MANUAL

# PLASTIC-LINED STEEL PIPES AND FITTINGS

DEP 30.48.50.12-Gen.

December 1995
(DEP Circular 29/98 has been incorporated)

**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.

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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 DEP specifies requirements for the qualification testing of suppliers and the fabrication, application, installation, testing, inspection and transportation of plastic-lined steel pipes, fittings and flanges.

This DEP is a revision of the DEP of the same number entitled "Application and Installation of Plastic-Lined Steel Piping", issued in April 1988, combined with a revision of DEP 30.48.50.32-Gen. "Requirements for Plastic-Lined Steel Pipes and Fittings", issued in May 1988 (which is now withdrawn).

This DEP is applicable to steel piping suitable for operating pressures up to 10 bar (ga) with nominal diameters from 25 mm to 450 mm, with plastic liners manufactured from:

- polypropylene (PP);
- polyvinylidene fluoride (PVDF);
- perfluoro (ethylene-propylene) copolymer (FEP);
- polytetrafluoroethylene (PTFE); or
- perfluoro (alkoxyaline) copolymer (PFA).

This DEP is not applicable to transmission pipelines, for example in SIEP operations, where plastic-lined pipelines are used for the transport of oil, gas and water.

Reference is also made to piping classes for PP-lined steel pipe and PTFE-lined steel pipe, which are included in DEP 31.38.01.12-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 Manufacturer/Suppliers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants and, where applicable, in oil and gas production facilities and supply/marketing installations.

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

The **Principa**l 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 **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 sometimes 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 word **shall** indicates a requirement.

The word **should** indicates a recommendation.

## 1.4 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 (12).

## 2. APPLICATION

### 2.1 GENERAL

Plastic-lined piping is suitable for the transport of toxic, flammable or aggressive/corrosive products.

With respect to safety aspects, pressure rating, etc., the regulations which apply to steel piping are also valid for plastic-lined steel piping. They are not subject to the restrictions that may exist for the use of the plastics in connection with their mechanical weakness, low melting point or flammability.

Plastic-lined piping is mainly used in above-ground installations.

### 2.2 PIPE SELECTION

Plastic-lined steel pipe should be selected in consultation with a Materials and Corrosion engineer. The selection is determined by:

- service conditions (pressure, temperature and medium);
- design;
- fabrication method.

### 2.3 THERMAL CHARACTERISTICS

Each liner material has a specific temperature limit. The following table gives the upper and lower design temperature limit for each type. The maximum temperature limits shall be used for guidance only, since the chemical service conditions may significantly lower these limits.

| Material | Upper design temperature (°C) | Lower design emperature (°C) |
|---|---|---|
| PP | 105 | -18 |
| PVDF | 135 | -18 |
| FEP | 200 | -20 |
| PTFE | 260 | -29 |
| PFA | 260 | -29 |

Actual service temperatures should be based on experience or tests. Extreme temperature cycling may lead to failure of the liner, and should be avoided.

Although the thermal conductivity of plastic-lined steel piping is lower than that of steel, it is suitable for use in a heat-traced system.

### 2.4 VACUUM APPLICATIONS

The standard type of plastic-lined piping can be applied only to a limited extent in vacuum service. The amount of vacuum to which a specific pipe can be exposed is dependent not only on the operating temperature and the medium to be transported, but also on pipe characteristics such as:

- type of liner;
- liner thickness;
- manufacturing method;
- pipe diameter.

In general, lined pipes manufactured in accordance with the swaging technique can be exposed to a higher degree of vacuum than pipes with a loose liner, unless the loose liner

thickness has been increased.

The vacuum failure threshold must be known before applying a specific liner in vacuum service, see (7.2.9).

To avoid liner buckling and collapse a vacuum breaker should be installed if an excessive vacuum is expected, for example caused by condensation of hot vapours, or cooling and contraction of hot liquids.

## 2.5 FLOW CHARACTERISTICS

The friction factor for the flow of fluids in plastic-lined pipes is approximately 25% lower than in unlined steel pipes.

