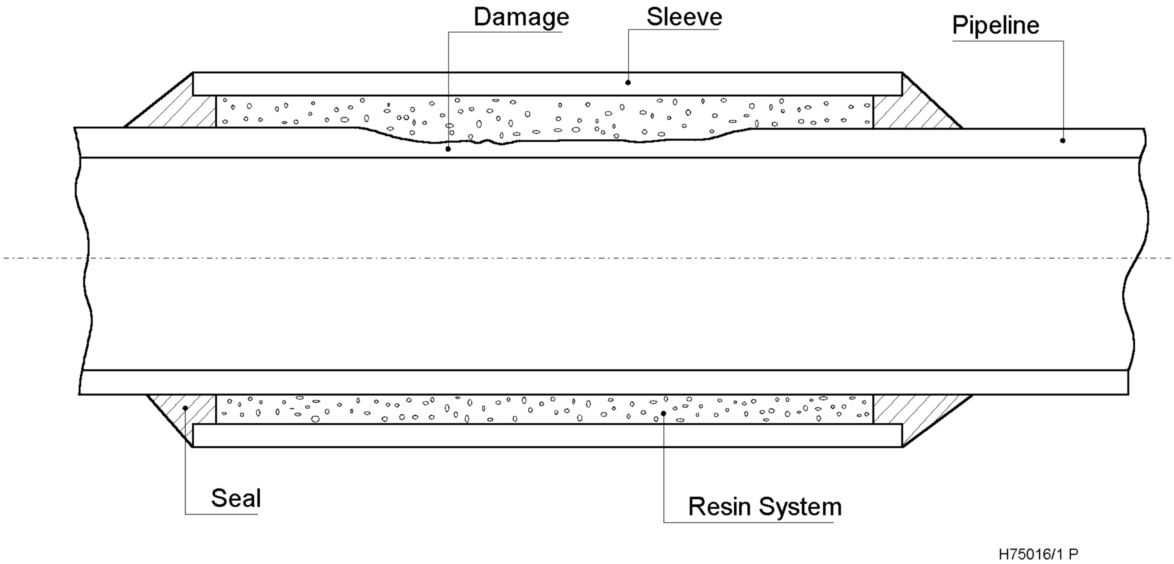

FIGURE 4 COMPOSITE REINFORCEMENT SLEEVE

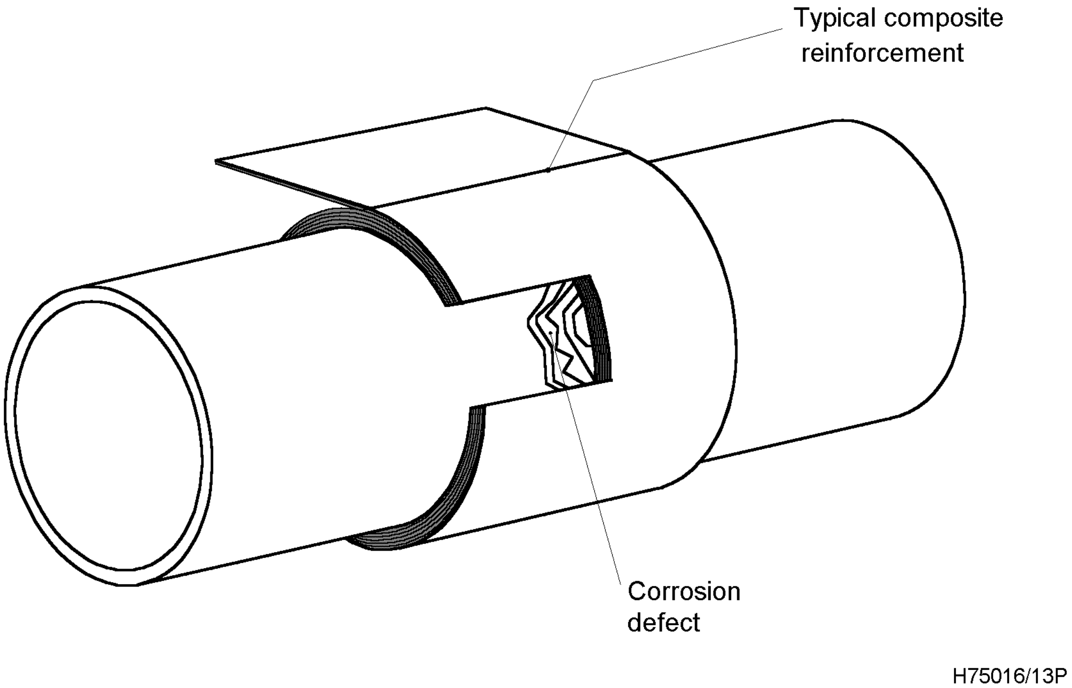
Typical composite
reinforcement
Corrosion
defect
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FIGURE 5 FULL-ENCIRCLING PRESSURE-CONTAINING SLEEVE

