

Lining of equipment with polymeric materials for the process industries —

Part 5: Specification for lining with rubbers

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- Associated Offices Technical Committee
- Association of Consulting Engineers
- British Chemical Engineering Contractors' Association
- British Compressed Gases Association
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- Liquefied Petroleum Gas Industry Technical Association (UK)
- Process Plant Association
- Water-tube Boilermakers' Association
- Welding Institute
- Coopted member

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Rubber Manufacturers Association
- Institution of Corrosion Science and Technology
- Plastics and Rubber Institute
- Rubber and Plastics Research Association of Great Britain

This British Standard, having been prepared under the direction of the Pressure Vessels Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 July 1985

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Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
Section 1. General	
1.1 Scope	1
1.2 Definitions	1
1.3 Exchange of information	1
1.4 Compliance	2
Section 2. Design, fabrication and surface finish of equipment to be lined	
2.1 General	3
2.2 Design of metal equipment to be lined	3
2.3 Fabrication of metal equipment to be lined	4
2.4 Design of concrete equipment to be lined	4
2.5 Construction of concrete equipment to be lined	5
Section 3. Selection and quality of linings	
3.1 Selection of lining	9
3.2 Quality of lining	9
Section 4. Method of lining	
4.1 Surface preparation	11
4.2 Adhesion system and application	11
4.3 Production of lining material	11
4.4 Application of the sheet to the substrate	12
4.5 Vulcanization	13
Section 5. Inspection and testing	
5.1 Responsibility for inspection and testing	15
5.2 Inspection	15
Section 6. Methods of test	
6.1 Continuity testing	18
Section 7. Rectification of faults in fully cured linings	
7.1 General	19
Section 8. Storage, handling, transportation and installation	
8.1 General	20
Appendix A Characteristics of lining materials specified in 3.1	21
Appendix B Continuity testing	22
Appendix C Vulcanization	24
Appendix D Lining of used equipment	25
Appendix E Maintenance of rubber lined equipment	25
Appendix F Effect of materials on water quality	26
Figure 1 — Weld profile details: flanges	5
Figure 2 — Pipework details	6
Figure 3 — Weld profile details: butt welds	7
Figure 4 — Weld profile details: external corners and edges	7
Figure 5 — Weld profile details: internal corners and edges	8
Figure 6 — Weld profile details: concave heads	8
Figure 7 — Typical joints in rubber linings	13
Figure 8 — Unacceptable faults in joints in rubber linings	16
Table 1 — Maximum length between flanges	3
Table 2 — Test loads for adhesion of vulcanized soft rubber to carbon steel and concrete substrates	17
Publications referred to	Inside back cover

Foreword

This Part of BS 6374 has been prepared under the direction of the Pressure Vessels Standards Committee. It is the last of five Parts of a new standard that supersedes Parts 1, 4, 5 and 6 of CP 3003 which are withdrawn. The change in format arises from the fresh approach adopted to conform with developments in the associated lining technology.

The Technical Committee would like to acknowledge the contributions made by the British Rubber Manufacturers' Association and the Rubber and Plastics Research Association of Great Britain both of which contributed to the preparation of the initial draft document.

The linings referred to in this standard which are based on natural and synthetic rubbers are used for a number of different duties, including protection against corrosive environments and prevention of contamination of products. Specific linings are used for protection against abrasion or erosion.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1.1 Scope

This Part of BS 6374 specifies requirements for the lining of equipment for the process industries using cold rubber.

It includes requirements for the choice of lining and its application and also requirements for inspection of the lining and the rectification of faults. It applies to equipment fabricated in metal or concrete.

The materials considered include natural and synthetic rubbers applied as unvulcanized or prevulcanized sheet.

Brushed or sprayed rubber linings are not included.

NOTE 1 The linings may be applied at the applicator's works or on site.

Requirements for design and fabrication of the equipment and the state of preparation necessary for the surfaces to be lined are specified in section 2.

