BRITISH STANDARD

BS 4508-1: 1986

Incorporating Amendment No. 1

CONFIRMED DECEMBER 2007

Thermally insulated underground pipelines —

Part 1: Specification for steel cased systems with air gap

UDC [66.026 + 697.34:697.334]:621.644.2:662.998

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Refrigeration, Heating and Air Conditioning Standards Committee (RHE/-) to Technical Committee RHE/9, upon which the following bodies were represented:

British Ceramic Research Association
British Gas Corporation
Chartered Institution of Building Services Engineers
Combustion Engineering Association
Cranfield Institute of Technology
Department of Health and Social Security
Department of the Environment (Building Research Establishment)
Department of Trade and Industry (National Physical Laboratory)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Eurisol (UK) Association of Manufacturers of Mineral Insulation Fibres
Gypsum Products Development Association
Institution of Gas Engineers
Phenolic Foam Manufacturers' Association
Refrigeration Industry Board
Royal Institute of British Architects
Structural Insulation Association
Thermal Insulation Manufacturers and Suppliers Association (TIMSA)
Thermal Insulations Contractors Association
Water-tube Boilermakers Association

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

Associated Offices Technical Committee
British Rigid Urethane Foam Manufacturers' Association
British Steel Industry
Combined Heat and Power Association
Department of the Environment (Property Services Agency)
National Coal Board
Pipeline Industries Guild
Pre-Insulated Mains Contractors Association (PMCA)

This British Standard, having been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee, was published under the authority of the Board of BSI and comes into effect on
30 May 1986

First published October 1969
First revision May 1986

The following BSI references relate to the work on this standard:
Committee reference RHE/9
Draft for comment 84/78101 DC

ISBN 0 580 15025 9

Amendments issued since publication

Amd. No.	Date of issue	Comments
7727	July 1993	Indicated by a sideline in the margin

Contents

Foreword

This revision of this Part of BS 4508 has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee and is one of a series specifying requirements for thermally insulated underground piping systems for conveying or circulating steam, hot or chilled water, heated oil and other fluids. The series does not include systems that employ a high vacuum in the annulus as the sole means of insulation.

This Part of BS 4508 deals with pipe-in-pipe systems having a welded steel outer casing and air gap between the casing and the insulated service pipe. As such the system is suitable for fluids of all temperatures above 5 °C, including high temperature hot water and steam, and should withstand the effects of ground, surface and flood water, which is often aggressive and usually under some pressure due to hydraulic flow or static head.

When first published in 1969, this Part of BS 4508 included an appendix which described tests for identifying whether a site could be considered as Class A (wet) or Class B (dry). However, it is no longer considered practical to classify any site as other than wet and these tests were deleted from the standard by amendment.

Experience gained since 1969 has enabled the requirements to be specified in greater detail but the standard of workmanship, particularly for field installation work, is of paramount importance. The revised layout of this Part of BS 4508 should assist in separating the responsibilities of the manufacturer of the pipework and equipment from those of the installation contractor.

This Part supersedes BS 4508-1:1969, which is withdrawn.

Other published Parts of BS 4508 are as follows:

— *Part 3: General requirements for cased systems without air gap;*

— *Part 4: Specific testing and inspection requirements for cased systems without air gap.*

This Part and BS 4508-3 and BS 4508-4 should be used in conjunction with CP 3009, which gives guidance on the method of selecting the most suitable system for particular applications. The installation of pipelines is covered in CP 2010 and other relevant information may be found in CP 413 and BS 5970.

The system described in this Part of BS 4508 utilizes established techniques that are the culmination of several decades of development through field trials and extensive operational experience by major authorities and other users. However, if a fault condition arises, it should be notified to the Installer/Guarantor and rectified at the earliest opportunity in order to prevent deterioration of the system, including the external protective coating. Partial failure due to damp insulation can result in continuous and expensive fuel wastage and other severe penalties and it should be noted that an air gap provides built-in facilities for routine testing. If required, the air gap may be sealed and a positive or negative dry air pressure, or nitrogen pressure, applied to indicate ingress of ground water.

Particular attention is drawn to the need for cathodic protection of piping systems, unless otherwise indicated (see **7.4**).

It is expected that the British Standard Registered Firms Scheme will be extended to include firms engaged in underground pipeline schemes.

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 to iv, pages 1 to 10, 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.

blank

1 Scope

This Part of BS 4508 specifies requirements for the design, materials, construction, installation, testing and fault monitoring of thermally insulated underground piping systems using a steel casing enclosing an insulated service pipe and incorporating an air gap, suitable for conveying fluids at temperatures exceeding 5 °C.

