

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

CEMENT LINING OF PIPES

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This revision of PTS **30.48.30.31 – CEMENT LINING OF PIPES (December 2009, Revision 1)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **30.48.30.31 (December 1998)** will be removed from PTS binder / e-repository from herein onwards.

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PREFACE

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The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

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TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE.....	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS.....	4
1.3	DEFINITIONS	4
1.4	CROSS REFERENCES.....	5
2.	CONTRACT STRATEGY	6
2.1	CONTRACTOR INVOLVEMENT.....	6
2.2	SELECTION OF CEMENT LINING MANUFACTURER.....	6
3.	DESIGN OF CEMENT LINED PIPING SYSTEMS	7
3.1	GENERAL	7
3.2	SERVICE CONDITION	7
3.3	SIZING CRITERIA	7
3.4	PIPING	7
4.	APPLICATION OF CEMENT LINING	9
4.1	SURFACE PREPARATION	9
4.2	LINING DESIGN AND CEMENT MORTAR.....	9
4.3	INSTALLATION OF SHOP CEMENT LINING.....	9
4.4	CURING	9
4.5	LINING REPAIR.....	10
5.	COATING OF CEMENT-LINED PIPES	11
6.	HANDLING OF CEMENT-LINED PIPE	12
7.	FIELD-JOINTING	13
7.1	GENERAL	13
7.2	BUTT-JOINTING.....	13
7.3	SLEEVE JOINTING	13
7.4	CUTTING TO SIZE IN SITU	13
7.5	FIELD WELDING	14
8.	QUALITY CONTROL	15
8.1	GENERAL	15
8.2	PROCEDURE QUALIFICATION TEST	15
8.3	QUALITY CONTROL DURING SHOP APPLICATION.....	15
8.4	QUALITY CONTROL DURING FIELD-JOINTING	16
8.5	PRODUCTION TESTS	16
9.	TESTS AND INSPECTION CRITERIA	17
9.1	GENERAL	17
10.	FABRICATION REPORT	19
11.	REFERENCES	20

APPENDICES

APPENDIX 1	PIPE JOINTS	22
APPENDIX 2	TYPICAL DETAILS OF FLANGED PIPE-TO-PIPE CONNECTIONS.....	25

1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the cement lining of carbon steel pipes from nominal size DN 100 to DN 900. This includes applying the cement mortar in the shop, joining the lined pipes in situ and applying cement mortar by hand at the field joints. This PTS is a revision of the PTS of the same number dated [December 1998](#).

This PTS complements the requirements of DIN 2614.

The in-situ lining of piping systems, other than the above mentioned joints, is outside the scope of this PTS and reference is made for this purpose to NSI/AWWA C602 issued by the American Waterworks Association.

Internal cement lining is usually applied to prevent internal corrosion of carbon steel cooling water or fire-fighting water piping systems containing sea-water or brackish water at ambient temperatures. These systems can be installed above and below ground. If an above ground lined piping system is drained for a prolonged period, special precautions are required to prevent cracking of the lining due to high or low temperatures and/or variations in temperature or humidity. The special precautions to be taken are outside the scope of this PTS.

Alternatives to cement lined carbon steel piping for sea-water and brackish water service are glass-reinforced epoxy (GRE) piping, concrete piping or epoxy coated/lined piping, their selection depending on local/process conditions and life-cycle costs.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of or managed by PETRONAS. It may be distributed to Contractors and Manufacturers/Suppliers nominated by them.

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

If national and/or legal regulations exist in which some of the requirements may be more stringent than in this PTS, 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, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document 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 objective of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

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

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS REFERENCES

Where cross references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (11).

1.5 CHANGES FROM THE PREVIOUS EDITION

The previous edition of this PTS was dated December 1998. Other than editorial changes, the following are the major changes to the previous edition

Old Section	New Section	Change
1.4	1.4	Change the “Other documents referenced in this PTS” chapter location to part 11.
4.1	4.1	Replace paragraph 1 with the following: The internal side of the pipe shall be cleaned from any trace of grease, mill scale, loose rust or other foreign materials, by blast cleaning to at least Sa2, or by power tool cleaning to St3 of Swedish Standard or in accordance with ISO 8501-1:2007 or any other equivalent standard provided approved by the industry and PETRONAS.
Reference	Reference	INTERNATIONAL STANDARDS Change the standard name for ISO 8501-1:2007 Part 1: Rust grades and preparation grades of uncoated steel substrates after overall removal of previous coating

2. CONTRACT STRATEGY**2.1 CONTRACTOR INVOLVEMENT**

The Contractor shall prepare a detailed specification for the Manufacturer of cement-lined piping. Additional detailed drawings shall be prepared if the details are not covered by the appendices of this PTS or the referenced Standard Drawings.