Requirements for storage, handling, transportation and installation of the lined equipment are specified in section 8.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

1.2 Definitions

For the purposes of this Part of BS 6374 the definitions given in BS 3558 apply, together with the following:

1.2.1 purchaser¹⁾

the organization or individual who buys the lined equipment for its own use or as an agent for the owner

1.2.2 fabricator¹⁾

the organization or individual responsible for the fabrication of the equipment to be lined

1.2.3 applicator¹⁾

the organization or individual responsible for the application of the lining

1.2.4 inspection authority¹⁾

the body or association appointed by the purchaser (or owner) to check that the design, fabrication, and lining comply with this standard

1.2.5 vulcanization

the chemical reaction resulting in the final polymerized product

1.2.6 pinhole

a small defect in the lining that would permit corrosion of the substrate under the conditions for which the lining is designed

NOTE The word "pinhole" is synonymous with "holiday" and "pore".

1.2.7 blister

a gas or liquid filled cavity within the lining material or between the lining and substrate

1.2.8 scarf joint

a joint made between two adjacent sheets of rubber by bevelling the edges of the sheets and over-lapping one prepared edge on the other (see Figure 7)

1.3 Exchange of information

Early consultation shall be arranged between all parties concerned with the application of this standard, to establish the following information which shall be fully documented. Both the definitive requirements specified in this standard and the documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

- a) Design and fabrication details of the equipment to be lined and provision of drawings (see 2.2, 2.3, 2.4 and 2.5).
- b) Details of gasket materials (see 2.2.9 and 2.2.10).
- c) Details of the contents of the vessels or equipment, including trace materials [see 3.1.1 a)].
- d) The design temperature [see 3.1.1 b)].
- e) The design pressure [see 3.1.1 c)].
- f) The details of any solids to be handled [see 3.1.1 e)].
- g) Any specific mechanical properties required of the lining including suitability for machining [see 3.1.1 g)].
- h) The methods of heating and/or cooling [see 3.1.1 b)].
- i) Cleaning methods, for example, water washing, solvent washing, boiling out or steaming [see 3.1.1 a)].
- j) Where the lining work will be done.
- k) Site conditions which may affect the work, for example, availability of services.

¹⁾ Where the words "purchaser", "fabricator", "applicator" and "inspection authority" occur in the text, they are intended also to include representatives of the purchaser, fabricator, applicator and inspection authority.

- l) Any special requirements for materials used in blast cleaning (see 4.1.1.1 and 4.1.1.2).
- m) The rubber lining to be used (see 3.1.1).
- n) The minimum thickness of the vulcanized lining and where applicable the maximum thickness (see 3.2.2).
- o) The provision of test plates [see 3.2.1 c)].
- p) When the lining is to be applied outside the applicator's works and the primers and/or adhesives as applied contain solvents, the types of solvents are to be stated, together with their flash points and threshold limit values.
- q) Specified adhesion system (see 3.1.1, 3.2.3 and 4.2).
- r) The minimum and maximum allowable temperature and allowable humidity which are required for the correct application of the lining (see 4.2 and 4.4).
- s) The minimum temperature required during the vulcanization of the lining (see 4.5).
- t) The vulcanization schedule, where applicable.
- u) Inspection techniques/procedures to be employed, acceptance levels and stages of inspection (see 5.1 and 5.2).
- v) Handling, transport, storage and installation procedure (see 3.1.1 g) and 8.1.1 to 8.1.7).

1.4 Compliance

1.4.1 Fabricator

The fabricator shall comply with the following:

- a) section 2 [see 1.3 a)];
- b) 5.1 a) and b);
- c) section 8 as agreed in 1.3 v).

1.4.2 Applicator

The applicator shall comply with the following:

- a) section 3 (but see 3.2.1);
- b) section 4;
- c) 5.1 c), d), e) and f);
- d) section 6;
- e) section 7;
- f) section 8 as agreed in 1.3 v).

Section 2. Design, fabrication and surface finish of equipment to be lined

2.1 General

The basic design, fabrication and testing for mechanical reliability of the equipment to be lined shall be carried out to the appropriate British Standards and shall comply with **2.2** and **2.3** or **2.4** and **2.5** before the lining operation commences.

NOTE Rubber lining will affect heat transfer and tolerances required for joints; both features need to be considered at the design stage of the equipment.