In addition to the definitive requirements given, it also requires the items detailed in clause **3** to be documented.

NOTE The titles of the publications referred to in this Part of BS 4508 are listed on page 10.

2 Definitions

For the purposes of this Part of BS 4508 the following definitions apply.

2.1
pipe-in-pipe

a pipe assembly consisting of an insulated service pipe or pipes encased in a pressure-tight casing of suitable material. The assembly may or may not incorporate an air gap between the insulation and the outer casing

2.2
air gap

an annular space between the service pipe insulation and the casing of a pipe-in-pipe assembly

2.3
duct

an enclosure provided for the distribution of services

2.4
holiday

a hole or flaw in the continuity of a protective coating

2.5
fault monitoring

a regime of inspection or examination to detect the presence of liquid in the outer casing or the access chambers of an installed system

2.6
fault monitoring system

a means of carrying out monitoring on a continuous automatic basis using sensing devices which may be interconnected in groups or connected to a single central source

NOTE Fault monitoring systems may be provided with alarm arrangements to signal automatically the presence of a fault condition.

2.7
access chamber

an enclosure to house isolating valves and other items of equipment associated with thermally insulated underground piping systems, and to provide adequate and safe access for operation and maintenance of the equipment housed

2.8
ground water

water occurring naturally in the ground

2.9
surface water

water from the ground surface, paved areas and roofs

3 Information to be supplied by the purchaser

3.1 General

The purchaser shall state the following in his enquiry and order:

a) the type of fluid to be carried in the service pipe and the design temperature and pressure (see **7.1**);

b) the thickness of the thermal insulation required or the maximum casing temperature (see **5.4.3** and Appendix A);

c) whether the insertion of control cables in the casing is required (see **5.7**);

d) whether leak detection and location equipment is required (see **5.8**);

e) whether continuous fault monitoring is required (see clause **9** and Appendix B);

f) the particular requirements of the authority with respect to access chambers (see note 1 in clause **6**);

g) particular requirements for surface temperatures in access chambers where these are to be lower than those recommended in BS 4086 (see **7.12**);

h) the requirements for weld testing at the works and in the field, e.g. radiographic, other types of non-destructive testing or visual inspection (see **5.1.3** and **8.1.1**);

i) whether or not a guarantee is required (see Appendix D).

3.2 Options

Certain options, that the purchaser may also specify, are permitted by this specification. Where no such options are specified, the following shall be at the discretion of the manufacturer:

a) the British Standard with which the material of the service pipe shall comply (see **5.1.1**):

b) general details of the cover above the pipe with particular reference to road crossings (see **5.2.1**);

c) the grade required for the type 2 material in accordance with BS 4147 or BS 4164 for external coatings for casings and access chambers (see **5.2.3** and **6.2**);

d) the working space in the access chamber where more than one person is needed for operation and maintenance functions, i.e. the number of persons and the location/nature of the necessary functions (see **6.1**);

e) the location of any casing drainage points in addition to those provided in access chambers (see **7.3**);

f) location and type of provision for temperature measurement (see **7.13**);

g) location and type of provision for the measurement of volume flow rate, e.g. venturi units, orifice plates, pressure-tapped valves, etc. (see **7.14**).

4 Information to be supplied by the manufacturer

The manufacturer shall state the following in his tender and quotation:

a) the protective treatment offered for the internal surface of the casing (see **5.2.2**);

b) detailed instructions for the handling, stacking and storage of prefabricated pipe sections (to be provided at the time of delivery of the product) (see **5.6**);

c) a statement of the need for cathodic protection where the manufacturer has been instructed to conduct a soil survey (see **7.4**);

d) the allowable drop in pressure throughout the system when tested by the method given in **8.2.2**.

5 Insulated pipe assembly

5.1 Service pipe

5.1.1 *Material*. Steel pipes shall comply with BS 1387, BS 3601 or BS 3602, as appropriate [see **3.2** a)].

Copper pipes shall comply with BS 2871-1.

5.1.2 *Finish*. The internal surface of service pipe sections shall be clean and free from foreign matter.

The external surface shall be suitably prepared, e.g. by power wire brushing, before the application of any coating or insulation.

5.1.3 *Welded joints*. All welded joints in the service pipe that would be rendered inaccessible by subsequent assembly shall be examined visually, or by non-destructive testing, in accordance with BS 2640 or BS 2971 as appropriate, prior to the assembly of the service pipe with the casing.