## 2.6 BLISTERING AND/OR DISCOLORATION

In PVDF-lined and PTFE-lined piping used for the transport of steam or fluids containing $Cl_2$ and/or HCl, occasional occurrence of blisters and/or discoloration can be observed, particularly in stretched areas. In general, this blistering is only a surface effect, and immediate failures have not been experienced. However, if blisters have a diameter of more than 1.5 mm the pipe length concerned shall be replaced.

In order to avoid excessive blistering in plastic-lined systems transporting warm or hot streams, insulation should be used to equalize the heat flow difference between the metal and the liner (i.e., a "cold bridge").

## 3. QUALIFICATION TESTING AND PRODUCTION INSPECTION/TESTING

### 3.1 QUALIFICATION TESTING

The Principal shall specify if the Manufacturer is required to perform qualification testing in accordance with Section 7.

The Principal shall specify if the qualification testing shall be performed by, or witnessed by, an independent authorised body approved by the Principal.

### 3.2 PRODUCTION INSPECTION AND TESTING

Production inspection and testing shall be as specified in Section 8.

## 4. MATERIALS REQUIREMENTS

### 4.1 GENERAL

A liner for steel piping is a dimensionally stable plastic, normally with a thickness of more than 1 mm, which is inserted or moulded into a steel housing, in order to combine the structural strength of steel with the chemical resistance of the plastic material. For chemical resistance of liner materials, see DEP 30.10.02.13-Gen.

### 4.2 LINER MATERIALS

Only virgin polymers shall be used for the production of the liner; with a maximum of 0.2% wt of additives (11.1). The use of colouring agents should be avoided. A larger quantity of additives (>0.2% wt) may be added if electrically conductive properties are required.

Additives or colouring agents shall be finely homogenized.

### 4.3 CARBON STEEL SUBSTRATE

The carbon steel piping and flanges shall be in accordance with the piping design code and/or the piping class specified by the Principal.

## 5. DESIGN, MANUFACTURING AND FABRICATION REQUIREMENTS

### 5.1 DESIGN

**Amended per Circular 29/98**

Standard Drawings S 38.150, S 38.151, S 38.152 and S 38.153 shall apply.

PTFE-lined and FEP-lined pipe and fittings shall be provided with a venting system in order to avoid entrapment of gases between the liner and the steel pipe.

Depending on the fabrication method, venting is achieved either by vent holes or by spiral grooves at the inside of the pipe, venting through a perforated metallic back-up gasket (a locking collar).

For vent holes, the following shall apply:

| PIPE SPOOL LENGTH | REQUIRED VENT HOLES | |
|---|---|---|
| | Diameter | Number |
| < 400 mm | 3 ± 0.5 mm | One at mid-point between the flanges. |
| 400 to 1000 mm | 3 ± 0.5 mm | One adjacent to each flange. |
| > 1000 mm | 3 ± 0.5 mm | Two, perpendicular to each other, at a distance of 150 mm from each flange. |

### 5.2 MANUFACTURE

#### 5.2.1 Plastic liners

The thickness of the plastic liner shall be in accordance with Appendix 2.

The physical properties of the plastic liner shall be in accordance with Appendix 3.

Pipe liners of PP, PVDF, FEP and PFA shall be manufactured by means of a melt extrusion technique. PTFE pipe liners shall be manufactured by one of the following methods, and shall fit snugly in the pipe:

- paste extrusion and sintering;
- ram extrusion and sintering;
- isostatic moulding and sintering;
- tape winding and sintering.

For alternative liner fabrication techniques, such as dispersion application and skived sheet welding, agreement from the Principal shall be obtained.

For fittings, liners of PP, PVDF, FEP and PFA shall be made by moulding, e.g. extrusion, injection, transfer moulding, or rotomoulding (for PFA liners).

For fittings, liners of PTFE shall be made by isostatic moulding or by applying pipe liners or preformed pipe liners in the fittings. Liners in fittings shall fit snugly to the steel substrate. Insertion methods are described in (5.3).

At the flanges the liner shall be flared or moulded and shall properly fit to the steel flange facing. The diameter of the flare shall be concentric to that of the lining in the pipe. The minimum flare diameter covering the flange shall be as specified in Appendix 2.