2.2 SELECTION OF CEMENT LINING MANUFACTURER

The Manufacturer selected shall be able to design and install complete systems, procure the required piping materials and provide technical services related to the products. In addition the Manufacturer shall be responsible for the proper application of the cement lining to the field-joints. Pre-qualification tests shall be performed in accordance with (8). The final selection of Manufacturer is subject to the Principal's approval.

Damage to the lining may occur during the application of the shop painting, handling, transport and storage of the pipes. The Manufacturer of the cement lining shall therefore be responsible for the shop-painting and/or wrapping of the outside of the pipe.

3. DESIGN OF CEMENT LINED PIPING SYSTEMS

3.1 GENERAL

Piping design shall be in accordance with ASME B31.3.

The cement lining shall be designed for a life of at least 20 years.

The cement lining shall be designed so that no repairs will be needed within the first five years' service.

3.2 SERVICE CONDITION

The Principal shall specify the service conditions for which the cement-lined pipe shall be suitable (normally sea water and/or brackish water at an operating temperature between minus 5 °C and plus 60 °C).

The Contractor shall obtain from the Principal a chemical analysis of the fluid to be conveyed.

The composition of the lining shall be agreed with the Principal.

**Amended per
Circular 15/03**

The lining applied shall have a design life of at least 20 years.

3.3 SIZING CRITERIA

The diameter of cement-lined piping systems shall be chosen so that the maximum water velocity inside the lined piping shall not exceed 3 m/s for pipes larger than DN 150 and 2 m/s for sizes DN 150 and DN 100.

The minimum outside diameter for piping and fittings to be cement lined is DN 100. The maximum diameter shall be DN 900. The straight length of the pipes shall be between 6 m and 13 m.

Where carrying capacity is of importance, calculations shall be made to determine the maximum friction and loss of water head.

Unless a greater thickness has been specified, the lining thickness after curing shall be in accordance with DIN 2614 section 6.5.3.

3.4 PIPING

3.4.1 Materials

Pipe, flange, fitting and valve materials shall be in accordance with piping class 11011 (see PTS 31.38.01.12).

3.4.1 Welding ends

Pipe DN 650 and larger shall have butt welding ends in accordance with ASME B16.25. Smaller sizes shall have plain ends, with a sleeve coupling externally welded to one end. Valves and fittings shall have sleeve couplings externally welded to both ends.

3.4.3 Fittings

For the selection and overall dimensions of fabricated fittings see Standard Drawings S 38.070 and S 38.071.

For typical details of a set-on branch for cement lined fittings see Standard Drawing S 38.076.

For dimensions of sleeves see Standard Drawing S 38.074.

Factory-made butt welding fittings shall be in accordance with ASME B16.9.

3.4.4 Flanges

Flanges shall be ASME rating class 150, raised face, except where flat face flanges are required for replacement in existing installations.

Slip-on flanges should be installed in pipe sizes from DN 100 through DN 600. For pipe sizes DN 650 and larger, welding neck flanges shall be used. Flanges from DN 100 through DN 600 shall be in accordance with ASME B16.5 and flanges DN 650 and larger shall be in accordance with ASME B16.47.

Flange facing finish shall be in accordance with ASME B16.5.

For flanged ends (slip-on) for cement-lined pipe and fittings, see Standard Drawing S 38.075.

3.4.5 Gaskets

Gaskets shall be 3 mm thick, reinforced chloroprene rubber with a Shore A hardness of 70.

The inside diameter of the gasket shall be equal to the inside diameter of the cement lining (Appendix 2, Figure 6). On some pipe-to-pipe valve connections the cement lining I.D. is tapered to equal the pipe I.D. at the gasket position to prevent possible interference of the valve disc with the cement lining (Appendix 2, Figure 7).

Full face gaskets shall be used for connecting flat face flanges.

4. APPLICATION OF CEMENT LINING

4.1 SURFACE PREPARATION

The internal side of the pipe shall be cleaned from any trace of grease, mill scale, loose rust or other foreign materials, by blast cleaning to at least Sa2, or by power tool cleaning to St3 of Swedish Standard or in accordance with ISO 8501-1:2007 or any other equivalent standard provided approved by the industry and PETRONAS.

4.2 LINING DESIGN AND CEMENT MORTAR

The lining design concept, constituents of the cement mortar, mortar types and preparation and testing shall be in accordance with DIN 2614 sections 2, 3, 5, 6 and 7.

4.3 INSTALLATION OF SHOP CEMENT LINING

4.3.1 General

Straight sections of pipes, diameters from DN 100 up to and including DN 900, length 6 m to 13 m, shall be lined by the spinning method. The interior surface shall be smooth, straight and true and the sand/cement particles shall be equally distributed throughout the lining thickness, after completion of the lining process.