5.2 Casing

5.2.1 *Material*. The casing shall be seamless or welded steel pipe complying with grade 410 of BS 3601 with a specified minimum wall thickness as given in Table 1.

Table 1 — Specified minimum pipe wall thickness

Nominal size	Specified minimum wall thickness
mm	mm
150 to 450	3.2
500 to 650	5.0
700 and above	5.9

NOTE These wall thicknesses assume that there will be not less than 500 mm cover above the pipe generally, and not less than 600 mm cover under roads [see **3.2** b)].

Where the outer casing is used for prestressing or for the transfer of stresses to the ground, calculations shall be made to substantiate that the wall thickness of the outer casing is adequate. No account shall be taken in the calculations for bracing provided by non-structural pipe supports.

5.2.2 *Internal finish*. A suitable protective treatment shall be applied to the internal surface of the casing to inhibit rusting before assembly.

NOTE See DD 24 for recommended methods of protection against corrosion. See also clause **4** a).

5.2.3 *External coating*. The external surface of the casing shall be protected by hot applied coating material in accordance with BS 4147 or BS 4164, using the appropriate grade of type 2 material [see **3.2** c)].

The coating shall include the primer and a flood coat of the coating material applied in accordance with CP 2010, BS 5493 and the manufacturer's instructions. Before the flood coat is applied the primer shall be dry. Inner and outer wrapping of non-woven glass fibre tissue shall be applied simultaneously to the flood coat of coating material.

The inner wrap shall have a minimum mass of 42 g/m^2, a minimum thickness of 0.25 mm and a longitudinal tensile strength of 306 N for a sheet width of 150 mm.

The outer wrap shall be saturated with the coating material and have a minimum mass of 460 g/m^2, a minimum thickness of 0.60 mm and a longitudinal tensile strength of not less than 535 N for a sheet width of 150 mm.

Both wraps shall be spirally wound with a minimum overlap of 25 mm. The finished external coating shall have an average thickness of not less than 4 mm with an absolute minimum thickness at any point of 2.4 mm and an absolute maximum thickness of 7 mm. The completed external coating shall be well bonded to the casing material, uniform, smooth and free from holidays and shall be trimmed off 150 mm from the ends of each casing section and bevelled throughout its thickness over a minimum length of 25 mm.

NOTE 1 When a measurement of the average coating thickness is required, it should be determined by non-destructive means with a minimum of 10 thickness measurements taken at random over a selected length of casing from the batch.

NOTE 2 Where it is required to verify the bond strength of the coating, the method given in Appendix E should be used.

NOTE 3 Bitumen based materials may not be suitable as an external coating material in certain contaminated soil conditions. For this reason, an analysis of soil samples should be carried out, and a suitable coating material selected that is resistant to attack.

5.2.4 *Coating spark test.* The finished coating on all casing sections shall be spark-tested for holidays at a minimum of 7 000 V. All holidays detected shall be repaired and retested.

5.3 Pipe supports

Supports shall be provided within the casing at such intervals that the safe working stress on the casing due to all imposed loads is not exceeded.

NOTE Reference should be made to Chartered Institution of Building Services Engineers (CIBSE) Guide, Section B16.

Supports shall be of a design that will permit thermal expansion and drainage. They shall be protected against corrosion and incorporate a thermal break to minimize conduction of heat from the service pipe.

5.4 Insulation

5.4.1 *Material.* The insulating material shall be calcium silicate complying with BS 3958-2, or bonded preformed man-made mineral fibre complying with BS 3958-4 with a density of not less than 140 kg/m^3.

It shall be supplied in complete or half-sections. Each section shall be secured to the pipe by not less than three stainless steel bands complying with grade 430S15 or 432S19 of BS 1449-2, and not less than 20 mm wide.

Spacers or other pipe supports for mineral wool insulated applications shall be arranged in conjunction with load bearing cladding or other means such that they do not bear directly on the mineral wool insulation itself.

5.4.2 *Air gap.* A gap of at least 20 mm shall be provided between the external surface of the insulation and the interior surface of the casing.

5.4.3 *Thickness of insulation or temperature limitations.* The thickness of insulation required, in terms of heat loss, and the thickness required to achieve certain temperature limitations shall be calculated by using the formulae in Appendix A. [See also **3.1** b).]

NOTE The thickness of insulation required will vary according to the design requirements of the system.