#### 5.2.2 Steel piping preparation

The interior surface of the steel pipes and fittings shall be smooth, clean and free from burrs, scale or other deposits. All welds shall be ground smooth to prevent mechanical damage to the liner.

Pipes used in the swaging operation do not have a smooth inner surface; these are provided with an upset roughened inner surface or a spiral groove surface.

If the plastic is present as a loose liner, the flange edges covered by the liner shall be

rounded off to a minimum radius of:

- 2 mm for pipe sizes to 65 mm;
- 3 mm for pipe sizes to 100 mm;
- 4 mm for pipe sizes of 150 mm and 200 mm;
- 5 mm for pipe sizes of 250 mm and larger.

For the swaged type of lined piping it is not necessary to round-off the flange edges.

The locking collar which has to be fitted between the steel flange facing and the plastic flare (Appendix 1) shall be rounded with the same radius as mentioned above.

Carbon steel parts shall be painted externally in accordance with DEP 30.48.00.31-Gen.

## 5.3. FABRICATION OF LINED PIPING

Basically, two techniques are used to apply the plastic lining to the steel pipe. These are:

- the "loose liner" process, or
- the swaging process.

For other methods, agreement from the Principal shall be obtained.

In the loose liner process, a stretched plastic tube is relaxed by thermally treating it when inside the steel pipe. As the longitudinal strain is relaxed, the plastic liner diameter increases, producing a tight fit in the steel pipe. Each end of the plastic tube is flared or moulded over the pipe flange face to produce a gasket surface.

Tape-wound PTFE liners are inserted in the steel pipe without stretching.

In the swaging process a plastic tube is inserted in an oversized steel pipe that has had its inner surface roughened. The steel pipe is then swaged to a standard diameter. In this operation, a mechanical "lock" between the liner and the steel tube is obtained. The liner ends are also flared or moulded over the flange at each end of the steel pipe.

Fittings are lined with melt processable plastics by in-situ moulding. PTFE liners are usually installed by isostatic moulding, using special moulds.

Fittings can also be lined by the "loose liner" process.

## 5.4. CONNECTIONS

Connections in plastic-lined piping shall be made with flanges.

### 5.4.1 Flanges

The type of flanges shall be in accordance with the piping design code and/or the piping class specified by the Principal.

### 5.4.2 Gaskets

PTFE envelope gaskets shall be used if plastic-lined steel piping is connected to flanges of a dissimilar material.

No gaskets are required between flanges of lined pipes and fittings unless repeated connections and disconnections have to be made, in which case PTFE envelope gaskets should be used.

## 6. INSTALLATION

### 6.1 GENERAL

The installation of plastic-lined piping is performed similarly to normal flanged steel piping with respect to supporting, thermal expansion, etc.

### 6.2 FLANGE CONNECTIONS

The piping shall be installed such that no damage is caused to the liner. Smooth metal or glass-fibre support guide plates, 1 mm nominal thickness, should be used when making connections or when installing sections in an existing line. Flange facings shall be cleaned prior to installation. Gaskets should only be installed under circumstances mentioned in (5.4).

A lap-joint flange may be used on one end of each straight pipe to enable bolt alignment during installation, especially in combination with glass-lined piping or equipment; the other flange may be rigid to the pipe.

In the case of a totally plastic-lined system all flanges can be rigid to the pipes and fittings.

### 6.3 FLARING

Flaring shall not be performed in the field unless it is unavoidable.

Whenever possible, flaring shall be carried out in a workshop using equipment supplied by the Manufacturer of the plastic-lined pipe and according to a detailed procedure based on the Manufacturers advice. The prefabricated plastic-lined pipe lengths, having flanges with shop-flared or moulded ends should be supplied for installation in the field.

To adapt an existing plastic-lined pipe to the designed length, spacers or distance pieces lined with the same polymer shall be used. Solid spacers should be used only to a maximum thickness of about 6 mm.

In flaring, special attention shall be given to:

- cutting of steel tube (for swaged type pipes only);
- flare temperature;
- cooling rate after flaring.

The flaring tool shall not be removed before the pipe has cooled down to ambient temperature.

