

Code of practice for

Thermally insulated underground piping systems

Committees responsible for this British Standard

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

- Autoclaved Aerated Concrete Products Association
- Chartered Institution of Building Services Engineers
- Combustion Engineering Association
- Cork Industry Federation
- Cranfield Institute of Technology
- Department of Health
- Department of the Environment (Building Research Establishment)
- Department of Trade and Industry (National Physical Laboratory)
- Electricity Association
- Eurisol (UK Mineral Wool Association)
- Gypsum Products Development Association
- Phenolic Foam Manufacturers' Association
- Power Generation Contractors' Association (BEAMA Ltd.)
- Royal Institute of British Architects
- Thermal Insulation Manufacturers and Suppliers Association (TIMSA)
- Thermal Insulations Contractors' Association

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

- British Coal Corporation
- British Rigid Urethane Foam Manufacturers' Association
- British Steel Industry
- Combined Heat and Power Association
- Department of the Environment (Property Services Agency)
- Institute of Energy
- Pre-insulated Mains Contractors Association (PMCA)
- Pipeline Industries Guild

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Foreword

This British Standard code of practice has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Policy Committee. It supersedes CP 3009:1970, which is withdrawn.

This code provides guidance relating to the design and installation of pre-insulated buried piping systems. These operations involve the delivery to site of factory insulated sections of pipe, the joining of these sections, and then the burying of the pipe assembly directly in the ground. Other types of systems, including the use of ducts and subways, are mentioned in less detail, as these have generally found less acceptance in the UK.

In preparing the code it has been recognized that service pipes installed underground should be designed to protect against mechanical failure due to overstressing and corrosion. Where service pipes are to be installed, the ingress of ground water into the insulation can cause corrosion of the service pipe and a reduction in insulation quality. This will result in high repair costs and operational shortcomings through water and heat loss, and loss of service in extreme cases. Facilities for regularly monitoring the condition of the thermal insulation and to detect the presence of water in the insulation are usually justified.

Ground water is the greatest single hazard affecting underground piping systems and is often aggressive and under pressure at some periods on most sites in the UK. Water in the ground will naturally collect or flow where resistance has been lowered, such as a back-filled trench.

Pre-insulated piping systems are being continuously developed. Therefore new products not directly covered by this code may become available. It is the intention of this code to provide general guidance to permit the selection of the most effective equipment available and not to inhibit innovation or constrain the designer to the methods specifically described in the code.

The code user should possess the necessary technical knowledge. Deviation from the guidelines of the code may be considered where soundness of such deviation can be substantiated and supported by advances in engineering understanding of the systems and the development of improved materials and methods.

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.

1 Scope

This British Standard gives recommendations for the design, planning, pre-fabrication, transport, installation, testing and operation of thermally insulated underground piping systems for conveying steam, chilled or hot water. It does not deal in detail with the ground engineering, civil engineering and building works necessary with the use of ducted systems, nor does it cover systems which depend upon a vacuum for thermal insulation.

Two types of system are covered in detail, both of which are pre-insulated pipe-in-pipe systems which are buried directly in the ground.

- a) Steel-in-steel system with air-gap for steam, chilled and hot water at operating temperatures up to 180 °C (see clause 5).
- b) Steel-in-plastics system without air-gap for chilled water and for hot water at operating temperatures generally up to 120 °C (see clause 6).

NOTE 1 Both of these systems have been installed over many years in the UK and the considerable experience available has been incorporated into the code.

NOTE 2 Other systems are briefly outlined in clause 4 where advice is given on their use.

NOTE 3 The titles of the publications referred to in this standard are listed on the inside back cover.

Other systems currently available in the UK which might be considered by the designer but which are not covered directly by this code are as follows:

- a) sliding pre-insulated steel-in-plastics systems;
- b) plastics-in-plastics systems;
- c) glass-reinforced plastics casings and service pipe systems;
- d) asphalt insulated systems;
- e) buried duct systems;
- f) subways.

2 Definitions

For the purposes of this British Standard, the following definitions apply.