5.5 Sealing prefabricated pipe sections

The casing and service pipe(s) of prefabricated pipe sections shall be sealed at the factory with protective caps to avoid the ingress of water vapour, water and foreign matter. The protective caps shall be mechanically strong and designed to prevent accidental or careless damage to the pipe sections.

5.6 Instructions

The manufacturer shall provide instructions for the handling, transporting, stacking and storage of prefabricated pipe sections with protective coatings [see clause **4** b)].

5.7 Control cables

Where a cable or cables are inserted within the casing for the purpose of conducting signals from items of equipment attached to the district heating network to a central position [see **3.1** c)], the integrity of the casing shall be maintained.

5.8 Leak detection and location equipment

Where leak detection and/or location equipment is installed [see **3.1** d)], it shall be provided as part of the pipe-in-pipe system. It shall not constitute an electrical hazard during operation or maintenance.

6 Access chambers

NOTE 1 Attention is drawn to the statutory requirements for access chambers and to any requirements of the authority responsible for the site in respect of the safety aspects of their design, operation and maintenance [see **3.1** f)].

NOTE 2 The design should take account of the Health and Safety Executive Guidance Note GS 5.

6.1 Size

Adequate space for one person (or for more than one where necessary) shall be provided for safe installation, operation and maintenance of the service pipes and components, bearing in mind that some components may be hot. There shall be space for a person to stand upright to facilitate operation or maintenance of the equipment.

Additionally, space and access arrangements shall be sufficient to facilitate the rescue of injured or incapacitated persons in the event of an accident contingency.

NOTE For typical recommendations, see CP 301, CP 413 and CP 2005. [See also **3.2** d).]

6.2 Materials

Access chambers shall be prefabricated in steel in accordance with BS 4360, and externally protected by hot-applied coating material in accordance with BS 4147 or BS 4164, using type 2 material [see also **3.2** c)].

6.3 Sump

Access chambers shall be provided with a sump, or sumps, to accommodate a pump or its suction parts.

6.4 Covers

Covers for access chambers shall incorporate a sealing arrangement to withstand the pressure of an external depth of water of 75 mm. The design of the sealing arrangement shall not permit the entrapment of stones, etc. between the sealing surfaces.

NOTE Manhole covers at ground level provided for access chambers should be in accordance with BS 497, wherever possible.

6.5 Ladders

Rungs or a ring ladder complying with BS 4211 shall be provided and fixed to the walls of access chambers that personnel are required to enter.

7 Design and installation of the pipe system

NOTE Reference should be made to CP 2010 and CP 3009.

7.1 Compatibility of materials

Materials used in the manufacture of the pipe system shall be chemically compatible with the fluid to be used, and shall be able to withstand physically the effects of the fluid at its maximum temperature pressure [see **3.1** a)].

7.2 Casing loads

Surcharge loadings on the buried casing shall be determined in accordance with BS 153-3A.

NOTE The pressure on the buried casing of a piping system is caused by the mass of the soil cover plus any surcharge loading.

7.3 Drainage and venting

Piping systems shall be laid to a uniform fall of not less than 1 in 500 and facilities for drainage of the casing shall be provided at access chambers and where necessary [see **3.2** e)]. Vents shall be provided at high points and, where practicable, shall terminate above ground level. Where this is impracticable they shall terminate in a manhole. Vent pipes shall be threaded to facilitate sealing for pressure testing of the casing. Drain cocks shall be fitted. For positively or negatively pressurized systems, all vent and drain points shall be sealed with a suitable material.

7.4 Cathodic protection

Cathodic protection for the piping system, including access chambers, shall be provided unless a soil survey over the finally agreed route indicates that it is unnecessary [see clause **4** c) and CP 1021].

7.5 Prevention of electrolytic corrosion

Where dissimilar metals are used in the same underground system, they shall be electrically isolated.

7.6 Precautions against ingress of water

During installation, precautions shall be taken to prevent the ingress of water to the system. Protective caps shall be left in position on the casing and service pipes until final connections or closures are made, and arrangements shall be made for the drainage of water from the excavations.

Where flooding of the piping system occurs, the water shall be removed from the affected section(s) and the thermal insulation dried out before proceeding further with the installation.

7.7 Welding and brazing

The welding of steel service pipes, casing, bends and components shall be carried out in accordance with BS 2971 or BS 2640. The electrode used shall be in accordance with BS 639 and shall be supplied in moisture-proof containers.