4.3.2 Spinning Method

The lining shall be applied by a spinning machine specifically designed and built for the purpose of applying cement mortar linings to the interior of steel pipe by means of centrifugal forces and rotation of the pipe. To prevent distortion or vibration during spinning, each section of pipe shall, if required, be braced with external or internal supports. The entire quantity of mortar required for the lining of one section of pipe shall be placed without interruption. The pipe shall be rotated slowly until the mortar has been equally distributed along the inside periphery of the pipe.

Thereafter the rotation speed shall be increased to produce a dense lining with a smooth surface and a minimum of shrinkage. Provisions shall be made for removal of surplus of water.

4.3.3 Bends and fittings

Bends and fittings which cannot be machine lined in accordance with (4.3.2) may receive a hand-applied mortar lining. Hand-applied mortar shall have a uniform surface. Cement mortar for hand work shall be of the same consistency and material as the mortar for machine method. Surfaces to be lined shall be cleaned in accordance with (4.1) and damped with water immediately prior to placing the hand-applied mortar. Steel finishing trowels shall be used for the hand application of cement mortar.

4.4 CURING

4.4.1 General

The lining shall be cured in accordance with DIN 2614 section 4.

After application of the lining, the pipe and/or fittings shall be sealed with plastic caps and left to cure in situ, or they may be transferred carefully to a curing yard.

The curing area shall be sheltered so that lined pipes and fittings are protected from harmful climatic conditions (e.g. exposure to direct sun, frost, etc.). Within 24 hours after application of the cement lining the bores shall be inspected and water added to aid curing if required. Curing will take place for a period of at least 7 days after application of the cement lining.

After the final inspection, the ends of the pipes and fittings shall be re-capped with the plastic caps. These covers shall not be removed within 14 days after cement lining in order to protect the lining from drying out.

Pipes or fittings shall not be removed from the curing yard until the curing procedure is completed and the mortar has reached its specified strength.

4.4.2 Normal Curing

The lining shall be protected from drying out as specified above for the whole period of the hardening process of the mortar in order to minimise shrinkage cracks. The minimum period of hardening shall be 28 days.

4.4.3 Water Curing

The lining shall be kept totally submerged for the total period of the hardening process of the mortar in order to minimise shrinkage cracks. The minimum period of hardening shall be 4 days.

4.4.4 Steam Curing

Steam curing shall only be applied if required and approved by the Principal. Recording thermometers shall be installed.

4.4.5 Membrane Curing

Membrane curing by application of any moisture-retaining liquid is not permitted.

4.5 LINING REPAIR

Dummy, spalled and excessively cracked areas etc. in fully accessible pipes shall be removed and repaired by hand to the required thickness of the lining.

Cracks with a width less than 0.8 mm may be left, providing they will not impair the stability of the lining, as the self-healing effect will set them tight as soon as the pipes are in operation. Cracks with a width greater than 0.8 mm can be washed in by means of soft brush with a liquid sand/cement mixture consisting of one part cement and one part fine sand (0.1 mm). The mixture should be liquid similar to heavy paint.

Larger local damages, other than cracks, shall be repaired by removing all loose particles, old mortar, grease and dirt by brushing with a stiff/wire brush. All traces of oil and grease shall be removed with a suitable de-greasing agent. The sides of the existing cement lining shall be primed with a multi-purpose adhesive, based on synthetic resin.

The damaged area shall be filled with a ready mixed mortar. The repaired lining shall be finished by means of a trowel or a spatula and brushed flush with the original cement, and shall be kept moist for at least three days. Minor damage can be repaired by means of a multi-purpose adhesive.

5. COATING OF CEMENT-LINED PIPES

Flange faces shall be coated with Shell Ensis Fluid "G", after which they shall be provided with protective covers.

If the pipe is to be externally wrapped it shall be done before installing the lining.

Shop-painting of the outside surface of the pipe shall be done after installing and curing the cement lining.

6. HANDLING OF CEMENT-LINED PIPE

Lined pipes and fittings shall be handled carefully to avoid internal damage to the cement lining.

The end caps shall be kept in place during transport and storage in order to prevent dust, dirt, foreign matter etc. entering the pipe.

For loading and unloading of very heavy pipes, it is recommended to use slings with cushion pads or a suitable fork arrangement placed at the centre of the joints. Hooks or other devices which are inserted into the ends of the pipe shall not be used. A flat-bed trailer provides the best support for the lined pipes during transport. During loading or unloading, lined pipes shall not be dropped onto or off the transporting vehicle.

