



**OFFSHORE TECHNOLOGY
REPORT - OTO 97 022**

**SPECIFICATION FOR THERMOPLASTIC
LINED PIPELINES FOR AGGRESSIVE
HYDROCARBON SERVICE**

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Specification for thermoplastic lined pipelines
for aggressive hydrocarbon service.

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FOREWORD

This specification has been prepared by the members of a Joint Industry Sponsored Project evaluating the performance of thermoplastic lined pipelines for aggressive hydrocarbon Service.

The following companies were members of the project:

Agip, Italy
Amerada Hess, UK
BG E&P, UK
BP Exploration, UK
Coflexip Stena, UK
Health and Safety Executive, UK
Marathon Oil, UK
McDermott Engineering, UK
Mobil North Sea, UK
Shell Exploration and Production, UK
Statoil, Norway

1. SCOPE.

1.1 This document refers to the use of tight fitting, non-bonded, thermoplastic linings in ferritic steel pipelines, for conveying aggressive mediums which would normally require the use of corrosion resistant alloys or inhibitors. It is applicable to above ground, buried and sub-sea pipelines.

The operational temperatures shall be within the range -20° to $+150$ deg. C. This range will be dependent on the material properties of the thermoplastic liner. The maximum operating pressure will be determined by the design of the steel pipeline. The strength contribution of the lining shall not be included when designing the pipeline.

1.2 This standard covers pipelines which will be lined at the time of construction and prior to testing. Renovation of existing pipelines is excluded.

2 REFERENCES

- ISO 3183 Linepipe standard
- Part 1: Pipes of quality level A
- Part 2: Pipes of quality level B
- Part 3: Pipes of quality level C
- ISO 4427 Polyethylene (PE) pipes for water supply
- ISO 4437 Buried Polyethylene (PE) pipes for the supply of gaseous fuels.
- ISO 10931 Plastics piping systems for industrial applications:
Poly(vinylidene fluoride) Part 2 Pipes.
- ISO 11414 Preparation of polyethylene pipe/pipe or pipe/ fitting test piece assemblies by butt fusion.
- ISO 11922 Thermoplastic pipes for the transport of fluids-
Dimensions and tolerances
-Part 1: Metric series
- ISO DIS 13847 Welding steel pipelines:
-Part 1: Field welding
-Part 2: Shop welding
- ISO 13953 Polyethylene pipes and fittings - Determination of the tensile strength of test specimens from a butt fused joint.
- ASME B16.5 Steel pipe flanges , flanged valves and fittings.
- ASTM D2513 Thermoplastic gas pressure pipe, Tubing and fittings.

ASTM F714 Polyethylene plastic pipe based on outside diameter.

MSS SP-44 Steel pipe line flanges.

BS 4515 Specification for welding of steel pipelines on land and offshore.

3 ABBREVIATIONS AND SYMBOLS.

3.1 Abbreviations

PE Polyethylene

PVDF Polyvinylidene Fluoride

SDR Standard Dimension Ratio $\frac{\text{(Nominal outside diameter of liner)}}{\text{(Nominal wall thickness)}}$

3.2 Symbols.

4. HANDLING AND STORAGE OF PE PIPES ON SITE

4.1 Pipes and associated materials delivered to the site shall be unloaded carefully.

4.2 All materials delivered to site shall be inspected for obvious physical defects. Rejected material shall be clearly marked **DO NOT USE** and reported to The Engineer who will make the necessary arrangements for its return to the supplier.

4.3 Pipes shall be stored on firm, level ground, free from damaging material, with suitable safe access for vehicles.

4.4 Pipes shall be wedged to prevent accidental movement.

4.5 Pipes shall be stacked not more than four layers high.

4.6 When pipes are to be stored outdoors for periods greater than 3 months in areas with high UV radiation, the pipes shall be covered to limit their exposure.

5. STEEL PIPELINE

5.1 The steel pipe shall conform to ISO 3183 Part 1, 2 or 3, or an equivalent recognised standard.

5.2 The welding of the steel pipes shall be carried out in accordance with BS 4515 (ISO DIS13847), or an equivalent recognised standard.

NOTE: The lining technique used to install the thermoplastic liner may have restrictions on the weld root penetration (or bore reduction). Limits on the

maximum weld root penetration should be obtained from the installer of the liner. These limits should not be exceeded as they may damage the liner or prevent satisfactory insertion of the liner. (see clause 7.1, --Installation of liner).

5.3 Flanged connections shall meet the requirements of ASME B16.5 or MSS SP-44.

Compliance with the design requirements of ASME B16.5 shall be demonstrated when deviating from the flange dimension specified in that standard.