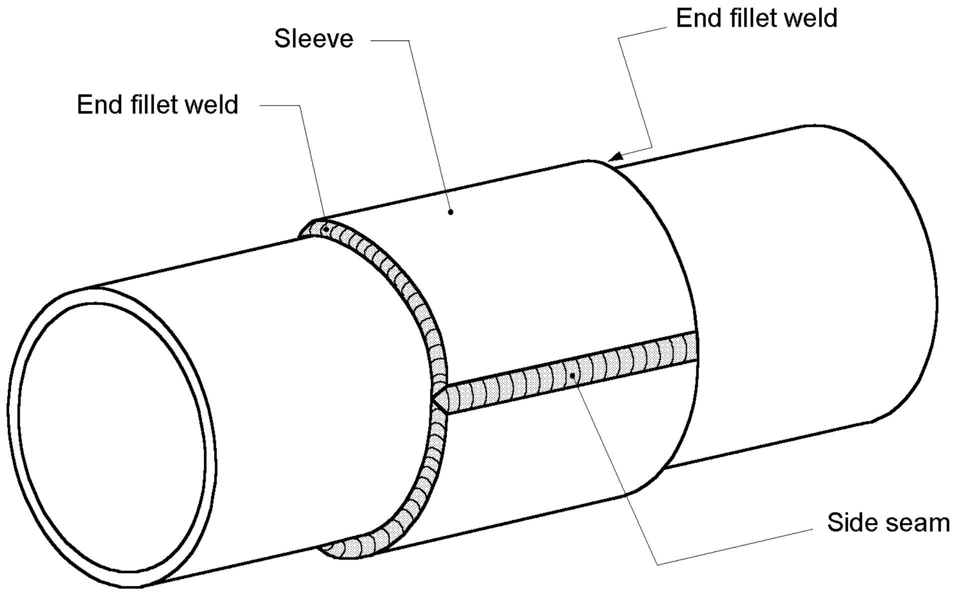

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FIGURE 6 PRESSURE-CONTAINING CLAMP