2.1

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

2.2

air-gap

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

2.3

bonded system

a pipe-in-pipe system in which there is a bond between the service pipe, the insulations and the casing, to transfer limited stress and strain from one component to the other

2.4

casing

the pipe protecting the insulation and the service pipe from ground water and mechanical damage

2.5

contractor

the company responsible for the complete installation

2.6

designer

the company responsible for the overall working design of the pipe distribution network, including economics, routes, pipe sizing, equipment selection, and the method of installation

2.7

duct

an enclosure for the distribution of services

2.8

fault monitoring

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

2.9

fault monitoring systems

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

2.10

ground water

water occurring naturally in the ground at or below the water table

2.11

holiday

a hole or flaw in the continuity of a protective coating

2.12

HDPE

high density polyethylene

2.13

installer

the company responsible for welding, jointing and installing the pipe in the ground and for testing and commissioning the installation

2.14 manufacturer

the company responsible for assembling the pre-insulated system and for supplying and manufacturing other fittings and joint materials

2.15 pre-insulated systems

systems in which pipe elements consisting of protective casing, insulation and service pipe form part of an integrated bonded assembly which is transported to the site in suitable lengths, together with similarly fabricated fittings

2.16 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 insulated service pipe and the outer casing

2.17 pipeline

a line of pipes having a considerable length; it may have branch lines, but these would not normally be numerous

2.18 pipe distribution network

a network or grid of pipes comprising transmission mains, which may be lengthy, and a number of branches with short connections serving individual user points, for example, industrial process plant and district and group heating schemes

2.19 purchaser

the ultimate owner of the system

2.20 service pipe

the pipe that contains the service medium

2.21 specifier

the person(s) responsible for defining the equipment to be used. Normally the client or his agent

2.22 surface water

water from the ground surface, paved areas and roofs

2.23 system design life

the maximum operating life under design conditions without major replacements predicted at the time of the design

2.24 subway

a passage or duct large enough to accommodate the services required and large enough for an operative to walk through

3 Basic considerations

3.1 General

Distribution of heat from a central boiler plant will be economic when lower bulk fuel costs, bulk heat supply and centralized operating and maintenance arrangements compensate for the additional capital for distribution pipework. The distribution pipework may be through buildings, above or below ground, depending on the economics and routing constraints.

A buried service offers less obstruction to pedestrians or vehicular traffic, does not present aesthetic problems for the site and provides a high level of security against damage, except where later excavations are necessary. Also, because the bedding material and backfill contributes to the thermal insulation of a buried service, heat losses are generally lower than those for above ground or ducted services operating at the same conditions.

Heat losses from a buried pipe system will vary with the type of bedding and backfill materials used to surround the pipe and the water content of the ground. The designer should consider the relative costs of different materials including costs of compacting these. The amount of settlement and the ability of the materials to spread surface loads should also be evaluated and any specified requirements for particular backfill materials should be complied with.

3.2 Investment appraisal

The benefits of large-scale heat distribution stem from the ability to produce lower-cost heat from a centralized source when the capital costs of the central plant and buried piping are, in effect, recovered by the saving in the costs of heat production. An investment appraisal should be carried out, taking account of the following factors:

- a) the cost of capital, often expressed as a test discount rate;
- b) the capital cost estimate of the piping system;
- c) the cost of heat production from a central source including capital, operating and maintenance costs;
- d) the cost of heat production from individual building plant, including capital, operating and maintenance costs;

e) the sensitivity of the result to:

- 1) fuel price changes;
- 2) capital cost overruns;
- 3) operating and maintenance costs.

3.3 Environmental impact assessment

An environmental impact assessment may be carried out for both the centralized heat source and the alternative individual building heat sources. Such an assessment should consider the following:

- a) the emission of sulfur oxides, nitrogen oxides and carbon monoxide;
- b) the emission of carbon dioxide;
- c) the effects of construction works on the local environment;
- d) the environmental and resource consequences arising from the extraction and consumption of the primary fuels;
- e) the environmental effects arising from the materials used in the construction of the piping system;
- f) the environmental effects of the pipe in the ground. Local ground temperature will be raised depending on the insulation employed. Deterioration of insulation will produce very high ground temperatures. Leaking from service pipes will produce flows of high-temperature treated water.