5.4 The installer of the liner shall specify the maximum length of steel pipe to be lined in one operation, the maximum permissible deviation across each joint and maximum curvature of the steel pipe prior to lining.

6. THERMOPLASTIC LINER.

6.1 Material

6.1.1 Factors to be considered during the selection of the liner material shall include (but not limited to)

- Long term effects of the fluid(s) on the liner
- Resistance to pressure change (blistering) and collapse
- Operating temperature and temperature gradient across liner
- Compatibility with pigging operations.
- Absorption of liquids

6.1.2 The thermoplastic liner material shall conform to a recognised International Standard, which takes into account the materials ability to withstand loads associated with the insertion procedure and surface defects introduced during site handling or insertion. (eg .For polyethylene acceptable standards are ISO 4427, ISO 4437, ASTM D2513, ASTM F714. For PVDF consideration should be given to the requirements of ISO 10931-2).

6.1.3 The dimensional tolerances of the thermoplastic liner shall comply with ISO 11922-1.

The supplier of the lining system shall specify the outside diameter of the liner to ensure a tight fit inside the steel pipeline (Section 5).

6.1.4 The liner shall be sized to remain in contact with the bore of the steel pipe at -10°C and not cause buckling at the maximum operating temperature of the pipeline.

6.2 Liner Fabrication

6.2.1 The liner pipes shall be inspected for cuts, deep scratches or other damage before use. Any defective material shall be discarded. (Scratches deeper than 10% of the liner pipe wall thickness shall be cause for the liner to be rejected).

6.2.2 Before the liner pipe is fusion jointed, bores shall be inspected and any foreign matter cleared. Use should be made of end caps or stoppers for temporary sealing of ends.

6.2.3 Precautions should be taken when carrying out pipe jointing when the air temperature is below -5°C or above 40°C .

6.2.4 It is essential that the pipe is supported to prevent it being moved during the heating, fusion and cooling phases. Pipes shall be supported on rollers to avoid misalignment due to sagging.

6.2.5 The pipes shall be joined using an approved, written, butt fusion procedure. Fusion joints prepared in accordance with ISO 11414, using this procedure shall be evaluated against the requirements of ISO 13953. The operator shall be trained in the techniques of butt fusion and quality control. A written quality control procedure for butt fusion joints should be available.

6.2.6 The butt fusion machines shall be in good working order. An automatic butt fusion machine, with a print out of fusion parameters, should be preferred over a manually operated machine. All correctly sized pipe shells shall be available for the diameters being joined. At the beginning of a project, a calibration certificate shall be available for pressure gauges, transducers and hot plate temperature profile.

6.2.7 Butt fusion heater plates shall be connected to the power source at all times during jointing operations.

6.2.8 Consideration should be given to the use of portable shelters at the jointing location and temporary end caps at the exposed ends of the pipe to protect the fusion joint from the effects of weather and wind blown dust. The heat loss from fusion tools should be minimised by using purpose built boxes or heater muffs.

6.2.9 Before the first joint of the day is made, or any change of pipe diameter, the hot plate shall be placed in the machine and the pipes brought up to form a weld bead. **Do not fuse this joint.** Remove the hotplate, allow the melt to cool for a few minutes, then trim back beyond the bead. Normal jointing may then continue. This is to remove any dust particles which may be on the heater plate.

6.2.10 The weld bead width shall be measured and checked against agreed tolerances, based on pipe diameter, wall thickness, melt viscosity etc. All external and internal weld beads shall be removed for inspection. The bead removal tool shall not impair the performance of the pipe material or joint performance.

Where bead inspection identifies a faulty joint the joint shall be cut out and the jointing procedure repeated.

7. INSTALLATION OF LINER

7.1 The internal bore of the pipeline should be sized using a suitable gauging pig. This should establish the minimum bore of the pipe to be lined and also

highlight any internal obstructions which may impede the insertion of the liner. Any obstruction (eg excessive weld root or misalignment) shall be removed prior to lining.

7.2 The contractor undertaking the lining operation should provide a technical file with details of the installation method, including initial liner outside diameter, unrestricted recovered diameter (demonstrating a tight fit can be achieved inside the steel pipeline) and reversion procedure.

7.3 The lining operation shall be carried out following the installers written procedure.

7.4 Before installation, the liner shall be pneumatically pressure tested to 100 mbar for 10 minutes, during which time appropriate safety precautions shall be taken. A test certificate shall be issued on completion of the test.

7.5 The lining of steel pipelines involves the use of winching equipment. The following essential precautions shall be taken:

- The engineer shall ensure that all equipment is of suitable construction for its duty and in good working condition. Those who operate the equipment shall be adequately trained.
- The rig, winch, lifting and towing equipment (eg cable, rope) shall be visually inspected for damage and wear prior to use.
- Shackles, chains, lifting slings and towing eyes shall be clearly stamped with SWL details and test certificates shall be available upon request.
- The lining rig shall be of adequate design to withstand the forces likely to be imposed during operation. It shall be proof tested and labelled with its SWL.
- The winching equipment shall be fitted with a calibrated load indicator.