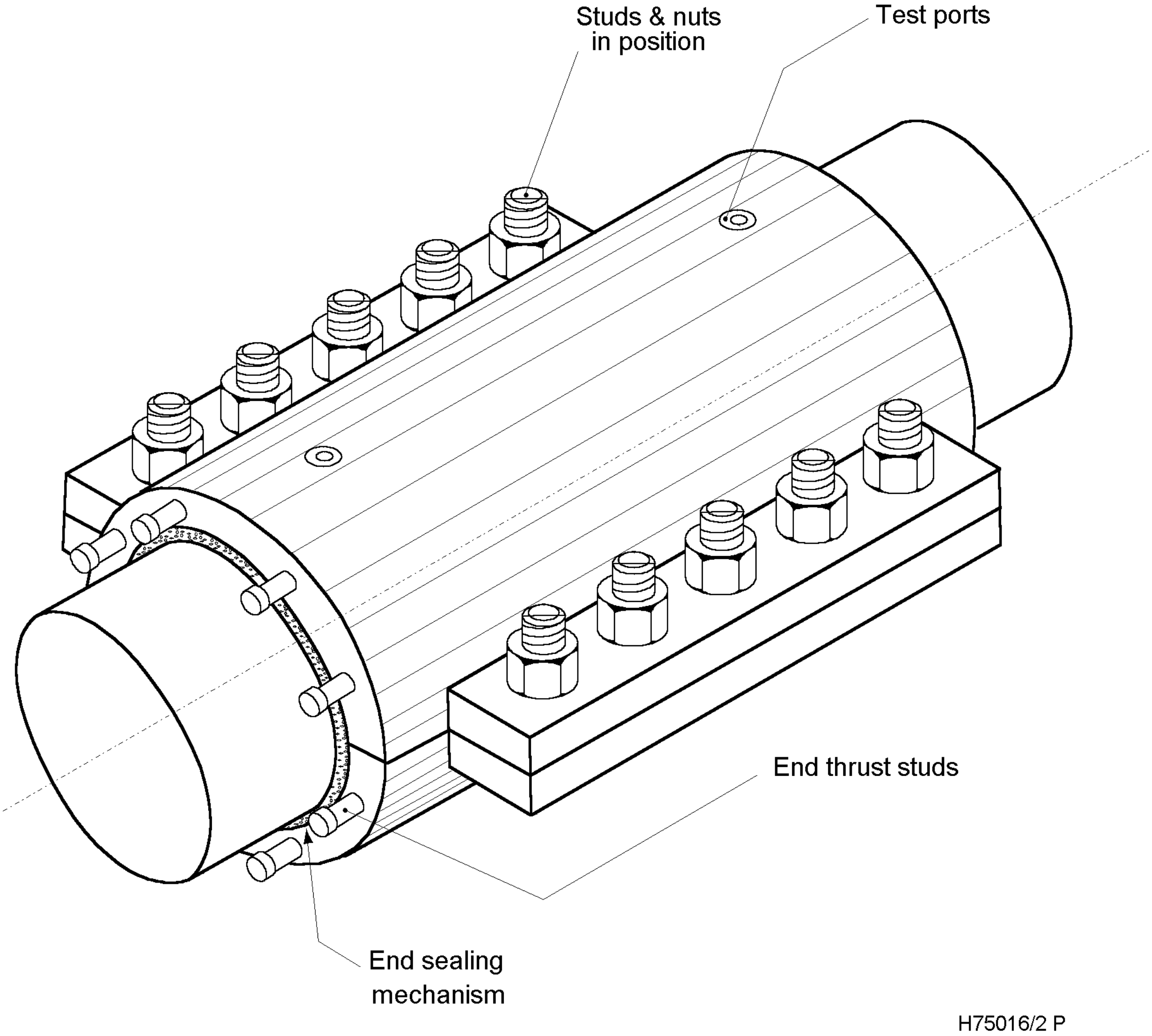
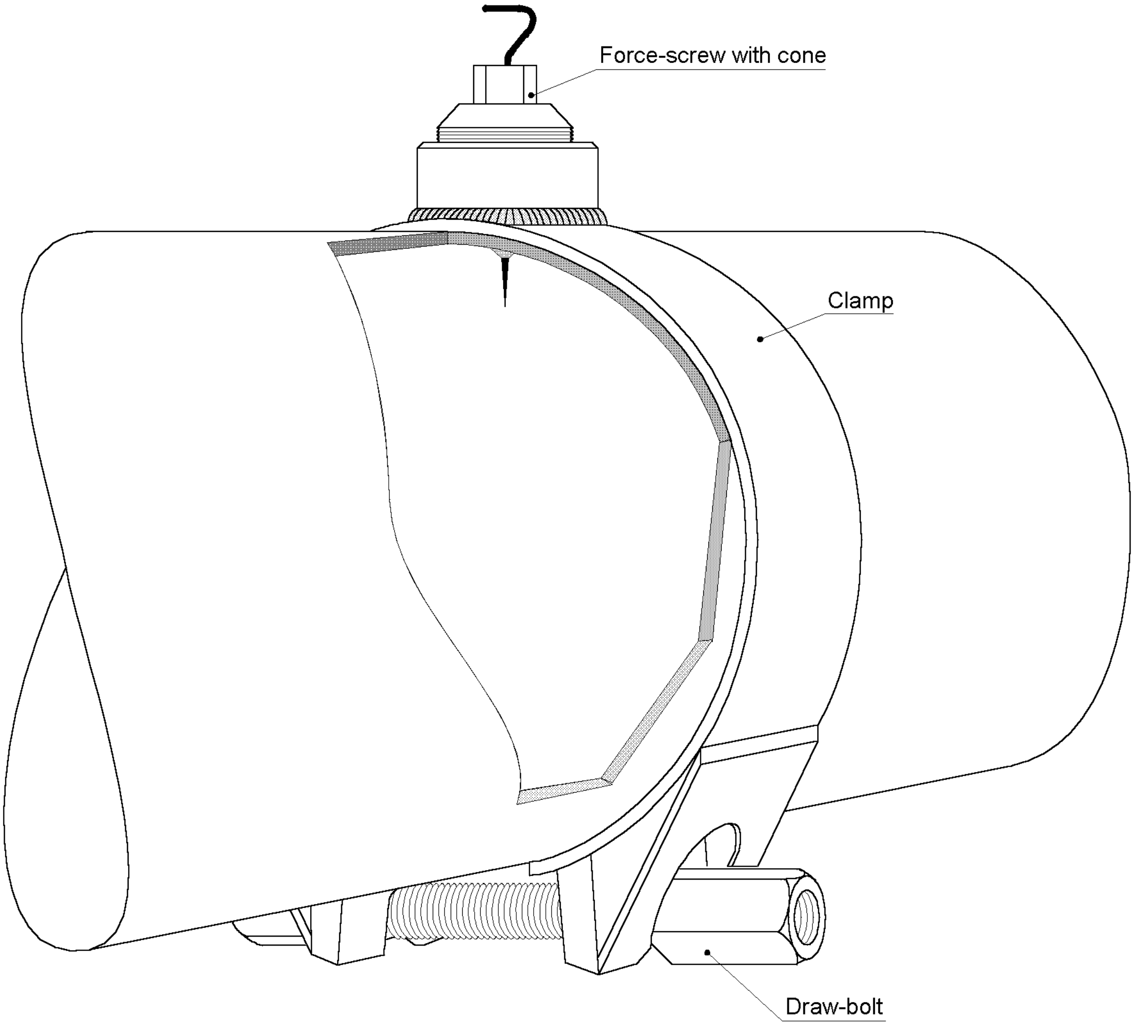