For swaged-type pipes, only threaded flanges with straight or tapered thread shall be used for field fabrication. Flanges shall be fully tightened and secured by tack-welding in order to prevent inadvertent turning, which will damage the liner. The pipe end shall be provided with sufficient threading to accommodate the flange.

A perforated metal ring shall be used as a back-up gasket for pipes made by the swaging method. No back-up gasket is required if a socket flange with a fully radiused edge is used.

Immediately after the flaring operation a wooden or metal flange protector shall be installed to prevent mechanical damage prior to installation and to keep the flared end in position.

### 6.4 BOLTING

Flange bolts shall be tightened with a torque wrench, using greased bolts and nuts, in the sequence and to the torque values as specified by the Manufacturer of the plastic-lined pipe. Too great a bolt loading may damage the plastic facing on the flanges.

Appropriate spring washers should be used between the nut and the flange. Bolts should be retorqued after a service period of 24 hours.

### 6.5 WELDING

No welding shall be performed on lined piping, nor shall lined piping be used as a welding

earth, as these will cause irreparable damage to the liner.

## 6.6 VENTING SYSTEM

Care shall be taken that the vent holes (5.1) do not become blocked by paint or other deposits. Regular inspection of the vent holes should be made. Sharp tools shall not be used to clean the vent holes. If lined piping is insulated, vent hole extensions shall be used.

## 6.7 DISASSEMBLING

Plastic-lined steel pipes and fittings shall be dismantled from an existing pipeline only at temperatures below 40 °C to prevent retraction of the plastic flange face. Immediately after disconnection, a flange protector shall be installed on each flange face.

## 6.8 MARKING

The lined piping system shall be marked to identify it as lined in order to prevent inadvertent damage of the liner, e.g. by welding.

## 7. QUALIFICATION TESTING

### 7.1 GENERAL

The qualification testing shall be carried out on products with representative diameters. The type of product, number of tests, etc. shall be agreed with the Principal.

The resin or granulate used to fabricate the liner shall comply with the specification of the resin or granulate Manufacturer.

The welds in the lined steel pipes and fittings shall comply with the piping design code and/or the piping class specified by the Principal.

### 7.2 FINISHED PRODUCTS

The following qualification requirements apply to the finished products. All tests shall be carried out at ambient temperature on an inspectable pipe length, unless otherwise indicated.

#### 7.2.1 Appearance

The internal surface of the plastic liner shall be free from defects, such as blisters, cracks, scratches, dents, nicks or sharp tool marks which would be expected to affect the performance of the liner.

Absence of these defects shall be determined visually or with a liquid penetrant.

The plastic liner shall fit snugly to the steel housing, and no entrapments shall be present between the plastic liner and the internal surface of the substrate.

Vent holes, if applicable, in the steel pipe shall not be blocked by paint or other deposits.

#### 7.2.2 Microscopic examination

Microscopic examination at 10 times magnification or visual examination by means of transmitted light shall show no voids, foreign inclusions or other internal defects which could affect the performance of the liner. For alternative non-destructive testing techniques the Principal shall be consulted.

#### 7.2.3 Thickness of the liner

The thickness of the plastic liner shall be measured at both ends of the pipes and fittings at the facing of each flange, and shall comply with Appendix 2. A reduction of 20% at the flange facing due to the flaring is acceptable.

Variations in wall thickness shall not be greater than 25%.

#### 7.2.4 Physical properties

The physical properties of the liner shall shall comply with Appendix 3.

#### 7.2.5 Holiday test

A holiday test shall be performed in accordance with ASTM D 5162 (with a maximum voltage of 25 kV) and the acceptance criterion shall be zero holidays.

#### 7.2.6 Hydrostatic pressure test

Pipes and fittings shall not show any sign of leakage when subjected to a hydrostatic pressure test in which the test pressure is equal to 1.5 times the design pressure and is maintained for at least 3 minutes.

#### 7.2.7 Thermal cycle testing

Pipe fittings lined with FEP, PTFE and PFA shall not show buckling, cracking or any other defects except small blisters with a maximum diameter of 5 mm and a maximum height of 0.5 mm, and shall pass the high-voltage spark test as described in (7.2.5) after being

subjected to one of the following cycling tests.