Copper pipes shall be brazed. Brazing materials shall comply with BS 1845. Soft solders shall not be used.

NOTE See clause **8** for the field tests to be carried out prior to, and after welding or brazing.

7.8 Casing terminations

The casing shall be adequately sealed to the service pipe at termination points such as access chambers and inspection points within buildings, in order to ensure that the system remains pressure and vacuum tight.

7.9 Anchors

Anchors shall be provided where necessary to control expansion and contraction. Anchors for the service pipe shall be designed to allow a free flow for air and drainage.

7.10 Expansion and flexibility

Where provision is made for expansion, there shall be sufficient clearance within the casing to permit expansion and contraction of the service pipe under working conditions without damage to the insulation.

NOTE The use of expansion bellows or slip joints on the service pipe is not recommended unless they are accessible for inspection.

7.11 Electrical equipment in access chambers

Electrical sockets or equipment situated in access chambers shall have a working voltage not exceeding 110 V, with a 55 V maximum to earth from a double-wound transformer earthed at the centre point and core.

7.12 Surface temperatures in access chambers

Thermal insulation shall be applied to all service pipework and fittings.

NOTE 1 This requirement does not apply to items that need to remain exposed or unobstructed for operational purposes, e.g. valve handwheels.

The insulating material used shall be suitable for the temperature of the conveyed fluid and non-combustible when tested in accordance with BS 476-4.

Temperatures of accessible surfaces, other than those left uninsulated for operational purposes, shall not exceed those recommended in BS 4086 [see also **3.2** f)].

NOTE 2 Attention is drawn to PD 6504 and BSRIA Technical Note 4/76.

NOTE 3 Reference should be made to BS 5970 in respect of the methods of installation and the use of thermal insulating materials.

7.13 Temperature measurement

Where it is required to measure temperatures within the service pipe, facilities for this shall be provided at major demand and supply points [see **3.2** f)].

NOTE It is not recommended that these points be within casing sections. Reference should be made to BS 1041 for the selection of appropriate methods.

7.14 Volume flow rate measurement

Where required [see **3.2** g)], equipment or facilities shall be provided at specified points in the distribution system, for the periodic measurement of volume flow rate.

8 Field tests

NOTE Arrangements should be made to carry out these tests in accordance with a suitable programme to avoid undue delay to the final completion of the installation.

8.1 Tests on service pipeline

8.1.1 *Test on welded joints.* Prior to welding the casing joints, the field joints in the completed service pipeline shall be subject to radiographic tests in accordance with BS 2600 or BS 2910, as appropriate, or other non-destructive tests as specified by the purchaser [see **3.1** h)]. The fault limitations of BS 2640 or BS 2971, as appropriate, shall apply.

8.1.2 *Pressure test.* During installation, when only part of the system is to be tested, the service pipeline shall be subjected to a hydrostatic pressure of 1.5 times the internal design pressure or a pressure resulting in a circumferential stress of 90 % of the yield stress, whichever is less, for a period of 24 h. There shall be no observable pressure drop that cannot be accounted for by temperature changes.

On completion of the installation, the service pipeline shall be hydrostatically tested at 1.5 times the internal design pressure for a total duration of 24 h at the test pressure, with no observable pressure drop that cannot be accounted for by temperature changes (see **2.5.6** and **2.5.7** of CP 2010-2:1970).

8.2 Tests on casing

8.2.1 *Spark test.* In addition to a visual examination, the coating on the casing shall be spark tested for holidays, at a minimum of 7 000 V. All holidays detected shall be repaired and retested. This shall be carried out on each length before assembly and on the complete length after assembly.

8.2.2 *Pressure test.* Before backfilling, the completed casing shall be subjected to a pressure test using air or nitrogen at a gauge pressure of 1 bar[1)] for a duration of 2 h. The pressure drop on the test gauge over this period shall not exceed that specified by the manufacturer [see clause **4** d)].

This test shall be repeated after completion of backfilling.

8.2.3 *Dryness test.* The installation, particularly the thermal insulation, shall be dried by blowing air through the length of the casing whilst maintaining the service pipeline at the design temperature until there is no increase in moisture content of the air passing through the casing.

The fluid in the service pipeline shall be maintained at the design temperature for at least 4 h before taking measurements.

NOTE Air is blown through the casing using a fan and/or compressor as necessary.

The moisture content of the air shall be determined from measurements of the wet-and-dry-bulb temperatures at entry and exit using mercury-in-glass thermometers complying with BS 1704 or other instruments of equivalent accuracy, and derived from psychrometric data in CIBSE Guide, Section C1.