7.6 The length of exposed cables/ ropes under tension shall be kept to a minimum and contained or constrained against breakage. Adequate precautions shall be taken to ensure that all personnel are protected from the length of exposed cable or rope under tension.

7.7 Anchorage should be provided to prevent unexpected movement whilst the liner is set out on rollers.

7.8 During the lining operation the towing rates, inserted pipe sizes and towing loads should be recorded. The maximum towing force on the liner should not exceed the maximum value recommended by the system contractor.

7.9 After insertion the liner should be allowed to relax for a period of not less than 6 hours.

7.10 Guidance on pressure testing a lined pipeline is given in Appendix 1.

8. INTERMEDIATE AND END CONNECTIONS

8.1 Intermediate connectors.

8.1.1 Intermediate connectors are required to connect the lined sections of pipe together to form the completed pipeline. The connector shall provide a means of anchoring the liner to the pipeline, providing a leak tight seal between the pipe bore and liner annulus and allow the lined pipe sections to be connected (by welding or bolting flanges) together whilst retaining the corrosion control over the joint area.

8.1.2 Intermediate joints shall be subjected to approval testing to show fitness for purpose, against a specification prepared by the pipeline installer. This specification should include welding trials and bend and end load tests, as appropriate.

8.1.3 Intermediate joints should have the same outside diameter as the lined pipeline (unless flanged).

8.2 End Connectors.

8.2.1 End connectors are required to connect lined sections of pipe together or to connect onto flanges, valves, or mechanical fittings. They may contain a flanged body or a geometry to suit the connecting part. The connector shall provide a means of anchoring the liner to the pipeline, providing a leak tight seal between the pipe bore and liner annulus.

8.2.2 Any exposed (un-lined) sections of the end connectors shall be at least equal to the corrosion resistance offered by the liner.

8.2.3 End connectors shall be subject to approval testing to show fitness for purpose, against a specification prepared by the pipeline installer.

9. TESTING.

9.1 The lined pipelines shall be tested in accordance with the conditions of the contract prior to hand over.

9.2 Any special requirements for the pressure testing of the lined pipeline shall be identified by the contractor in his tender submission.

9.3 All test and inspection equipment shall have valid calibration certificates.

10. DOCUMENTATION.

10.1 The contractor shall record and maintain records of the following :

- Liner material and specification
- Liner original dimensions
- Butt fusion parameters and test data
- Result of QA on each butt fusion joint
- Lining installation procedure
- Die/ Roller reduction (if appropriate)
- Reversion procedure
- End terminations
- Pressure testing
- Process verification results, carried out to show fitness for purpose.

APPENDIX 1

Pressure test procedure for thermoplastic lined pipelines

1.1 Introduction

The need for pressure points to be welded to the pipeline prior to lining is still under review. These pressure points are to provide vents for liquids and gases trapped in the annulus between the liner and steel pipe. The size and distance between each vent point has still to be established.

The following procedure has been performed by Coflexip Stena Offshore Ltd (CSOL) on steel pipelines lined with polyethylene.

1.2 The vents are open during the insertion of the liner.

1.3 For insertion techniques which revert naturally through the 'elastic' properties of the material, the liner is allowed to relax/ recover for a minimum of 24hrs.

1.4 For insertion systems which require hydrostatic pressure to give the tight fitting liner should be reverted following the manufacturers guidelines. The reversion procedure may have to be modified to allow any trapped air to be expelled through the vents during the reversion process.

1.5 Install Liner End Connectors. The lined pipeline is sealed using eg Blind flanges or blanking plates, and the bore flooded.

1.6 Pressurise the bore in 1 bar increments whilst monitoring the passage of gases / rain water etc. out of the vent ports. When flow through the vents has stopped, increase to the next pressure increment; **Note:** this is not time dependant. Increase the bore pressure in this manner up to 35 bar where, for the HDPE liners used, the liner stresses are well past yield.

1.7 Hold the 35 bar pressure in the pipeline bore and seal the vents, thus ensuring the tight fit and minimum size of micro annulus.

1.8 Release the line pressure.

The pipestalk can be stored until reeling or installation/ pipelaying is commenced. Once installed the pipeline is flooded with water, at ambient pressures, and a calliper pig sent down the line. A standard pipeline pressure test can then be performed.

Pressure should be released back to ambient until full commissioning. (The pipeline may be pigged prior to commissioning with pressure differentials of up to 10 bar to drive the pig.)