1) 100 cycles of a steam/cold water test, each cycle consisting of:
   - 165 minutes steam at 180 °C and 10 bar pressure;
   - drain condensate;
   - 14 minutes cold water at ambient temperature;
   - drain water.

2) 500 cycles of a steam/cold water test, each cycle consisting of:
   - 3 minutes steam at 180 °C and 10 bar pressure;
   - drain condensate;
   - 3 minutes cold water at ambient temperature;
   - drain water.

Pipes and fittings lined with PP and PVDF shall be able to withstand the same thermal cycle testing and pass the high-voltage spark test except that cycling is carried out with water at 80 °C for PP and with steam at 110 °C and 1.5 bar pressure for PVDF.

### 7.2.8 Pressure/temperature testing

The liner of the pipes and fittings shall not show any cracks or distortions and shall also pass the high-voltage spark test as described in (7.2.5) after the lined parts have been heated with air for three hours at the following temperature and initial pressure measured at the inside:

| Liner material | Temperature (°C) | Initial pressure bar (ga) |
|---|---|---|
| PP | 105 | 6.2 |
| PVDF | 135 | 5.7 |
| FEP | 200 | 4.7 |
| PTFE | 260 | 4.1 |
| PFA | 260 | 4.1 |

Thereafter the pipe shall be cooled in air to room temperature without releasing the pressure. The heating/cooling cycle shall be repeated three times.

### 7.2.9 Vacuum testing

This test shall be performed only for piping intended for vacuum service or for services in which the gas can diffuse through the liner (e.g. chlorine, bromine). The Principal shall specify if this test is applicable.

To determine conformity with the Manufacturer's recommended vacuum rating, the testing shall be performed as follows.

A minimum of two pipes or fittings shall be tested. Pipe specimens shall have a length of at least 10 pipe diameters.

The tests shall be performed at the Manufacturer's maximum recommended service temperature, or at a lower temperature if the rated vacuum cannot be encountered at the maximum recommended service temperature. A flange incorporating a sight glass shall be installed at one end and a blind flange suitable for drawing vacuum at the other end. The specimens shall be externally heated in a uniform way, with the sight glass visible.

A selected initial vacuum level shall be applied after the steel housing has reached the desired temperature. This vacuum level shall be held for eight hours. If no buckling or collapse occurs, the vacuum level shall be increased by 50 mbar. This procedure shall be repeated every 24 hours until failure occurs.

The vacuum failure threshold is defined as 34 mbar less vacuum than the level at which failure occurs.

The Manufacturer's recommended vacuum rating shall be at least 20% more vacuum than

the vacuum failure threshold.

After completion of the test, a duplicate specimen shall be heated to the test temperature. After the steel housing has reached the test temperature, the manufacturer's recommended vacuum rating shall be applied within a period of two minutes. This vacuum level shall held for 48 hours. No buckling or collapse of the liner shall occur during this test.

## 8. PRODUCTION INSPECTION AND TESTING

### 8.1 GENERAL

Production inspection and testing shall be as specified in this Section. The Principal shall specify if additional inspections and tests are required.

### 8.2 SHOP INSPECTIONS AND TESTS

#### 8.2.1 Visual inspection

All pipes and fittings shall be visually inspected in accordance with (7.2.1).

#### 8.2.2 Thickness of the liner

The thickness of the liner of all pipes and fittings shall be inspected in accordance with (7.2.3).

#### 8.2.3 Holiday test

All pipes and fittings shall be holiday tested in accordance with (7.2.5).

#### 8.2.4 Hydrostatic pressure test

Ten per cent of the pipes and fittings shall be subjected to a hydrostatic pressure test in accordance with (7.2.6). The Principal shall be consulted for those cases where testing would result in damage of the pipe ends caused by the end caps. Alternatively, an underwater air test may be carried out under conditions agreed by the Principal.

### 8.3. HYDROSTATIC PRESSURE TEST OF INSTALLED PIPE

Installed piping systems shall be pressure-tested with water at ambient temperature at a pressure of 1.5 times the design pressure for a period of at least 4 hours. There shall be no weeping at flanges or through vent holes, if present, during this test. The pressure may fluctuate due to variations in ambient temperature, and care shall be taken that the test pressure does not exceed the lowest rated element in the system.