3.4 Existing routeing facilities

At an early stage of design, a thorough search of the site for existing ducts, service tunnels or subways, should be made to avoid the need for new excavations.

3.5 Aesthetics

For a similarly sized piped network, where aesthetic considerations do not apply the pipe system with the lowest installation costs is likely to be the above ground type. Heat losses from above ground pipework systems under design conditions will be higher than buried pipework systems, as air temperatures are significantly lower than ground temperatures.

Buried pipework systems offer an aesthetic solution as the visual impact is minimal and this should be recognized in assessing the design options.

3.6 System design life

The purchaser should specify to the designer the system design life which may be related to the expected life of the buildings served. The designer should select, design and specify the system so that the system design life is achieved and should state the particular predicted life for the system.

3.7 Service temperatures

In selecting service temperatures the designer should consider the following:

- a) the end users' requirements;
- b) the influence of service temperatures on the cost of heat supply;
- c) the requirements for pressurization and pumping;
- d) the extent of thermal expansion produced and effect of fluctuating temperatures on the pipe system;
- e) the behaviour and system design life of the materials used in different pipe systems.

A complete analysis is complex and general guidance only can be given. Unless it is necessary to operate at high temperatures for particular reasons such as high-temperature process use, it is recommended that new systems should be designed for a maximum continuous operating temperature of 130 °C.

3.8 Exchange of information

An insulated buried piping system may cross the routes of roads, railways, canals and water courses; it is also likely to cross, or lie adjacent to, existing underground utility services. At an early stage of the development of a buried pipe system, the appropriate bodies should be consulted by the specifier and plans of the relevant sections of the pipe distribution network should be submitted to them in sufficient detail to enable proper consideration to be given, and any necessary clearances negotiated.

Locations of existing buried services such as water, electricity, gas, etc. should be ascertained by the designer at an early date and before the initial route of the new pipe is determined. The drawing records obtained by the designer from the various authorities may be supplemented by trial holes or surveys carried out using remote detection equipment.

The contractor should be informed of the location and route of the prospective piping system and should be supplied with the necessary drawings or specification.

All work, including ground engineering work, should be the undivided responsibility of one contractor. Any subcontractor he appoints, should be under his direct control and be part of his overall responsibility. Ground engineering work, which may or may not include civil engineering, includes all the operations from digging the excavation and/or construction of the subway or duct to the final backfill and leaving ready for use. It should also include detailing of subways under roads, railways, rivers or existing services.

3.9 Regulations

Reference should be made to relevant statutory requirements, regulations and Bye-laws. The following list is provided for guidance but additional regulations may be applicable.

- a) The Water Acts, 1945 and 1948 which enable water companies to build pipelines for the conveyance of water, via their distribution systems, to individual consumers; and any Local Water Acts that may be relevant.
 - b) The Gas Acts, 1948 and 1965, which empower the Gas Council and the Area Gas Boards, set up by the 1948 Act, to build pipelines for the delivery of gas to consumers or for the conveyance of feedstocks to their works.
 - c) The Requisitions Land and War Works Acts, 1945 and 1948, and the Land Powers (Defence) Act, 1958, which empower the government to acquire land or rights for the purposes of government oil pipelines.
 - d) The Public Health Acts, 1936 and 1961, which enable local authorities to build water pipes, sewers and drains.
 - e) The Pipelines Act 1962, which regulates the development of privately owned industrial pipelines.
 - f) The Acquisition of Land (Authorization Procedure) Act, 1946, for procedures governing compulsory acquisition by local and public authorities and statutory undertakings.
 - g) The Public Utilities Street Works Act, 1950, for pipelines laid across or along streets.
- NOTE Thrust or auger-bored subways may reduce or obviate procedures in some cases.
- h) The Coast Protection Act, 1949, for parts of pipelines laid below high water.
 - i) The Land Drainage Act, 1961, for pipelines crossing rivers and streams.
 - j) The Health and Safety at Work etc. Act, 1974.
 - k) Regulations for the control of substances hazardous to health (COSHH)¹⁾.
 - l) Health and Safety Executive guidance note G55. Entry into confined spaces.
 - m) Regulations under the Electricity Acts.
 - n) Regulations under the Factories Act.
 - o) The Building Regulations.
 - p) The Gas Supply Regulations.
 - q) The IEE Regulations for Electrical Installations.
 - r) The Clean Air Act.

s) Local Bye-laws.

t) Any special requirements of British Telecom, the local electricity, gas or water undertaking and the Fire Fighting Authority.

u) The Highways Act.