To prevent bending of the pipes which can cause damage to the lining, supports shall be used during storage and shipping. The distance between the supports shall not exceed 3 m.

Pipes shall be stored in supported tiers. The height of the tiers depends on the diameter of the pipes and shall be as follows:

Pipe nominal size	Maximum number of pipes per tier
< DN 150	10
DN 200 to DN 400	6
> DN 400	4

7. FIELD-JOINTING

7.1 GENERAL

Welding shall be in accordance with PTS 31.38.01.31.

The pipes and fittings shall be joined in-situ by field welds or flanges.

Butt welds shall be used for pipe diameters DN 650 and larger (with the joint location internally lined in-situ after welding).

Sleeve joints shall be used for pipe diameters smaller than DN 650.

The Contractor and Principal shall agree upon the type of multi-purpose adhesive and the ready mixed mortar to be used for assembling the pipes.

Alternative methods for field jointing of cement lined pipes and fittings (e.g. with impregnated gaskets etc.) are subject to approval of the Principal.

7.2 BUTT-JOINTING

The bevelled ends of the cement lined pipes shall be thoroughly cleaned see (4.1) and all loose particles of the cement lining shall be removed over 20 mm at both ends of the pipe, i.e. 20 mm on either side of the joint (Figure 4 of Appendix 1). After the welding has been completed, a hand-applied mortar shall be used to finish the cement lining on the inside surface of the steel pipe at the location of the field weld (see Figure 5 of Appendix 1).

Unless another method has been agreed, the sides of the existing cement lining shall be sealed with a priming coat consisting of one part of a multi-purpose adhesive, based on synthetic resin, and one part of potable water. After this priming coat has become tacky (20-30 minutes), the ready mixed mortar shall be applied.

The application of the adhesive and ready mixed mortar shall be in accordance with the Manufacturer's specifications. The hand applied mortar shall be finished by means of a trowel or spatula and shall be brushed flush after which a curing compound shall be applied. Pressure testing of a pipe section with site-applied cement lining shall be delayed until 28 days after application or until the minimum compression strength has been reached (this will require an earlier compressive strength test in addition to the 28 day test, (9.1.4)).

7.3 SLEEVE JOINTING

The free-access length of the female part shall be determined prior to the jointing and shall be marked on the male part over the full circumference (see Figures 2A and 2B of Appendix 1). The cut end of the pipe inside the sleeve coupling shall be thoroughly cleaned, dry and free of dust and shall be provided with a concrete glue. This type of glue shall be based on a two component solvent free epoxy-resin suitable for application on moist mortar surfaces. Before installation of the male pipe end part, the concrete glue shall be tapered with a minimum thickness at the cement lining edge of 3 mm and with an angle of 75° (see also Figure 2 of Appendix 1).

Immediately after the application of the concrete glue, the male part shall be carefully pulled into the female part, without distorting the alignment (i.e. centre line) of the pipe, and shall be tack-welded in accordance with (7.5).

7.4 CUTTING TO SIZE IN SITU

If in-situ cutting is unavoidable, it shall be carried out at the required position by means of a cutting disk 3 mm wide. Flame cutting shall not be used. The end of the steel pipe shall be cut perpendicular to the pipe and bevelled (if required) depending on the type of the field joint. For a sleeve joint, the cut pipe end shall be used as the female part. For a butt-weld joint the cement lining shall be cut over a length of at least 20 mm at the end of the pipe. In both cases the cement lining shall be cut perpendicular to the pipe. Typical details of the pipe ends are shown in Appendix 1.

7.5 FIELD WELDING

The pipes shall be tack-welded at three equidistant positions.

The pipe shall be joined by the shielded metal arc welding process. The arc shall not come in direct contact with the cement lining or seal material.

Starts and stops shall be staggered so as not to start or stop more than once in the same place. Welding slag shall be cleaned from all weld passes.

Welding procedures and welders shall be qualified in accordance with ASME IX; the procedures shall be submitted to the Principal for approval.

8. QUALITY CONTROL

8.1 GENERAL

Before production of the actual cement lining is started, the Manufacturer shall make arrangements to execute line-up tests in order to demonstrate the suitability of the equipment for an uninterrupted production process. All required materials shall be supplied by the Manufacturer. The testing shall reflect the actual application conditions.

The entire process of applying cement mortar lining, at the Manufacturer's works and at the construction site, shall be subject to continuous inspection by a QC inspector appointed by the Contractor, but such inspections shall not relieve the Manufacturer of his responsibility to furnish material and perform the work in accordance with this PTS.