## 9. MAINTENANCE AND REPAIR

### 9.1 MAINTENANCE

Vent holes shall be kept free from paint or other deposits; sharp tools shall not be used for this purpose.

The vent holes and flange bolt torques shall be checked regularly.

Blocked pipes and fittings should be cleaned with low-pressure water only; the use of rods or steam jets shall be avoided.

Blisters and discolorations found in dismantled PTFE-lined and PVDF-lined pipes and fittings should not normally be a reason for rejection, see (2.6).

### 9.2 REPAIR

Lined pipes and fittings shall not be repaired by welding, since heat will cause damage to the liner. If damage occurs to a component of an installed piping system, the damaged component shall be replaced. Consideration may be given to returning damaged pipes to the Manufacturer for relining. Leakage at flanged connections shall be remedied by the measures in the following sequence:

- Retorquing of flange bolts to the specified values. Care shall be taken that these values are not exceeded;
- Installation of a new PTFE envelope gasket using the same specified bolting torques;
- Replacement of the pipe spool having the suspect flange face.

## 10. HANDLING AND STORAGE

### 10.1 MARKING

All pipes and fittings shall be permanently marked with the Manufacturer's name or trade name, the type and rating of the lining, the nominal diameter, and the pipe spool number if specified by the Principal.

The marking shall remain legible under normal handling and installation practices.

Markings for identification purposes shall be made such as not to impair the integrity of the pipe/fitting material.

### 10.2 PACKAGING

The pipes and fittings shall be packed in a manner which will ensure arrival at destination in an undamaged and clean condition. Pipe ends shall be protected with suitable protective cover plates. The cover plates shall be securely attached. The plates shall be such that they also prevent stretching of the flared liner ends.

### 10.3 HANDLING

Care shall be exercised to avoid damage to the plastic liner during handling. The protective cover plate mounted on the flanges shall be left in place until installation. If the plates have to be removed for testing or inspection, they shall be re-installed immediately thereafter.

### 10.4 STORAGE

Each pipe spool and fitting shall be stored with an identification label specifying manufacturer, type of liner, size, length, recommended bolting torque, design pressure and upper design temperature.

The pipes and fittings shall be stored in such a way that damage to the plastic liner is avoided. Pipe and fittings shall be stored with their protective cover plates installed.

Care shall be taken that the vent holes do not become blocked during storage.

## 11. DOCUMENTATION

The applicable dimensions and tolerances of pipes, fittings and flanges shall be stated on the Manufacturer's drawings.

The Manufacturer shall keep a traceable record of all materials and products and of the quality controls performed, and shall maintain this record for at least five years from the date of manufacture. These records shall be sufficient to demonstrate compliance with the purchase order and the Manufacturer's standards

If specified in the purchase order, the Manufacturer shall submit a certified record of inspection and testing together with a statement of compliance with the purchase order. This certification shall also state the maximum service ratings for temperature, pressure and vacuum.

## 12. REFERENCES

**Amended per
Circular 29/98**

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. |
| Non-metallic materials - Selection and application | DEP 30.10.02.13-Gen. |
| Painting and coating of new equipment | DEP 30.48.00.31-Gen. |
| SIOP piping classes | DEP 31.38.01.12-Gen. |

### STANDARD DRAWINGS

| | |
|---|---|
| Pipe spools and spacers for plastic-lined piping systems class 150 | S 38.150 |
| Flanged fittings for plastic-lined piping systems class 150 | S 38.151 |
| Flanged fittings for plastic-lined piping systems class 150 | S 38.152 |
| Branch piece, wafer type, for plastic-lined piping systems class 150 | S 38.153 |

### AMERICAN STANDARDS

| | |
|---|---|
| Steel pipe flanges and flanged fittings | ASME B16.5 |

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| | |
|---|---|
| Test method for tensile properties of plastic | ASTM D 638 |
| Test method for specific gravity (relative density) and density of plastics by displacement | ASTM D 792 |
| Standard practice for discontinuity (holiday) testing of nonconductive protective coating on metallic substrates | ASTM D 5162 |