FIGURE 7 LEAK CLAMP



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APPENDIX 3 DRESSING BY HAND-HELD ROTARY GRINDING TOOLS

1. The grinding tools used for dressing shall have a maximum power of 460W and a maximum cutting speed of 70 m/s, e.g. 11600 r/min with a 115 mm diameter wheel.
2. To provide additional safety, it is recommended that grinding machines having a preset overload clutch are used.
3. Grinding wheels of the depressed centre type are suitable but other types of wheel may be used. All wheels shall conform to the following requirements:

Wheel material	-	Aluminium oxide
Grade of grit	-	24 to 36
Bond grade	-	N, P, R, S or T
Bond material	-	Resin
Reinforcement	-	Fabric
Diameter	-	100 - 115 mm
Thickness	-	3 mm minimum

Wheels can be identified by the coding:

A	24	T	B	F	E
Wheel material	Grade of grit	Grade of bond	Bond material	Reinforcement	Manufacturer's code

4. Grinding shall be carried out carefully, avoiding sustained application of the wheel at any location. The aim of dressing shall be to increase the radius of any notches in the affected area until a smooth contour is produced. This shall be achieved by general dressing of the damaged area rather than concentrating on small areas. To avoid the possibility of introducing notches during the dressing operation, an angle of 45° or greater shall be maintained between the wheel axis and the damaged surface.