8.2 PROCEDURE QUALIFICATION TEST

Prior to the installation of the shop cement lining, or if there is any variation in the process or composition of the mortar or a change in any components, the Manufacturer shall perform procedure tests to demonstrate that he is able to produce a lining system in accordance with the design requirements. The constituents, mortar and finished pipe shall be tested; the samples shall be taken from one of the first finished test pipes or fittings, and testing shall be carried out as indicated below:

Individual constituents of the mix:

- cement/admixture;
- sand;
- water.

Cement mortar test specimen:

- density;
- compressive strength;
- flexural tensile strength;
- water absorption.

Finished product:

- visual inspection.

The acceptance criteria for the tests shall be in accordance with (9). Successful tests qualify the procedure for the installation of the actual lining.

A record shall be made of the complete test procedure, including:

- details of test piece;
- batch identification of cement mortar;
- test data and results;
- acceptance by Principal.

8.3 QUALITY CONTROL DURING SHOP APPLICATION

During preparation and subsequent application of the cement mortar, a regular production sampling programme shall be established and maintained.

A logbook shall be kept showing the portion of the completed lining which is represented by the sample and all information regarding the sample preparation and the operating parameters at the time of sample collection such as ambient temperatures, water content, cement/sand ratio, mixing times. Preparation of the samples shall be witnessed by the QC inspector.

Immediately after the final spin an inspection of the cement lining shall be carried out by looking through the pipe from each end, using a strong light. Lining defects, including but not restricted to sand pockets, voids, sags, over-sanded areas, blisters, excessively cracked and dummy areas and unsatisfactory thin spots, shall be removed before the initial set of the mortar.

Defective areas encompassing the full diameter of the pipe shall be repaired by machine. Small defects in pipes larger than DN 600 shall be repaired by hand to the full required thickness of the cement lining. In pipes DN 600 and smaller, any defective lining shall be removed before the initial set of the mortar. Defective linings rejected after initial set shall be replaced or repaired by the most practical method to be determined by the Manufacturer in accordance with a procedure approved by the Principal.

Most cracking occurs when the lining is allowed to dry out during curing, transportation and storage. The inspector shall ensure that the lining is still moist after inspection and that air-tight end caps are placed and maintained on the pipe.

8.4 QUALITY CONTROL DURING FIELD-JOINTING

Before being assembled, the pipes and fittings shall be inspected for possible cracks and damage. If required any cracks and damage shall be repaired prior to the assembling of the piping system; see (4.5).

The cement shall be the same as applied for the shop cement lining. The sand and cement shall meet the requirements of DIN 2614.

The lengths of pipe shall be butted together and checked for alignment and good contact of the cement lining and pipe ends.

A ready mixed mortar shall be used for the butt joints and butt joint lining repairs.

The piping system should be inspected 8 days after completion of the cement lining.

8.5 PRODUCTION TESTS

Production testing shall be performed during manufacture of the pipe lining and tests and inspections shall be carried out in accordance with the table below. All test results shall be reported and submitted to the Principal.

Test or inspection	Frequency
cement/admixture	once per batch delivered
sand/additives	once per week
water/cement ratio	twice per day
mixing ratio/times	twice per day
density	twice per day
compressive strength	twice per day
flexural strength	twice per day
ambient temperature	once per day
visual inspection	continuously
lining thickness	20% of pipes and fittings
pipe and fitting ends	each pipe and fitting
surface condition	each pipe and fitting
lining structure	once per week

The acceptance criteria for the tests shall be in accordance with (9).

9. TESTS AND INSPECTION CRITERIA

9.1 GENERAL

All bare pipes shall be inspected before cleaning and lining. The surface on which the cement lining is to be installed shall be free from all grease, mill scale, loose rust or other foreign materials prior to the installation of the cement lining.

Test samples of the cement lining mortar shall be prepared by the Manufacturer. Each sample shall be clearly marked with the Contractor's code numbers for that day/shift/crew and for sequence of production. The Manufacturer shall be responsible for regular transport of samples to an independent qualified laboratory, subject to Principal's approval.

If the samples or completed lining do not meet the specified criteria, the installed cement lining represented by the failed sample(s) shall be removed and replaced.

Completed lining not meeting the specified criteria of (9.1.7, 9.1.8, 9.1.9 and 9.1.10) shall be rejected.

9.1.1 Sand, cement and water

Test criteria shall be in accordance with DIN 2614.

9.1.2 Water/cement ratio

The water/cement ratio shall be in accordance with DIN 2614 section 6.4.2, determined in accordance with DIN 1048-1 "Drying to constant weight".

9.1.3 Mixing ratio

The mixing ratio shall be in accordance with DIN 2614 section 3.3.

9.1.4 Compressive and flexural strength

The compressive and flexural strength shall be tested in accordance with DIN 2614 section 7.6.1 after a curing period of 28 days and the results shall be in accordance with DIN 2614 section 6.6.1.