4 Systems for pipe-in-pipe underground distribution

4.1 Steel cased systems with air-gap conforming to BS 4508-1

This pipe system consists of one or more steel service pipes insulated with calcium silicate, magnesia or high density mineral wool, all supported within a single steel casing, which is coated with epoxy resin and a bitumen or coal tar impregnated reinforced wrap.

The thermal insulation applied to this type of system should be capable of retaining its physical and thermal properties after occasional wetting due to flooding and subsequent drying in situ.

The system is designed to distribute chilled water, hot water or steam over a wide range of temperatures.

The steel casing although wrapped and treated, cannot be guaranteed against corrosion attack from ground water. Cathodic protection is therefore advised to provide a further level of corrosion protection.

The capital costs of a pipe network using this system are generally higher than for the steel-in-plastics bonded systems (see 4.2). It is recommended only where higher temperatures in excess of 120° warrant its use.

4.2 Cased systems without air-gap conforming to BS EN 253

This pipe system consists of a steel service pipe bonded to rigid polyurethane foam insulation and a high density polyethylene casing. The foam provides a bond between the steel pipe and the casing so that the ground friction acts as a partial restraint on thermal expansion.

Systems are available conforming to BS EN 253, for distributing hot water up to a 120 °C continuous operating temperature for a design life of 30 years. The life of the system is a function of the strength of the foam insulation which is temperature and time dependent. Hence system life expectancy could be extended by reducing operating temperature when the demand for heat is low.

¹⁾ Available from HMSO.

4.3 Other systems

4.3.1 General

Other systems currently available in the UK which might be considered by the designer but which are not covered directly by this code are:

- a) sliding pre-insulated steel-in-plastics systems;
- b) plastics-in-plastics systems;
- c) glass-reinforced plastics casings and service pipe systems;
- d) asphalt insulated systems;
- e) buried duct systems;
- f) subways.

Whilst this code provides only limited reference to these systems, a number of the clauses covering, for example, contracts, ground engineering and installation, will be equally relevant.

Clauses 4.3.2 to 4.3.7 provide some general comments for designers to consider when assessing the suitability of systems, and the need for alarm and fault detection methods.

4.3.2 Sliding pre-insulated steel-in-plastics system

This system incorporates a bitumen or other layer between the service pipe and insulation which permits the linear expansion of the service pipe independently of the insulation and casing. The designer therefore should consider the differential movement between the casing and the steel service pipe. The systems are not entirely friction free and the friction will reduce as temperature increases. The designer should also be assured that maintenance of the sliding feature over the design life is achievable. Allowance for anchoring and expansion of the casing as well as the service pipe will be necessary.

Automatic monitoring and alarm systems to detect the presence of moisture in the insulation should be considered by the designer.

4.3.3 Plastics-in-plastics system

Two materials are in use for the service pipe: polybutylene and cross-linked polyethylene. Both have similar properties, with a severely restricted operating life for temperatures above 90 °C and internal pressures above 6 bar²⁾ gauge. The designer should consider advantages such as the resistance to corrosion of the service pipe. Also the higher material costs may be offset by the ease of installation arising from the flexibility of the pipe. As lengths of up to 100 m are available, the requirement for bends and joints is reduced. The low stiffness means that expansion stresses are accommodated within the material. To be successful, the butt welding of these materials requires a significant level of skill and site cleanliness, although electrofusion techniques are also available which can improve weld quality.

In the case of plastics pipes carrying water that is oxygen scavenged the designer should consider the use of a protective barrier against the diffusion of gases through plastics. Whilst the service pipe is not vulnerable to corrosion from ground water, automatic monitoring and alarm systems could still be appropriate to protect the thermal insulation from damage.