2.2 Design of metal equipment to be lined

2.2.1 Equipment to be lined shall be sufficiently rigid that there is no possibility of deformation which would result in damage to the lining during transportation, installation and operation. When stiffeners are required, they shall normally be applied to the unlined side of the equipment.

NOTE In the case of hard rubber and ebonite linings this requirement is of particular importance.

2.2.2 The arrangements for the lifting of equipment shall be determined at the design stage.

2.2.3 The design of all equipment shall allow for access during the preparation of the surface and application of the lining and for venting of fumes evolved during the operation.

In completely enclosed vessels there shall be at least one manhole that after lining complies with BS 470 and one additional branch of not less than 75 mm bore to permit adequate circulation of air.

NOTE It is recommended that, where practicable, the minimum diameter of a manhole should be 600 mm.

2.2.4 Riveted constructions shall not be used.

2.2.5 Bolted joints shall be permitted only if they can be dismantled for lining.

2.2.6 When calculating clearances, allowance shall be made for the thickness of the lining.

2.2.7 Surfaces to be lined shall be of a smooth contour.

2.2.8 Discontinuities, crevices and sharp projections shall be avoided.

2.2.9 Fittings which have to be installed after the completion of the lining process shall be designed to be lined or fabricated from materials that will not be affected by the process conditions.

2.2.10 Normally all connections to lined parts of equipment shall be flanged. If for any reason screwed connections are required, then these parts shall be fabricated in corrosion-resistant materials.

2.2.11 Branches and outlets, except for plain ended pipes, shall be as short as possible and flanged so that the lining may be taken over the flange face to prevent the ingress of process fluid between the lining and the substrate.

NOTE Acceptable flange systems are shown in Figure 1.

Plain-ended pipes shall be designed so that the lining may be turned over the end and the outside of the pipe.

Where pads are required they shall be designed as shown in Figure 1(d). Drilled and tapped holes in pads for studs shall not penetrate the shell of the equipment.

2.2.12 Heating coils, immersion heaters and sparger pipes shall be installed after the completion of the lining process and shall be located so that no part is closer than 100 mm from a lined surface. In the case of nozzles through which heating coils, etc. enter equipment, a smaller clearance is permitted provided that the temperature of the pipe through the nozzle does not exceed 80 °C. In no case shall this clearance be less than 25 mm. Fluids introduced through sparger pipes or dip pipes shall not impinge directly on to the lining. External heating of equipment shall not be permitted without full consultation with the applicator of the lining.

2.2.13 The design of pipework shall be such as to allow ready access to welds and bends for weld and surface preparation.

NOTE 1 Pipe systems made from straight lengths with separate "standard" (1.5D) bends and tees meet this requirement. Bends should not be greater than 90°.

Where pipe systems include "non-standard" fittings their suitability for lining shall be established [see 1.3 a)]. Suitable arrangements are illustrated in Figure 2.

The maximum dimensions of pipes and fittings which can be rubber lined shall be determined during the exchange of information [see 1.3 a)]. Typical maximum lengths of straight pipe which can be rubber lined are detailed in Table 1.

Table 1 — Maximum length between flanges

Nominal pipe size	Maximum length between flanges
mm	mm
25	2 000
32	2 500
40	3 000
50	3 500
65	4 000
80 to 600	6 000

Cast iron pipework and fittings manufactured to BS 2035 are of suitable dimensions and shall be permitted for lining.

Pipes less than 25 mm diameter shall not be rubber lined. Pipes less than 450 mm diameter shall be of seamless construction only. Screwed fittings shall not be rubber lined.

Where flat face or raised face flanges are used they shall be welded square to the pipe or fitting according to normal manufacturing tolerances.

Flanges which are attached to a pipe by fillet welding (for example slip-on flanges) shall be suitably vented to allow any air trapped between fillet welds to escape to atmosphere during lining and vulcanizing.

NOTE 2 This may be accomplished by using a vent hole in the flange, providing this meets piping design standard requirements.

2.3 Fabrication of metal equipment to be lined

2.3.1 All welds shall be continuous on surfaces to be lined.

NOTE Butt welds are preferred to fillet welds.

Stitch welding, spot welding and other non-continuous welding processes shall not be used.