9.1.5 Density

The density, measured in a saturated, surface dry condition, shall be not less than $2\,160\text{ kg/m}^3$.

9.1.6 Water absorption

The water absorption of the sample shall not exceed 10%.

9.1.7 Lining thickness

The thickness of the lining shall be measured in accordance with DIN 2614 section 7.5.3.

9.1.8 Pipe and fitting ends

Pipe and fitting ends of pipes and fittings DN 650 and larger assembled in-situ by means of field welding shall have the cement lining removed over a length of 20 mm at each end of the pipe.

The ends of the lined pipes shall be considered defective if the lining end is:

- a) not located as specified; or
- b) not perpendicular to the longitudinal axis of the pipe; or
- c) not square; or
- d) chipped or cracked; or
- e) separated from the steel pipe surface; or

f) not to the specified thickness.

In addition to the above the welding bevel shall be free of cement.

9.1.9 Surface condition

The surface condition of the finished cement lining shall be smooth and even, not be flattened at individual spots, not have loose sand, not have dummy, spalled or excessively cracked areas and not exhibit waves or grooves. Single waves or grooves are acceptable providing the minimum specified lining thickness is maintained. However, the maximum peak to trough height shall not exceed 1.0 mm. Aggregate grains may only protrude at the surface sporadically. Hairline cracks and sporadically occurring surface cracks up to 0.8 mm wide shall not be cause for rejection.

There shall be no voids (i.e. locations where the cement lining is not continuous, which occur during the spinning process when the cement does not distribute evenly).

Sags, appearing as large smooth lumps in the lining at the top of the pipe, are not acceptable.

9.1.10 Lining structure

The polished section of a cement lined pipe sample shall not have visible pores and the individual grains of the sand shall be surrounded on all sides with the cementing agent.

10. FABRICATION REPORT

After finishing the work as defined in the purchase order, the Contractor shall provide a fabrication report with the following contents:

- project references such as: location, project number, piping system;
- bill of materials including lining;
- reference drawings and specifications;
- registration of date and time of application of all phases;
- registration of the produced samples and tests results;
- final inspection results;
- welding procedures used.

This report shall also include certificates for the following materials:

- piping, fittings, flanges, gaskets and valves;
- welding consumables;
- sand.

Cement mill test certificates shall be provided for each shipment of:

- cement;
- admixtures and additives;
- adhesives, concrete glue and ready-mixed mortar.

11. REFERENCES

In this PTS reference is made to the following publications.

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

PETRONAS STANDARDS

Index to PTSs and Standard Specifications	PTS 00.00.05.05
Piping classes – Refining & Chemicals	PTS 31.38.01.12
Shop and field fabrication of piping	PTS 31.38.01.31

STANDARD DRAWINGS

Dimensions of cement-lined fittings, nominal size DN 100 through DN 600	S 38.070
Dimensions of cement-lined fittings, nominal size DN 650 through DN 900	S 38.071
Sleeves for cement-lined pipe and fittings	S 38.074
Flanged ends for cement-lined pipe and fittings	S 38.075
Typical detail of set-on branch for cement lined fittings	S 38.076

AMERICAN STANDARDS

ASME Boiler and Pressure Vessel Code Section IX: Qualification standard for welding and brazing procedures, welders, brazers, and welding and brazing operators	ASME IX
Pipe flanges and flanged fittings, NPS 1/2 through NPS 24	ASME B16.5
Factory-made wrought steel butt welding fittings	ASME B16.9
Buttwelding ends	ASME B16.25
Large diameter steel flanges, NPS 26 through NPS 60	ASME B16.47
Chemical plant and petroleum refinery piping	ASME B31.3

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York NY 10017
USA

Cement-mortar lining of water pipelines - 4 inch (100 mm) and larger - in place	NSI/AWWA C602
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Issued by:
American Waterworks Association
6666 West Quincy Avenue
Denver
Colorado 80235
USA

GERMAN STANDARDS

Testing concrete:

Part 1 - Testing of fresh concrete

DIN 1048-1

Cement mortar linings for ductile iron and steel pipes and fittings; application, requirements and testing

DIN 2614:1990

*Issued by:
Beuth Verlag GmbH
Burggrafenstrasse 6
D-10787, Berlin
Germany*

INTERNATIONAL STANDARDS

Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness

Part 1: *Rust grades and preparation grades of uncoated steel substrates after overall removal of previous coating*

ISO 8501-1:2007

*Issued by:
International Organisation for Standardisation
1, Rue de Varembe
CH-1211 Geneva 20
Switzerland
Copies can also be obtained from national standards organizations.*