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*1916 Race Street*
*Philadelphia, Pa 19103*
*USA*

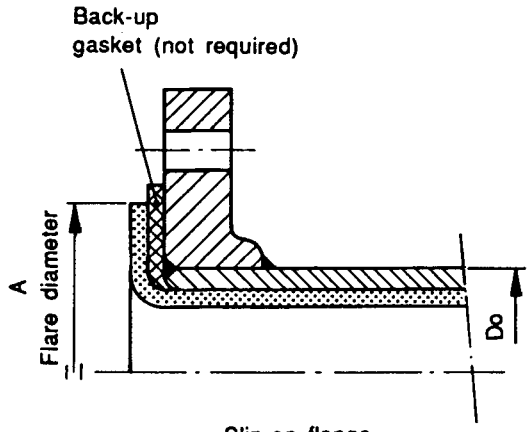
### INTERNATIONAL STANDARDS

| | |
|---|---|
| Plastics; determination of tensile properties. | ISO 527 |
| Plastics; methods for determining the density and relative density of non-cellular plastics. | ISO 1183 |

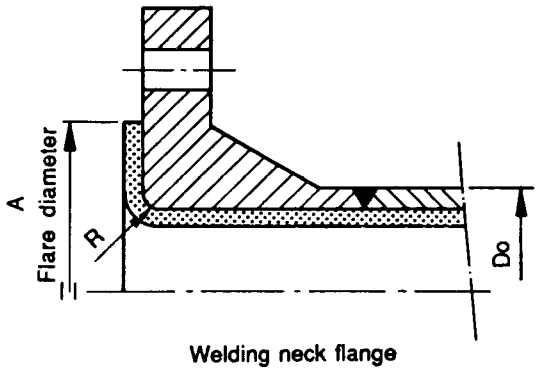
*Issued by:*
*International Organisation for Standardisation*
*1, Rue de Varembé*
*CH-1211 Geneva 20*
*Switzerland*

*Copies can also be obtained from national standards organizations.*

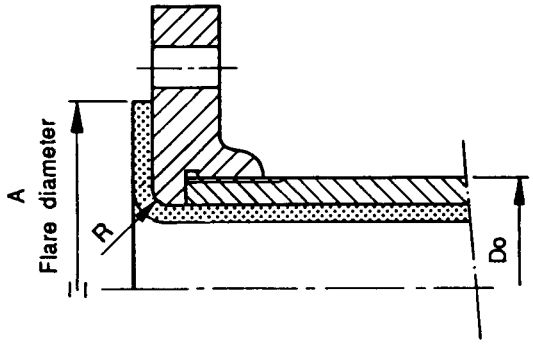
## APPENDIX 1 TYPICAL FLANGE CONNECTIONS