2.3.2 Weld surfaces shall be smooth. Some welding procedures provide surfaces of adequate smoothness but, in other cases surfaces shall be ground wholly or partly to remove weld ripples. The grinding process shall be done so that the remaining weld does not have sharp edges.

2.3.3 Welding procedures shall be chosen to avoid porosity on the side of the weld to be lined.

NOTE It is preferable that capping runs are applied to the lining side in order to minimize this effect.

All welds shall be free from the following surface defects:

- a) undercutting;
- b) cracks;
- c) porosity;
- d) any other type of surface cavity;
- e) lack of fusion.

Weld defects that are exposed either on initial inspection or after blast cleaning shall be repaired. Repairs shall be by grinding or by welding (with or without subsequent grinding) provided that the requirements for equipment design and fabrication are met.

2.3.4 Weld profile details shall be generally in accordance with Figure 1 and Figure 3 to Figure 6.

NOTE Incorrect details are also illustrated.

2.3.5 Filler materials, such as resin, putties, fillers and low melting point solders and brazes, shall not be used.

2.3.6 Before the equipment is passed for lining, all attachments to be made by welding, for example lagging cleats and lifting lugs, shall be complete.

2.3.7 All drilling shall be completed before the equipment is passed for lining. Holes to be lined shall have their edges radiused.

2.3.8 External corners and edges shall be furnished to a radius at least equal to the thickness of the rubber, internal corners and edges to a radius of at least twice the rubber thickness.

NOTE For typical edge configurations see Figure 4 and Figure 5.

2.3.9 Castings including cast iron shall be produced by foundry techniques which give dense smooth surfaces free from slag, sand and inclusions, shrinkage cavities, scabs, cracks, porosity and burrs and the entrapment of air in surface defects.

Removal of defects shall be by welding and grinding or by grinding alone. Grinding alone shall be used only for small defects such that the ground cavity blends smoothly with the casting surface and does not reduce the sound wall of the casting below the requirements of the design standard. For larger defects welding shall be used and the repair weld shall be ground flush such that it does not impair the requirements of the design standard.

2.3.10 Where there is a requirement that a rotating part shall be balanced, then this balancing shall be done both before and after lining.

2.3.11 All slag, anti-spatter compounds or similar materials shall be removed.

All weld spatter shall be removed by chipping and/or grinding.

2.3.12 Surface defects such as scores, pitting and rolling defects shall be removed by grinding, or where necessary repaired by welding provided that the requirements of design and construction are met.

2.3.13 Surfaces shall be presented to the lining applicator in a clean condition free of all contamination, for example oil, grease, temporary protective coatings, such that no pre-treatment is required other than any grit blasting which is to be part of the lining process.

2.4 Design of concrete equipment to be lined

2.4.1 Whilst it is not possible to eliminate shrinkage cracks in concrete, the design shall be such that structural cracking is eliminated. Particular attention shall be paid to avoiding cracking due to thermal stresses.

The ability of the lining to accommodate cracking of the concrete shall determine the selection of the rubber.

Equipment shall be designed to BS 8110 or BS 5337.

NOTE Equipment designed and constructed to class A of BS 5337 is liable to develop cracks up to 0.1 mm wide. Equipment designed and constructed to class B of BS 5337 is liable to develop cracks up to 0.2 mm wide.

The concrete in the case of class A of BS 5337 shall have a minimum compressive strength of 30 N/mm² and in that of class B of BS 5337, 25 N/mm².

2.4.2 If necessary, extra reinforcements shall be used and construction joints treated so as to promote a bond between adjacent areas of concrete. Expansion joints create special problems in lining and shall not be used without consultation between the purchaser and the applicator of the lining.

2.4.3 Pipes and fittings shall be designed with puddle flanges and cast into the concrete. Where necessary such fittings shall be designed in a corrosion-resistant material. Pipes and fittings shall normally be rubber lined before being cast into the concrete.

2.4.4 The arrangements for the lifting of equipment shall be determined at the design stage.

2.4.5 The design of all equipment shall allow for access during the preparation of the surface and application of the lining, and for venting of fumes evolved during the operation.