4.3.4 Glass reinforced plastics system

This system uses a glass reinforced plastics (GRP) service pipe with joints made using taper bushes applied with adhesive. It has not found widespread use for hot water systems although it is used for handling chemical fluids.

4.3.5 Asphalt insulated system

The principle of this system is to surround the steel service pipe with a water resistant material comprising a mixture of insulant and asphalt. This mixture is heated and poured over the pipes as a viscous liquid. When the service pipe is at operating temperature the material in contact with it will be liquid or viscous so that thermal movement can take place. The designer should consider the economics of the system and the performance of the asphalt material in contact with thermal expansion devices under rapid temperature build up at system start up.

²⁾ 1 bar = 100 kN/m² = 100 kPa

4.3.6 Buried duct system

This comprises a concrete duct, often constructed from pre-fabricated components. Pipes can be installed with glass or mineral fibre insulation or other insulants. As it is difficult to effectively seal the duct against underground water, the duct should be laid to fall with a secure method of drainage. Remote monitoring of drainage pits and access chambers may be employed.

In considering drainage the designer should take account of the fact that the drainage system could block to an extent where the pipework insulation could become submerged.

The buried duct construction reduces the risk of damage from ground loadings or from third party excavation work. A means of visual inspection of pipelines may be provided by removal of local duct coverings.

The disadvantage of this system is its high cost for small diameter pipework; however for the larger diameter (over 300 mm) pipelines, the cost difference is likely to be less and may be worthwhile for the additional protection it provides.

4.3.7 Subways

A subway structure may be used as a common enclosure where many services are required to pass beneath a road, railway or river, or within the basement of a building. Access for personnel to inspect and maintain such services should be provided for in such an arrangement.

The pipe-in-pipe system should be continued through the subway with proper attention given to supports, guides and rollers as free expansion will occur.

A subway will generally have a high capital cost and is only likely to be required in special circumstances and where a high degree of reliability is required from a number of services or a high degree of structural integrity with respect to the surrounding ground such as a route under a railway.

5 Steel cased systems with air-gap conforming to BS 4508-1

5.1 Application

This system is suitable for steam and high temperature hot water applications, up to 180 °C continuous operating temperature. It is only suitable for systems where maintenance and regular inspections are feasible and are likely to be carried out. The system consists of a steel casing containing the service pipes and is laid to fall. The casing is capable of being drained but in normal operation it is sealed.

5.2 Ground engineering

The volume of trench to be excavated will be relatively large and care should be taken to maintain trench wall supports. Where joints are to be made in situ, local dimensions of the trench need to be sufficient to permit the welding of the entire circumference of the steel casing.

As the pipe is to be laid to falls the trench will be excavated on a similar profile, and a firm support to the casing is necessary so that the falls will be maintained throughout the system life.

Trenches should be kept free from water from whatever source.

5.3 Manufacturer's instructions

These should be carefully followed to minimize damage to the wrapping and coating on the casing.

5.4 Service pipes, steel, copper, etc.

Steel service pipes may comply with BS 1387, BS 3601 or BS 3602 or other similar standards. The pipe system may contain a number of pipes with different functions. Copper pipe which complies with BS 2871 may also be considered. However, insulating arrangements should be used to prevent direct metal contact where the copper pipe passes through a steel endplate. Where dielectric insulating fittings are used the designer should consider the integrity of water sealing arrangements. If the casing should become flooded, the presence of dissimilar metals will greatly exacerbate the corrosion of the casing and service pipes.

5.5 Insulation

The insulation should be capable of withstanding high operating temperatures. Calcium silicate, or mineral wool are usually used. The insulation should retain its physical condition and insulating properties after immersion in water so that if the casing becomes flooded the system can be repaired and re-commissioned after drying out.

The insulation should be fixed to service pipes in such a way that it cannot fall off and cause the drainage channel to block.

5.6 Supports

Supports to service pipes should be such that conducted heat transfer to the casing is minimized, otherwise the local casing temperature could affect the integrity of the wrapped bituminous coating.

Supports should permit free drainage between the casing and the service pipes. The supports should allow pipe movement, as a result of thermal expansion, to take place without axial restraint.