APPENDIX 1 PIPE JOINTS

Figures 1, 2, 2A, 2B and 2C SLEEVE JOINTS



Fig. 1

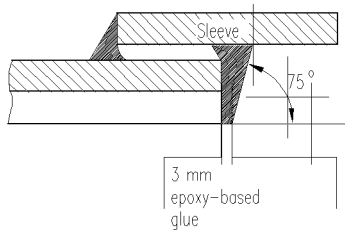


Fig. 2

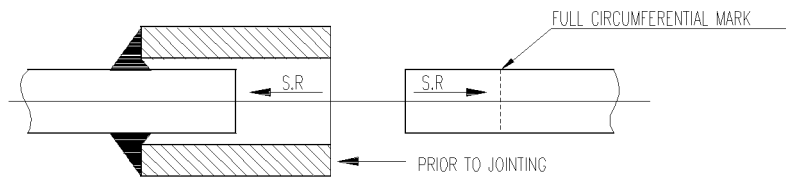


Fig. 2A

Fig. 2B

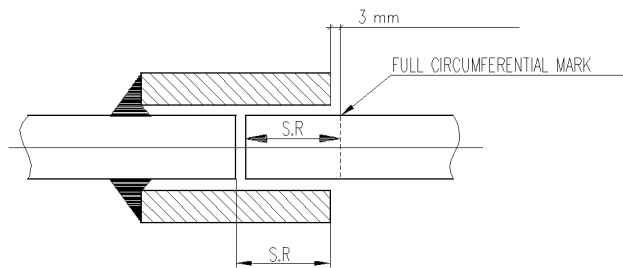


Fig. 2C – Correct Installation

S.R. = SLEEVE RECESS

Figures 2D, 2E and 3 SLEEVE JOINTS

Fig. 2D

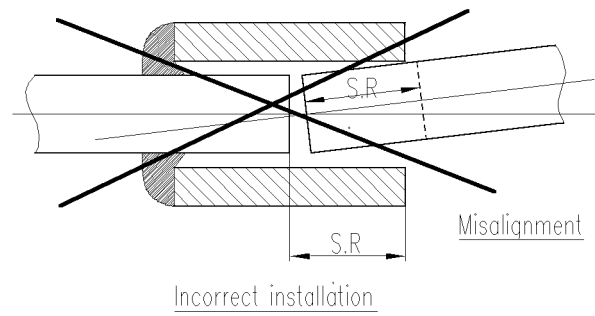


Fig. 2E

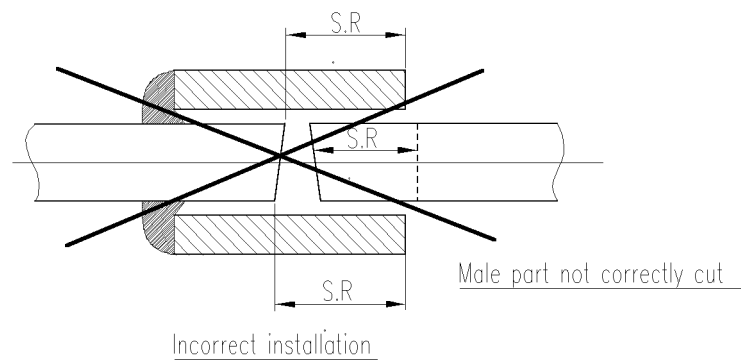
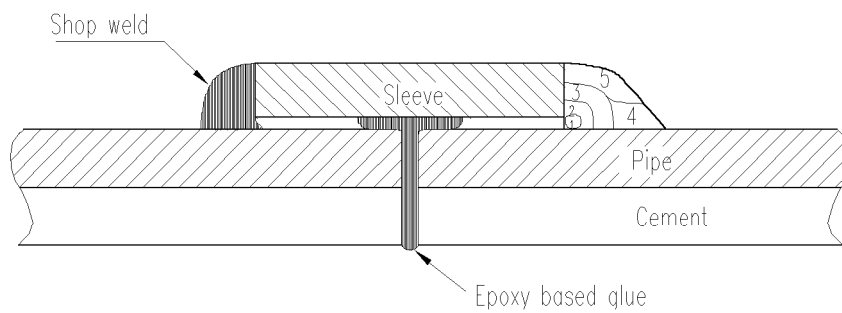