In completely enclosed vessels there shall be at least one manhole complying, after lining, with BS 470 and one additional branch of not less than 75 mm bore to permit adequate circulation of air.

NOTE It is recommended that, where practicable, the minimum diameter of a manhole should be 600 mm.

2.4.6 All corners shall be designed to be formed with a 45° fillet with a minimum leg length of 20 mm.

2.4.7 All equipment to be placed below ground level or subject to external water pressure shall be provided with a waterproof barrier on the outside of the equipment.

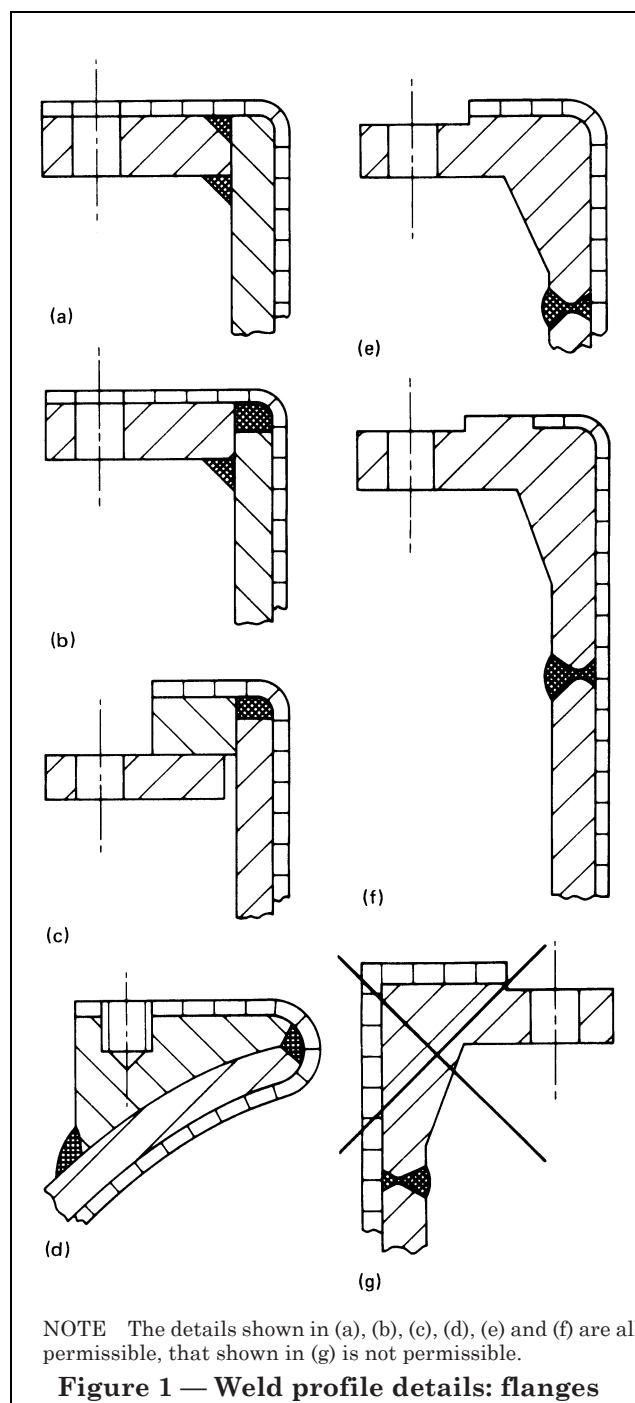
2.4.8 All equipment shall be designed with a minimum of 20 mm of concrete over reinforcement.

2.5 Construction of concrete equipment to be lined

2.5.1 Concrete equipment shall be constructed in accordance with BS 5337 or BS 8110 as appropriate.

2.5.2 Proper curing of the concrete shall be ensured by the use of curing membranes. If shuttering is removed in under 7 days a curing membrane shall be applied.

Concrete equipment shall be allowed to cure for 28 days before the work of lining proceeds. Concrete hardening solutions shall not be used.