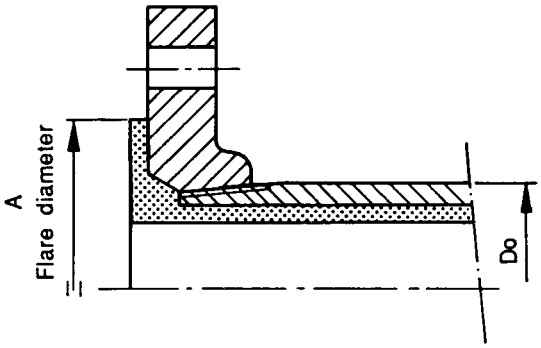

Slip-on flange



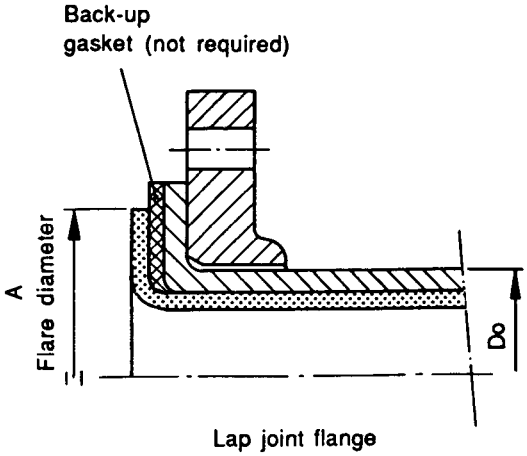

Welding neck flange



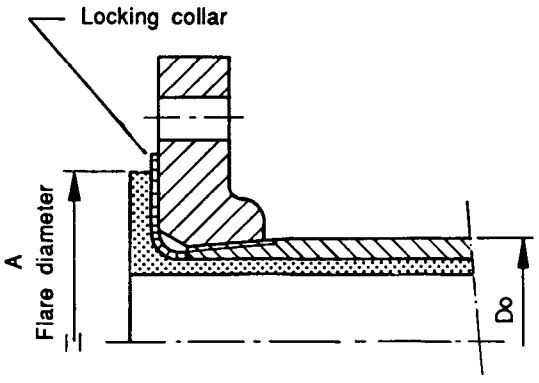

Threaded socket flange
with flared liner




Threaded flange
with moulded liner




Lap joint flange




Threaded flange with perforated
metallic back-up gasket

## APPENDIX 2 DIMENSIONS OF LINERS AND FLARES

| Nominal pipe size, mm | Minimum liner thickness, mm | | | | | | Minimum flare diameter, mm (2) |
|---|---|---|---|---|---|---|---|
| | PP | PVDF | FEP | PTFE | PTFE(1) | PFA | |
| 25 | 3.2 | 3.8 | 1.9 | 1.5 | 3.0 | 1.9 | 51 |
| 40 | 3.8 | 4.0 | 1.9 | 1.6 | 3.9 | 1.9 | 73 |
| 50 | 4.3 | 4.3 | 1.9 | 1.7 | 3.9 | 2.0 | 92 |
| 80 | 4.4 | 4.4 | 2.3 | 2.4 | 4.0 | 2.2 | 127 |
| 100 | 5.2 | 5.2 | 2.4 | 2.7 | 4.5 | 2.4 | 157 |
| 150 | 5.5 | 5.5 | 3.3 | 3.7 | 5.0 | 3.3 | 216 |
| 200 | 5.5 | 5.5 | 3.3 | 4.0 | 5.0 | - | 270 |
| 250 | 6.3 | - | 3.5 | 5.0 | 6.5 | - | 324 |
| 300 | 6.3 | - | 3.5 | 5.3 | 8.1 | - | 381 |
| 350 | 7.2 | - | 3.5 | 6.0 | - | - | 413 |
| 400 | 7.2 | - | 3.5 | 6.3 | - | - | 470 |
| 450 | - | - | - | 7.5 | - | - | 533 |

NOTES: 1) Special thickness for vacuum service **or** for gases that can diffuse through the liner service (e.g. chlorine, bromine), only applicable when specified by the Principal.

2) Based on the diameter of the raised face in accordance with ANSI/ASME B16.5.

## APPENDIX 3 PHYSICAL PROPERTIES OF PLASTIC LINER MATERIAL

| | LINER MATERIAL | | | | | | |
|---|---|---|---|---|---|---|---|
| | PP | PVDF | FEP | PTFE | | | PFA |
| **PROPERTY** | | | | paste-extruded | ram-extruded | isostatic moulded | |
| Density ($kg/dm^3$) (1) | 0.90 to 0.92 | 1.75 to 1.79 | 2.14 to 2.17 | 2.10 to 2.20 | 2.10 to 2.20 | 2.10 to 2.20 | 2.12 to 2.17 |
| Minimum nominal tensile strength, $MN/m^2$ (2) | 28.0 | 37.9 | 20.7 | 26.0 | 22.0(3) 25.5(4) | 25.5 | 20.7 |
| Minimum elongation at break, % (2) | 300 | 250 | 300 | 275 | 230(3) 265(4) | 280 | 275 |

NOTES: (1) Testing shall be performed in accordance with ISO 1183 or ASTM D 792.

(2) Testing shall be performed in accordance with ISO 527 or ASTM D 638.

(3) Value taken in the transverse direction.

(4) Value taken in the longitudinal direction.