Fig. 3



NOTE: S.R. = SLEEVE RECESS

Figures 4, 4A, 4B and 5 BUTT JOINTS

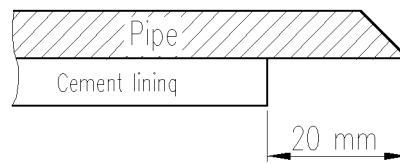


Fig. 4

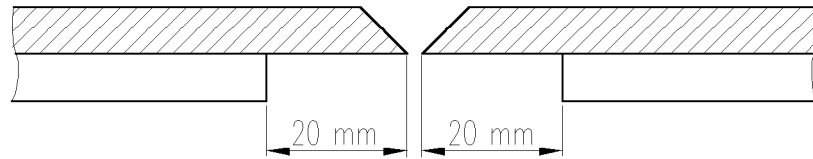


Fig. 4A

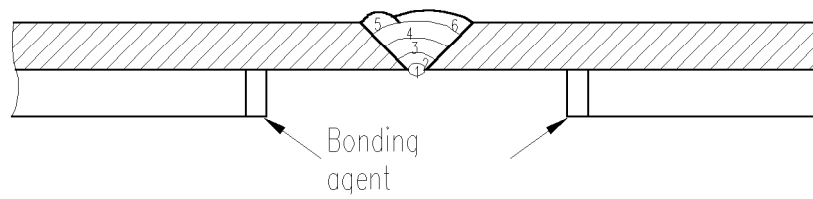


Fig. 4B



Fig. 5

Joint ready for pressure test and operation
immediately after completion of final welding

APPENDIX 2 TYPICAL DETAILS OF FLANGED PIPE-TO-PIPE CONNECTIONS

Figure 6 Pipe connection

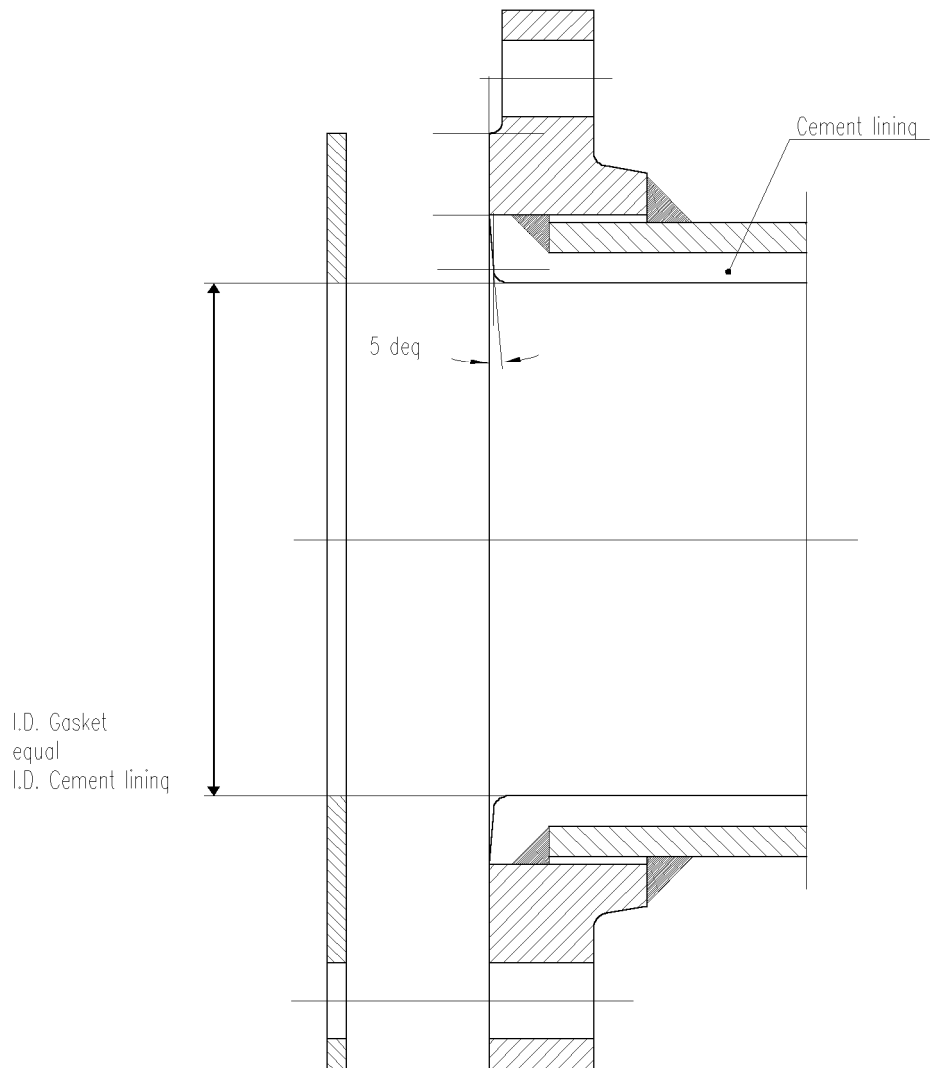


Figure 7 **Valve (butterfly) connection**