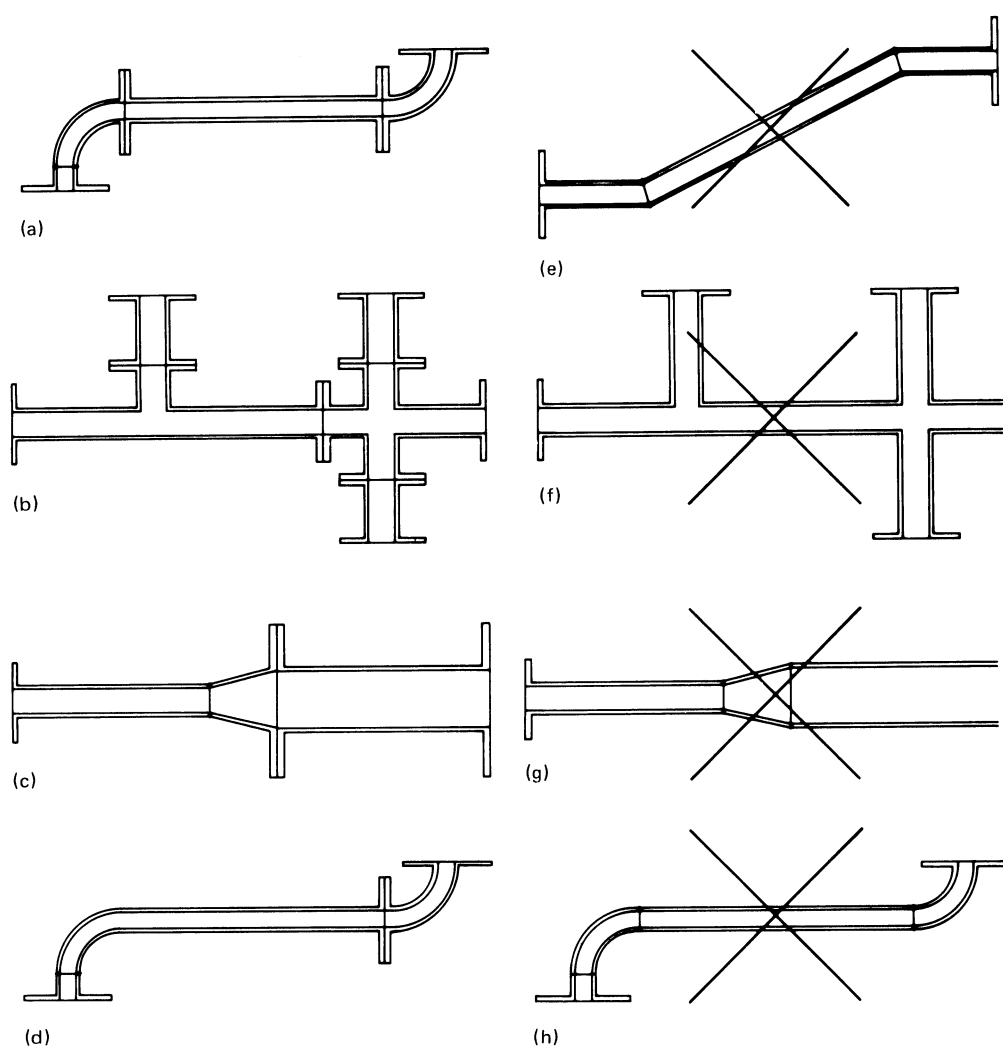
2.5.3 Equipment which is slip formed shall be bagged as the concrete leaves the formwork before the curing membrane is applied.

NOTE This process will reduce the amount of laitance.

2.5.4 All surfaces not cast against shutters shall be finished with a wooden float. Curing membranes shall be applied and not disturbed for 7 days.

2.5.5 Any steps in the concrete due to misalignment of shutters or surplus material formed because of gaps at joints in shutters shall be dressed off and ground smooth.

2.5.6 All holes left after removal of ties to secure and align formers shall be filled. Any surface defects such that the aggregate is exposed shall be filled. The material used for filling shall be a sand/cement grout with a high cement content or a sand/cement water miscible epoxy resin grout or an epoxy resin mortar.



NOTE The details shown in (a), (b), (c) and (d) are all permissible; those shown in (e), (f), (g) and (h) are not permissible.

Figure 2 — Pipework details