9 Fault monitoring

NOTE Guidance on the location of the leakage source is given in Appendix C.

[1)] 1 bar = 10^5 N/m^2 = 10^5 Pa.

9.1 Periodic monitoring for faults

Provision for periodic manual monitoring for faults shall be incorporated as follows.

a) *Ingress of liquid into the casing*. Suitable tappings or connections shall be provided in the casing at low points in the distribution system. The design shall enable monitoring to be carried out at ground level.

b) *Liquid collecting in sumps*. Means shall be provided to enable the volume of liquid in a sump in an access chamber, or other enclosure, to be monitored without the need to enter the chamber or enclosure.

9.2 Continuous monitoring

Continuous monitoring facilities, which may be specified by the purchaser [see **3.1** e)], are given in Appendix B.

Appendix A Thickness of insulation and temperature limitations

A.1 Thickness of insulation

This specification does not specify any particular value for the insulation thickness. The required value will vary according to the desired balance between capital costs and scheme running costs, the necessary mechanical strength of the insulation, and the commercial thicknesses readily available.

The rate of heat loss by the insulation Q (W/m) is given by the following equation:

$$Q = \frac{\theta_w - \theta_a}{R_i + R_s} \quad (1)$$

where

R_i is the thermal resistance of the insulation (m·K/W) given by:

$$R_i = \frac{\text{In } (1 + 2t/d_1)}{2\pi\lambda_i} \quad (2)$$

and

R_s is the thermal resistance of the soil (m·K/W) given by:

$$R_s = \frac{\text{In } (4h/d_2)}{2\pi\lambda_s} \quad (3)$$

where

θ_w is the fluid temperature (°C);

θ_a is the air temperature(°C)[a]

d_1 is the outside diameter of service pipe (m);

d_2 is the outside diameter of casing (m);

t is the insulation thickness (m);

h is the depth of burial of pipe centreline (m) (assumed to be greater than $2d_2$);

λ_i is the thermal conductivity of the insulation [W/(m·K)];

λ_s is the thermal conductivity of the soil [W/(m·K)] (see **A.4**);

In is the napierian log.

[a] For the purposes of this calculation θ_a should be taken as 5 °C, which is the general minimum soil temperature at a depth of 1 m in the UK.

The temperature θ (in °C) at the outer surface of the casing may be derived from the following equation:

$$\frac{\theta_w - \theta}{\theta_w - \theta_a} = \frac{R_i}{R_i + R_s} \quad (4)$$

A.2 Casing temperature limitation

If the casing temperature θ is required to be below a specified value, for agricultural or other reasons, determine R_s for the depth of burial and soil in question using equation (3), insert this in equation (4) to find the required value of R_i, and insert this in equation (2) to obtain the required value of t.

A.3 Temperature change limitation

If the temperature change of the fluid is required to be less than a specified value for a given distance, e.g. if water is available at a temperature θ_1 at the initial point and is not to be cooler than θ_2 at the final point, then this condition is satisfied if:

$$R_i + R_s = \frac{L}{Mc \text{ In } \dfrac{\theta_1 - \theta_a}{\theta_2 - \theta_a}}$$

where

L is the given pipe length (m);

M is the minimum mass through the service pipe (kg/s);

c is the specific heat capacity [J/(kg·K)];

In is the napierian log.

A.4 Soil thermal conductivity

The thermal conductivity of the soil makes only a small contribution to the overall heat loss of a pipe buried and insulated in a normal manner as the main factor determining the heat loss is the pipe insulation. An approximate value of the soil conductivity is all that is required and, for general calculation purposes, a value of 1 W/(m·K) should be used. Moisture is the main factor affecting soil conductivity and the values given in Table 2 should be chosen where more detail is required.

Table 2 — Soil thermal conductivity and moisture values

Soil type	Moisture	Thermal conductivity at a temperature of 5 °C
	%	W/(m·K)
Wet sand	22	2.1
Wet gravel	12	1.8
Wet clay	30 and more	1.7
Medium clay	about 20	1.0
Dry clay	10 or less	1.7

NOTE The effect on the calculated heat loss of choosing either of the extreme values of thermal conductivity rather than a mean value is not likely to exceed 10 %.

Appendix B Continuous monitoring for fault conditions

B.1 General

NOTE Continuous monitoring for faults is recommended because of the damage that can result directly from some fault conditions within a short period.

Where such fault monitoring arrangements are required [see **3.1** e)], they shall be applied to provide a check on the volume of liquid collected in a sump in an access chamber or other enclosure, and on the ingress of liquid into the casing.

B.2 Monitoring the liquid in a sump

A float switch or other suitable liquid level sensing device that gives a continuous indication shall be provided in the sump.

B.3 Monitoring the casing

The void in the casing shall be monitored by use of the following methods.

a) *Liquid sensing device method*. A liquid sensing device shall be located in a drain connection at a low point in the installation.

b) *Constant pressure method*. The following requirements apply to the casings.

1) The casing shall be maintained at a constant pressure, either above or below atmospheric pressure. Fluctuations in the pressure are assumed to be caused by leakage into or out of the casing.

NOTE 1 For various reasons it is impossible to achieve total pressure tightness in an installation of this type. Each installation, therefore, will contain small imperfections which will result in an aggregate leakage characteristic for the system. For the purposes of monitoring, constant leakages of this nature should be discounted.

2) Where the casing is to be maintained above atmospheric pressure, nitrogen or dry air shall be used as the pressurizing fluid. The pressure maintained shall be not less than 0.4 bar gauge.

NOTE 2 Where the casing is maintained above atmospheric pressure, failure of the casing itself would tend to result in a decay of pressure.

Failure of the service pipe would, dependent on the internal pressure of the system, tend to result in an increase in the pressure in the casing. Checks in closed systems should also be made of the service fluid make-up records to see whether any indication is shown of a change in make-up rates.

NOTE 3 Subject to the approval of the local water authority, dyes or trace agents may be added to the system water or to any suspect ground water origins to help to confirm any initial indications of leakage source.

3) Where the casing is to be maintained below atmospheric pressure, the pressure maintained shall not exceed 0.6 bar absolute.

4) The pressure differential used to initiate a fault signal shall be not less than 0.2 bar.

5) Each casing section maintained above atmospheric pressure shall be provided with relief valve(s). The relief valves shall be arranged to discharge in a safe position external to access chambers or other enclosures. The size and setting of relief valve(s) shall be related to the maximum operating pressure of the service fluids (see BS 1123).

B.4 Fault indication signals

Wherever possible, all sensing devices shall be interconnected to indicators and alarm arrangements located in a convenient central position. Where central indication is not provided it is essential that arrangements shall be made to permit sensing devices to be checked locally without the need to enter access chambers or other enclosures or areas not readily accessible.

Appendix C Location of the leakage source

C.1 General

Owing to the expense of excavation and replacement it is important to locate the leakage before trench excavation is started. Trial holes should be dug and inspection windows cut in the casing so that visual inspection of the service pipe and casing can be undertaken to establish location of the leakage.

Following repair of the leak and replacement of windows, a testing sequence as detailed in clause **8** should be undertaken prior to reinstatement.

C.2 Acoustical methods

Location of leakage should be undertaken when the first indication of a fault occurs. Location of leakage in a service pipe may be determined by acoustic detection after having isolated the suspect section of the pipe and drained the heating medium.

A negative pressure should be imposed on the service pipe or a positive pressure on the casing, and a microphone should be inserted and passed along the service pipe to detect the maximum sound of escaping air.

This method, however, may not be capable of detecting and locating very small leaks. In such cases the service pipe under test should be flooded and the microphone should be used to detect the noise of bubble formation/collapse.

C.3 Thermographic surveys

Thermographic surveys to locate identified service pipe failures may, due to the spread of the service water, only provide an approximate indication of the leakage position. Unexpected gradients in the casing may also cause thermography to give an entirely false indication of the leakage position. Where records of previous surveys are available, however, comparison of thermographs may be interpreted to give an improved location of the leakage source.

Appendix D Guarantee and insurance arrangements

Where a guarantee is required [see **3.1** i)], arrangements should be negotiated prior to contract to enable the agreed standards of inspection to be implemented at works and on site.

The following are recommendations for guarantee and insurance arrangements.

a) The client should ensure that any guarantee provided by the supplier includes provision for the location of faults and the repair or replacement of defective materials and workmanship leading to operating failure and, in addition, the repair of leaks as a result of external corrosion of the service pipe.

b) It is recommended that such a guarantee should be underwritten by an insurer approved by the client in the joint names of the supplier and the client.

c) The insurance policy wording should be compatible with the guarantee provisions providing indemnity to both client and supplier. This ensures that in the event of the supplier not being available, for whatever reason, to fulfil his obligations in the event of a failure, the policy continues for the benefit of the client and effectively maintains the guarantee in full force throughout the guarantee period.

d) The client should ensure that the limits of indemnity in the policy are sufficient and have regard for the effects of inflation over the guarantee period.

e) Both the guarantee and policy wordings should be agreed between the parties at tender stage.

NOTE The insurer's engineers may be required to carry out field inspection and tests during installation which they regard as essential to their underwriting of the guarantee. These activities may be duplicated by the client's own insurers or by the independent Inspecting Authority.

f) The client should ensure that other insurances effected on plant, including underground piping systems, supplement and do not duplicate the guarantee insurance provisions.

NOTE On expiry of the guarantee period the client may wish to negotiate some form of continuation insurance to offer some cover against the risks defined in a).

Appendix E Method of test for the bond strength of the coating

From a selection sample length from the batch, make two parallel knife cuts in the finished coating about 100 mm long and 30 mm apart. With a stiff, flat blade loosen the coating the full width between the two cuts and lift into the wrap upwards at right angles to the casing surface. Provided the coating does not peel cleanly from the primer or the casing surface, the bond is considered satisfactory.

Publications referred to

BS 153, *Steel girder bridges.*

BS 153-3A, *Loads.*

BS 476, *Fire tests on building materials and structures.*

BS 476-4, *Non-combustibility test for materials.*

BS 497, *Specification for manhole covers, road gully gratings and frames for drainage purposes.*

BS 639, *Covered electrodes for the manual metal-arc welding of carbon and carbon manganese steels.*

BS 1041, *Code for temperature measurement.*

BS 1123, *Specification for safety valves, gauges and other safety fittings for air receivers and compressed air installations.*

BS 1387, *Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads.*

BS 1449, *Steel plate, sheet and strip.*

BS 1449-2, *Specification for stainless and heat resisting steel plate, sheet and strip.*

BS 1704, *Specification for solid-stem general purpose thermometers.*

BS 1845, *Specification for filler metals for brazing.*

BS 2600, *Radiographic examination of fusion welded butt joints in steel.*

BS 2640, *Specification for class II oxy-acetylene welding of carbon steel pipework for carrying fluids.*

BS 2871, *Copper and copper alloys. Tubes.*

BS 2871-1, *Copper tubes for water, gas and sanitation.*

BS 2910, *Methods for radiographic examination of fusion welded circumferential butt-joints in steel pipes.*

BS 2971, *Specification for class II arc welding of carbon steel pipework for carrying fluids.*

BS 3601, *Steel pipes and tubes for pressure purposes: carbon steel with specified room temperature properties.*

BS 3602, *Specification for steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties.*

BS 3958, *Specification for thermal insulation materials.*

BS 3958-2, *Calcium silicate preformed insulation.*

BS 3958-4, *Bonded preformed man-made mineral fibre pipe sections.*

BS 4086, *Recommendations for maximum surface temperatures of heated domestic equipment.*

BS 4147, *Specification for bitumen based hot applied coating material for protecting iron and steel including suitable primers where required.*

BS 4164, *Specification for coal-tar based hot applied coating materials for protecting iron and steel including suitable primers where required.*

BS 4211, *Steel ladders for permanent access.*

BS 4360, *Specification for weldable structural steels.*

BS 5493, *Code of practice for protective coating of iron and steel structures against corrosion.*

BS 5970, *Code of practice for thermal insulation of pipework and equipment (in the temperature range of – 100 °C to + 870 °C).*

CP 301, *Building drainage.*
CP 413, *Ducts for building services.*
CP 1021, *Cathodic protection.*
CP 2005, *Sewerage.*
CP 2010, *Pipelines.*
CP 2010-2, *Design and construction of steel pipelines in land.*
CP 3009, *Thermally insulated underground piping systems.*
DD 24, *Recommendations for methods of protection against corrosion on light section steel used in building.*
HSE GS5, *Health and Safety Executive Guidance Note. Entry into confined spaces*[2)].
CIBSE Guide Volume B, Section B16 Miscellaneous equipment[3)].
CIBSE Guide Volume C, Section C1 Properties of humid air, water, steam[3)].
BSRIA Technical Note 4/76 Permissible surface temperatures of heating equipment[4)].

[2)] Available from HMSO.
[3)] Available from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW1 9BS.
[4)] Available from the Building Services Research and Information Association, Old Bracknell Lane, West Bracknell, Berkshire RG12 4AH.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL