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Code of practice for

Selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture) —

Part 5: Installation and maintenance requirements for electrical apparatus protected by pressurization "p" and by continuous dilution, and for pressurized rooms

UDC 696.6:621.3-7:614.83

Committees responsible for this British Standard

This British Standard was published under the direction of the General Electrotechnical Engineering Standards Committee GEL/-, Its preparation was entrusted to Technical Committee GEL/114 upon which the following bodies were represented:

Association of British Mining Equipment Companies
Association of Consulting Engineers
Association of Supervisory and Executive Engineers
British Electrical and Allied Manufacturers' Association (BEAMA)
British Electrical Systems Association (BEAMA)
British Gas Corporation
British Industrial Measuring and Control Apparatus Manufacturers' Association (BEAMA)
British Industrial Truck Association
Civil Aviation Authority (Airworthiness Division)
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Lighting Industry Federation Ltd.
Ministry of Defence
National Coal Board
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Scientific Instrument Manufacturers' Association (BEAMA)
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Associated Offices Technical Committee
Chief and Assistant Chief Fire Officers' Association
Council for Electrical Equipment for Flammable Atmospheres (BEAMA)
Department of Energy (Petroleum) (Oil)
Department of the Environment (Building Research Establishment) (Fire Research Station)
Electric Cable Makers' Confederation
Electronic Components Industry Federation
Institution of Electrical Engineers
Institution of Gas Engineers

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Contents

Foreword

This British Standard code of practice has been prepared under the direction of the General Electrotechnical Engineering Standards Committee.

BS 5345 is a revision of CP 1003-1, CP 1003-2 and CP 1003-3 and should be used for all new installations of electrical apparatus in potentially explosive atmospheres. However, CP 1003 will be retained temporarily as a reference guide for the many existing plants installed according to the earlier code.

Many gases, vapours, mists and dusts encountered in industry are flammable. When ignited, they may burn readily and with considerable explosive force if mixed with air in appropriate proportions. It is often necessary to use electrical apparatus in locations where such flammable materials may be present, and appropriate precautions should therefore be taken to ensure that all such apparatus is adequately protected in order to reduce the likelihood of ignition of any external explosive atmosphere. When using electrical apparatus, potential ignition sources include electrical arcs and sparks, hot surfaces and, in certain circumstances, frictional sparks.

In general, protection against ignition by electrical apparatus is achieved by implementing one of two procedures. Either the electrical apparatus should be located, whenever practicable, outside hazardous areas; or the electrical apparatus should be designed, installed and maintained in accordance with measures recommended for the area in which the apparatus is located.

Several techniques are available for the protection of electrical apparatus in hazardous areas. Some of these techniques (or "types of protection" as they are known) have been used for many years and have come to be regarded as traditional. Other types of protection have been introduced more recently.

This code of practice describes the basic safety features of these types of protection, full details of which are given in the relevant standards, and recommends the selection, installation and maintenance procedures that should be adopted to ensure the safe use of electrical apparatus in hazardous areas. This code therefore takes account of the significant developments that have taken place in area classification and in the design, manufacture and use of electrical apparatus for hazardous areas since the preparation of CP 1003.

It is important to note that this code of practice deals with *explosion* hazards due to the presence of flammable gas/air mixtures; it does not provide guidance on the extra precautions to be taken where such gases involve a *toxic* hazard.

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 16, 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.

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0 Introduction

BS 5345 gives guidance in the selection, installation and maintenance of electrical apparatus for use in areas where flammable materials are generated, processed, handled or stored, and that are therefore potentially hazardous.

In common with the earlier code of practice for the use of electrical apparatus in hazardous areas (CP 1003-1:1964, CP 1003-2:1966 and CP 1003-3:1967) the present code is divided into a number of Parts. Each Part deals with the installation and maintenance requirements appropriate to one of the types of protection that may be used to achieve electrical safety, or with basic requirements and considerations that are fundamental to the use of electrical apparatus in hazardous areas, and that therefore provide the basis for the other Parts of the code.

The full list of Parts is as follows:

— Part 1: Basic requirements for all Parts of the code;

— Part 2: Classification of hazardous areas;

— Part 3: Installation and maintenance requirements for electrical apparatus with type of protection "d". Flameproof enclosure;

— Part 4: Installation and maintenance requirements for electrical apparatus with type of protection "i". Intrinsically safe apparatus and systems;

— Part 5: Installation and maintenance requirements for electrical apparatus protected by pressurization "p" and by continuous dilution, and for pressurized rooms;

— Part 6: Installation and maintenance requirements for electrical apparatus with type of protection "e". Increased safety;

— Part 7: Installation and maintenance requirements for electrical apparatus with type of protection "N";

— Part 8: Installation and maintenance requirements for electrical apparatus with type of protection "s". Special protection;

— Part 9: Installation and maintenance requirements for electrical apparatus with type of protection "o". Oil-immersed apparatus, and with type of protection "q". Sand-filled apparatus;[1)]

— Part 10: The use of gas detectors[1)2)].

This Part of BS 5345 should be read in conjunction with the other Parts, and in particular with Parts 1 and 2 which, taken together, describe the fundamental considerations which affect the selection, installation and maintenance of all electrical apparatus used in hazardous areas.

BS 5345 is based on the concept of area classification which recognizes the differing degrees of probability with which explosive (flammable) concentrations of flammable gas or vapour may arise in installations in terms of both the frequency of occurrence and the probable duration of existence on each occasion.

The detailed considerations that should be taken into account in deciding on an area classification are described in Part 2 of the code. For completeness, and for the convenience of readers, the definitions appropriate to area classification are repeated here. It should be noted that whereas, formerly, classified areas were known as "Divisions", they are now called "Zones". Three Zones are recognized, i.e.:

Zone 0 In which an explosive gas/air mixture is continuously present or present for long periods.

Zone 1 In which an explosive gas/air mixture is likely to occur in normal operation.

Zone 2 In which an explosive gas/air mixture is not likely to occur in normal operation, and if it occurs it will only exist for a short time.

It should be noted that this concept of area classification deals only with risks due to flammable gases and vapours and, by implication, mists. It does not deal with combustible dusts, which are outside the scope of this code.

By implication, an area that is not classified as Zone 0, 1 or 2 is deemed to be a non-hazardous or safe area. If doubt exists as to the classification of an area that is judged to be hazardous or potentially hazardous, guidance should be sought at an early stage from those with expert knowledge of the area classification of similar installations (see Parts 1 and 2 of the code).

Electrical apparatus used in each of the classified Zones should be suitably protected by design and manufacture, and should also be installed, operated and maintained so as to ensure its safe use.

[1)] In course of preparation.

[2)] It has been decided by the responsible Technical Committee that BS 5345 will not apply to combustible dusts and, therefore, the proposed Part "Installation and maintenance requirements for electrical apparatus for use with combustible dusts" referred to, as Part 10, in other Parts of this code published before this decision will not appear as a Part of BS 5345. The proposed Part 11 "Specific industry applications" will consist of a bibliography of relevant codes and requirements and will not be a Part of BS 5345.

BS 5345, in offering guidance in the selection, installation and maintenance of suitably protected apparatus, replaces CP 1003 and should be used for all new installations.

It should also be used for changes to existing installations, though it is recognized that minor changes only to certain existing installations may need to be made in accordance with the recommendations of the earlier code. it is intended however, that CP 1003-1, CP 1003-2 and CP 1003-3 will eventually be withdrawn.

Notwithstanding application of the installation recommendations of this code to existing installations, the recommendations for maintenance should be applied to all electrical apparatus and installations, irrespective of age and date of installation. It should also be noted that the installation and maintenance recommendations given in the code are supplementary to, and not alternative to, requirements that would apply to general industrial installations (see also Part 1 of the code).

Section 1. General principles

1 Scope

This Part of BS 5345 gives recommendations for the technique of using the pressure of a protective gas to prevent the ingress of an external atmosphere to a space which may contain a source of ignition, when selecting, installing and maintaining electrical apparatus in a hazardous area.

Recommendations are also given for the technique of continuous dilution to a concentration below the lower explosive limit (LEL) of the atmosphere within a space containing a source of gas emission that may result in an explosive gas/air mixture.

The code does not apply to the use of these techniques in Zone 0.

The code applies only to situations where the protective gas is non-combustible. It does not cover the additional precautions for specialized applications where flammable gas, vapour or liquid may be used to displace air that otherwise may be present, so that safety is assured by maintaining an atmosphere in a concentration above the upper explosive limit (UEL).

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

2 Definitions and explanation of terms

The definitions and terms generally applicable to hazardous areas and electrical apparatus used therein are included in Part 1 of this code, to which reference should be made. The definitions and terms that are particularly relevant to individual types of protection are given in the appropriate Parts of the code. For the purposes of this Part of BS 5345, the following definitions apply.

NOTE Definitions marked with an asterisk are identical or technically equivalent to definitions given in BS 5501-1 and BS 5501-3.

2.1
electrical apparatus*

all items applied as a whole or in part for the utilization of electrical energy. These include, among others, items for the generation, transmission, distribution, storage, measurement, regulation, conversion, and consumption of electrical energy and items for telecommunications

2.2
pressurization

the technique of preventing the ingress of the external atmosphere, which may be explosive, to enclosures by maintaining a protective gas therein at a pressure above that of the external atmosphere

2.3
continuous dilution

the technique of preventing the formation of an explosive gas/air mixture in an enclosure by the supply of a protective gas at such a rate that the concentration of the gas/air mixture is always kept below the lower explosive limit

2.4
pressurized apparatus

apparatus in which a protective gas is maintained at a pressure greater than that of the surrounding atmosphere

2.5
pressurized enclosure

the assembly of walls, surfaces or casings enclosing the electrical apparatus that serves to contain the protective gas

NOTE The pressurized enclosure may or may not be also the enclosure surrounding the live parts and ensuring the protection in other respects of the electrical apparatus.

2.6
over-pressure

that pressure at which an enclosure is maintained above the surrounding atmosphere so that the ingress of the external atmosphere is prevented

2.7
protective gas*

a gas used to maintain an over-pressure within the pressurized enclosure, e.g. air or inert gas

2.8
pressurization with leakage compensation*

a method of maintaining an over-pressure within a pressurized enclosure so that, when the exit apertures are closed, the supply of protective gas is sufficient to compensate for the inevitable leakages from the pressurized enclosure and its ducts

2.9
pressurization by circulation of protective gas*

a method of maintaining an over-pressure within a pressurized enclosure with continuous flow of the protective gas through the enclosure after purging

NOTE The protective gas may also be used for purposes other than the exclusion of the external atmosphere, e.g. for cooling motors.

2.10
purging*

the passing of a quantity of protective gas through the pressurized enclosures and ducts, before the application of voltage to the electrical apparatus, so that any explosive atmosphere in the pressurized enclosure is reduced to a concentration significantly below the lower explosive limit

2.11
pressurized system

the pressurized enclosure and the built-in or connected parts and accessories, including inlet and exit ducts, that are provided to establish and maintain pressurization

2.12
alarm

the operation of audible and visible annunciators in a manned location such as a control room

2.13
trip

the automatic disconnection of the electrical supply to a pressurized enclosure

3 Description of techniques

3.1 Pressurization is intended to exclude the external atmosphere from an enclosure so that the exposure of apparatus within that enclosure to a flammable atmosphere is prevented.

3.2 Continuous dilution is intended to maintain the atmosphere inside an enclosure at a concentration below the lower explosive limit of the flammable atmosphere that may be emitted into that enclosure.

3.3 Both pressurization and continuous dilution, either separately or together, permit electrical apparatus to be installed in hazardous areas when the use of other types of protection is impracticable or undesirable, e.g. large rotating machines which may be uneconomic if made to type of protection "d" or "e", and also where the cooling requirement for a machine necessitates the introduction of cooling gas from an external source, the designer may conveniently use that cooling gas as a protective gas.

4 Selection and construction

4.1 Normally the materials and methods of construction used for pressurized apparatus and systems should be in accordance with BS 5501-3.

In particular cases, such as site fabricated and assembled apparatus, it may not be practicable to meet all the requirements of that standard. In such cases any deviations from the standard should be carefully assessed to enable an equivalent level of safety to be achieved, taking account of all conditions of use. Any deviations from BS 5501-3 should be recorded (see clause **13**).

4.2 Local site conditions can affect the choice of pressurized apparatus and pressurized systems used for a particular installation, e.g. by determining the choice of materials of construction. It is thus necessary to consider all the problems posed by the intended installation site, e.g. radiation, corrosive conditions, thermal characteristics and the possibility of physical damage, together with any special conditions imposed on a particular site when an installation is envisaged.

4.3 Consideration should be given to the compatibility of the materials used for all components of a proposed installation.

4.4 Pressurized systems, particularly those intended for outdoor installations, should be protected against the entry of liquids. Such protection should not rely on the over-pressure within a pressurized system as this may not be continuous (see Appendix A of BS 5345-1:1976).

4.5 Components that have to remain in operation in the absence of the protective gas supply should have a type of protection suitable for the zone in which the pressurized system is installed. The presence of such items should be recorded (see clause **13**).

NOTE Special attention should be paid to the use of batteries inside pressurized enclosures because of the possible evolution of hydrogen and because batteries may remain a potential source of ignition in the absence of the protective gas.

4.6 Where conduit is used to provide mechanical protection for wiring to a system, it may be used also to supply the protective gas but in such cases it should be ensured that cable seals, particularly those made with compound, do not affect the flow of protective gas.

4.7 Outlet apertures should be arranged to ensure effective purging and, where the protective gas is also used as a cooling agent, effective cooling.

NOTE Where several systems in parallel are supplied from one source of protective gas, it is essential that care is taken to assure a balanced flow of protective gas in each of the parallel branches.

4.8 Outlet apertures may be operated manually but, if they are, they should be located in a non-hazardous area.

5 Protective gas

5.1 The protective gas used for purging, pressurization and continuous dilution should be non-combustible. It will usually be air, although an inert gas may be used.

The protective gas should not contain more oxygen by volume than that normally present in air. If enclosures pressurized with inert gas are accessible to people, all doors and covers through which entry may be made should be provided with a suitable warning notice and doors should be provided with a suitable lock.

5.2 The protective gas should be non-toxic and should be substantially free from moisture, oil, dust, fibres, chemicals, combustibles and other contaminating material that may be dangerous or affect the satisfactory operation and integrity of the apparatus.

5.3 Where air is used as the protective gas, the source should be located in a non-hazardous area and usually in such a position as to reduce the risk of contamination. Consideration should be given to the effect of nearby structures on air movement and of changes in the prevailing wind direction and velocity. The location of the air intake should be reviewed periodically, particularly after plant alterations.

5.4 The temperature of the protective gas should not normally exceed 40 °C at the inlet of the enclosure. (In special circumstances a higher temperature may be permitted or a lower temperature may be required, in which case the temperature should be marked on the pressurized enclosure.)

5.5 Consideration should be given to the rate of supply of the protective gas. The rate will normally be small for small enclosures, e.g. luminaires and pressure switches, but may be high for larger enclosures, e.g. electric motors, where the gas is required for pressurization by circulation of protective gas and for cooling purposes. Sources of protective gas should be designed to provide a flow rate which ensures adequate over-pressure whilst meeting the requirements of purging, leakage in the case of pressurization with leakage compensation, and flow in the case of pressurization by circulation of protective gas.

5.6 Particular attention should be given to installations using pressurization with leakage compensation where several pressurized enclosures are purged and pressurized from the same supply of protective gas. The supply of the protective gas should be so regulated that, if it is necessary to purge one or more enclosures when others are pressurized, pressures in the protected enclosures do not fall below the minimum acceptable over-pressure. For this reason, individual regulators for each pressurized enclosure are preferred.

5.7 It may be desirable to provide two sources of protective gas so that the alternative source may take over in the event of pressurization failure. Each source should be capable of maintaining independently the required rate of protective gas supply.

5.8 Inlet ducts and outlet ducts should be protected and so guarded that obstruction is prevented. Precautions should also be taken to prevent the entry of rain, snow and sleet, etc.

5.9 Pressurizing apparatus, such as an inlet fan or compressor, that is used to supply protective gas should be installed in a non-hazardous area. Where the drive motor and associated apparatus are located within the supply ducting, or where installation in a hazardous area cannot be avoided, the pressurizing apparatus should be suitably protected.

NOTE This protection is necessary, even in installations where the pressurizing apparatus is completely contained within the pressurized system because on failure of the protective gas supply the flammable atmosphere can be expected to reach the pressurizing apparatus.

6 Purging

6.1 Pressurized enclosures should be purged before switching on the electrical supply, both during the initial commissioning period and when recommissioning after loss of supply of the protective gas. The level of over-pressure during purging should satisfy the recommendations of clause **7**.

6.2 Purging should be at a rate and of a duration sufficient to dilute any explosive gas/air mixture that may have accumulated in the pressurized enclosure and its associated ducting to below the lower explosive limit.

NOTE Where apparatus is certified as complying with BS 5501-3, the purge flow and time will be specified in the certification documents.

6.3 In small pressurized enclosures, the minimum quantity of protective gas for purging will normally be five times the volume of the enclosure and its associated ducting. In large pressurized enclosures, tests may be required to establish the correct minimum rate, duration and volume.

6.4 The volume of gas should be monitored. Additionally, gas detectors may be used to check whether the gas in the pressurized enclosures is flammable.

6.5 Outlet vents for purging may be fitted to an enclosure or the ducting when using pressurization with leakage compensation to increase the flow of protective gas and so reduce the purging period. These vents should be closed after purging.

Apparatus to monitor the purge rate should be located in outlet vents or ducting.

6.6 The pressurized enclosure and its contents and the ducting should be designed to ensure effective purging. Baffles may be needed to ensure that the complete enclosure and the ducting is swept by protective gas.

6.7 The purge exhaust may be located in a non-hazardous area in which case there should be no sources of ignition in the vicinity of the exhaust outlet. Alternatively, the purge exhaust may be located in a hazardous area and where necessary devices preventing the emission of arcs, sparks and incandescent particles should be provided.

7 Over-pressure

An over-pressure of at least 50 Pa (0.5 mbar [3)]) should be maintained within the pressurized system at points where leakage can occur. Arrangements where the protective gas is drawn at reduced pressure through ducts in the hazardous area should be avoided wherever possible. Where this is not practicable, special precautions should be taken to prevent the ingress of the external atmosphere. Distribution of pressure in different arrangements of the pressurized enclosure and ducts is shown in Figure 1, Figure 2 and Figure 3.

NOTE Figure 1, Figure 2 and Figure 3 show examples where the over-pressure is maintained by a fan. This overpressure can, however, be provided by other means, e.g. by feeding air from compressed air cylinders and compressors. In such cases there would be different pressure drops up to the pressurized enclosure entry.

8 Surface temperatures

8.1 The maximum surface temperature of the pressurized apparatus should be less than the ignition temperature of the hazardous gas. Where pressurized apparatus has been certified (or assessed by a competent body) it will have been given a temperature classification in accordance with BS 5501-1.

8.2 If, during normal service, the temperature of an internal surface of the apparatus exceeds the maximum value of the temperature class, as specified in BS 5501-1, appropriate measures should be taken so that the external atmosphere does not reach the heated surface before it has cooled to below the permitted maximum value.

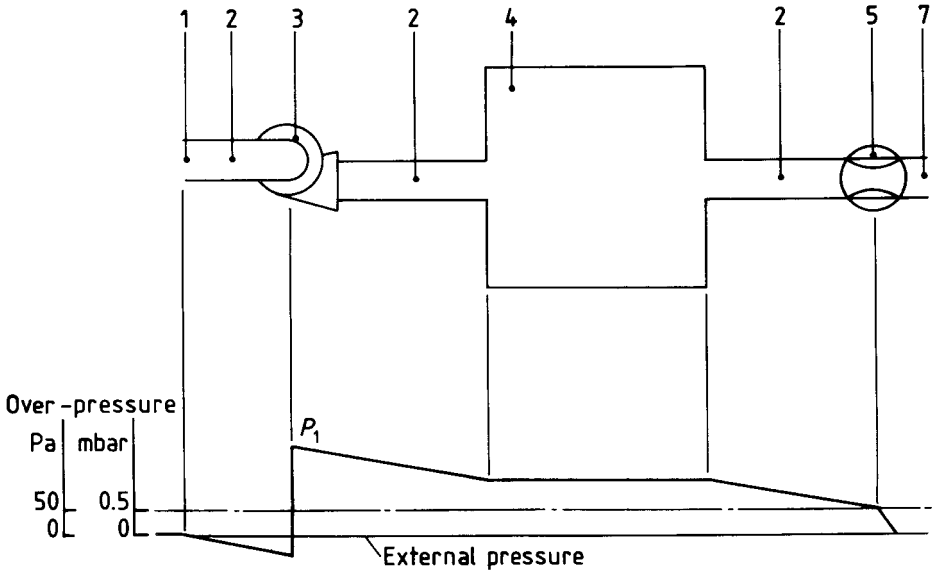
9 Ducts

9.1 Ducts should have adequate mechanical strength and be located where they are unlikely to suffer accidental damage. They should be adequately protected against corrosion throughout their length.

9.2 In cases where the density of the hazardous gas differs from that of the protective gas, advantage should be taken of the displacement effect to secure efficient purging. Where the protective gas is heavier than the hazardous gas, the protective gas inlet should be at the bottom of the pressurized enclosure and the purging outlets at the top. Where the protective gas is lighter than the hazardous gas, the protective gas inlets should be at the top of the pressurized enclosure and the purging outlets at the bottom. If density variations can occur in the hazardous gas, the position of the inlets and outlets should be chosen to suit the predominant density of the hazardous gas.

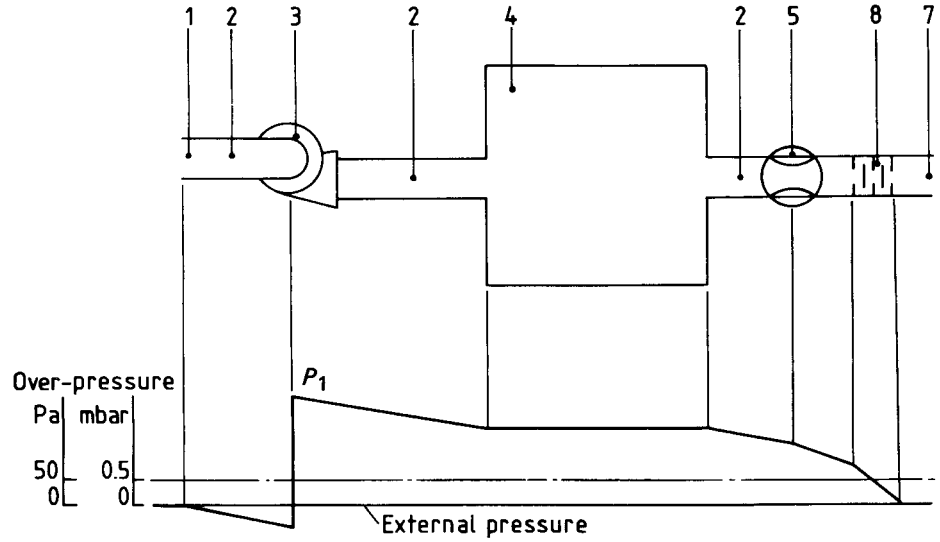
NOTE Alternatively, purging may be carried out in either direction, up or down as appropriate, provided that the effectiveness of purging has been verified, preferably using gases of equivalent density to the hazardous gases and with the purging gas flowing in the specified direction.

[3)] 1 mbar = 100 N/m^2 = 0.1 kPa.



NOTE See the key following Figure 3.

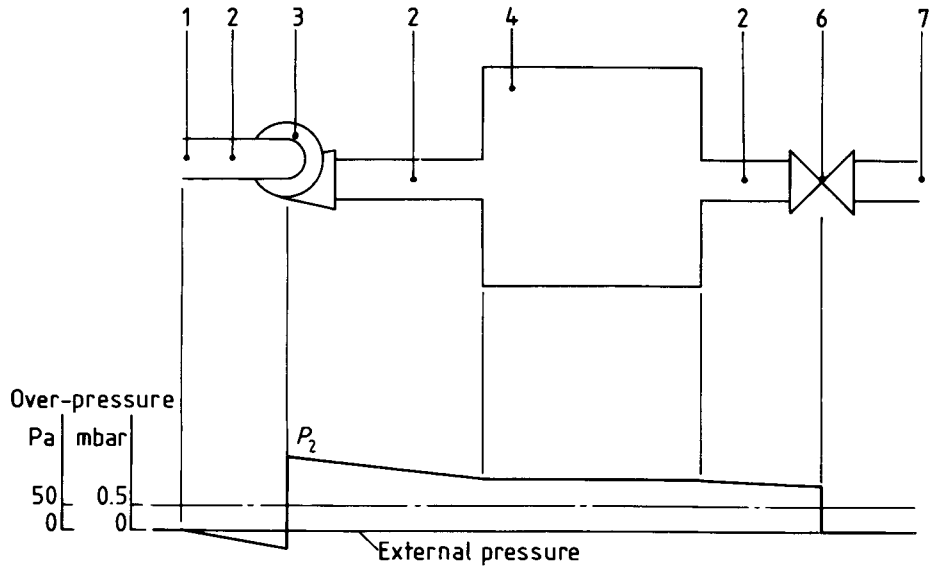
(a) Protective gas outlet without a spark and particle barrier



NOTE See the key following Figure 3.

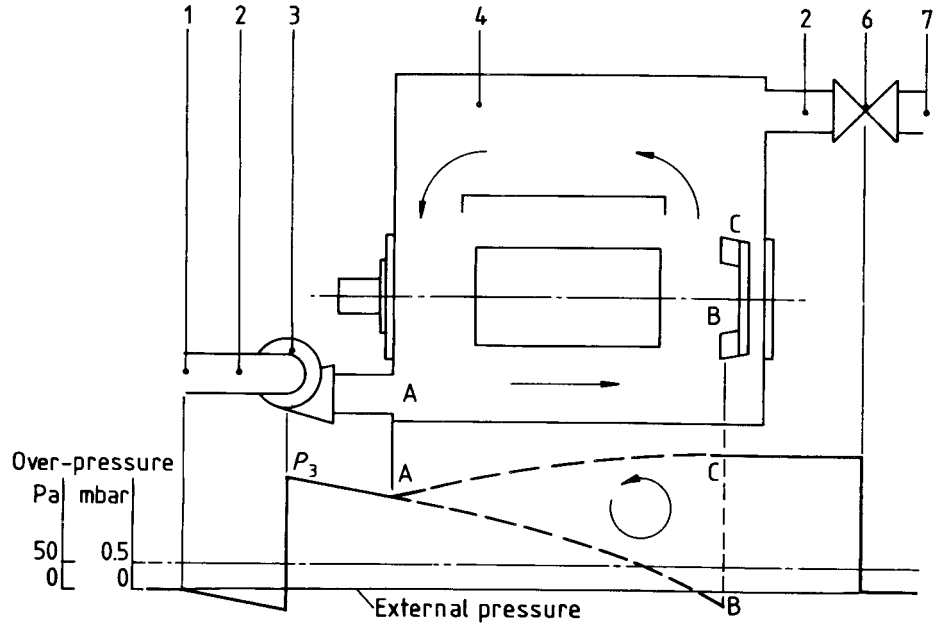
(b) Pressurized apparatus with a spark and particle barrier

Figure 1 — Pressurized apparatus with continuous circulation of the protective gas



NOTE See the key following Figure 3.

Figure 2 — Pressurized apparatus with leakage compensation: enclosure without rotating parts



NOTE 1 Pressure at every point where leakage can occur is above the minimum of 50 Pa.
NOTE 2 See the key following this figure.

Figure 3 — Pressurized apparatus with leakage compensation: rotating electrical machine with internal fan

Key to Figure 1, Figure 2 and Figure 3

P_1 is the pressure of protective gas (determined by the flow resistance through the ducting, the parts within the enclosure and in certain cases through a choke or a spark and particle barrier)

P_2 is the pressure of protective gas (almost constant)

P_3 is the pressure of protective gas (determined by the flow resistance of the internal parts, and influenced between A, B and C by the internal cooling fan)

1 Protective gas inlet (in a non-hazardous area)

2 Ducting

3 Fan

4 Enclosure

5 Choke (when required to maintain the over-pressure)

6 Outlet valve

7 Protective gas outlet

8 Spark and particle barrier

9.3 The ducts used should be of sufficient size to ensure adequate purging and should be chosen with regard to the design and disposition of the apparatus within the pressurized enclosure. Consideration should be given to any subcompartments into which the enclosure might be divided; in particular, for systems with pressurization by circulation of protective gas. The number of ducts should be selected having regard, not only to purging requirements, but also to the prevention of undue turbulence of the protective gas which might be caused by the disposition of the apparatus within the pressurized enclosure.

NOTE These conditions can give rise to localized under-pressure which may impair pressurization.

9.4 Ducts should be continuous, except for those joints that are necessary to facilitate installation and the inclusion (as required) of a pressurization device, such as a compressor.

9.5 For equipment using pressurization by circulation of protective gas, the pressurized enclosure may have one or more outlet apertures for the connection of the outlet ducts for the protective gas. Such apertures may remain open to ensure the release of protective gas, particularly when this is used for cooling purposes. For equipment using pressurization with leakage compensation, the pressurized enclosure may have one or more outlet apertures that can be closed after purging, thus allowing pressurization to be fully established.

9.6 Electrical devices used for the operation of outlet apertures should be protected with types of protection appropriate to the zones of risk in which this system is located.

10 Wiring systems

10.1 Wiring systems should be in accordance with the principles established for all types of protection (see BS 5345-1) together with recommendations made in this Part of the code.

10.2 Where necessary to prevent the ingress of combustible gas or vapour by diffusion, or to prevent loss of protective gas, wiring systems should be sealed.

NOTE This does not preclude a cable duct or a conduit being purged with the apparatus.

11 Safety devices and procedures

11.1 Precautions should be adopted to maintain the safety of the pressurized enclosure in the event of failure to purge, pressurize or dilute continuously the internal free volume.

11.2 In pressurized systems one or more devices should be used to monitor the over-pressure. In continuous dilution systems, and during the purge period of pressurized systems, one or more devices should be used to monitor the flow and the over-pressure. These monitoring devices should act when the monitored values fall below their minimum prescribed limits.

The actions initiated by the monitoring device will depend upon the classification of the area in which the pressurized enclosure is located and the type of electrical apparatus installed, as shown in Table 1.

If de-energizing the ignition capable components could create a more dangerous condition, other precautionary measures should be adopted, e.g. duplication of protective gas supply.

11.3 Any devices used to ensure full closure of doors and covers should be supplementary to, and not alternative to, devices used to monitor over-pressure.

Table 1 — Minimum action on pressure failure

Classification of area in which enclosure is located	Minimum action on pressure failure	
	Enclosure contains apparatus suitable for Zone 2	Enclosure contains ignition-capable apparatus
Zone 1	Alarm[a]	Alarm and de-energize ignition capable components
Zone 2	Not applicable	Alarm[a]

[a] When the alarm is operated, immediate action should be taken to restore the integrity of the system.

11.4 Consideration should be given to the provision of continuous indication of the state of pressurization of the protected enclosure. Any instrument and pressure sensing device should be so connected as to monitor the conditions in those parts of the pressurized enclosure that have been found by test or experience to be the most difficult in which to maintain an acceptable over-pressure, e.g. the inlet side of the internal fans of rotating machines.

11.5 If, due to malfunction or other causes, it is possible for the pressurizing supply to create an over-pressure that is greater than 75 % of the maximum over-pressure which the pressurized enclosure and ducting has been declared to withstand safely, a pressure sensitive device or devices should be provided. These device(s) should be arranged to limit the over-pressure to an acceptable level.

11.6 All safety devices that are used for monitoring, alarm or indication should be protected, installed and maintained in accordance with the appropriate Parts of this code. Alarm devices should be positioned so that their operation is immediately apparent.

11.7 If monitoring, alarm or indicating devices are themselves protected by pressurization, their protective gas should be supplied by an independent system from a separate source.

12 Marking

NOTE Recommendations for marking on rooms are given in section 4.

12.1 Each enclosure should be marked with the following, unless it is impracticable to do so, in which case only items "c") and "d") need be marked.

a) Identification of the maker and installer.

b) The name or type designation of the equipment.

c) Identification of the method of protection used.

NOTE Apparatus that complies in all respects with the requirements of BS 5501-3 [EN 50016] will be marked EEx p (see also **4.1**).

d) The temperature class or maximum surface temperature of unprotected surfaces.

NOTE The classification is determined by the higher of the following temperatures:

1) the maximum external surface temperature of the pressurized enclosure; or

2) the maximum surface temperature of any internal parts that are protected by another type of protection and which remain energized even when the supply of protective gas is removed, e.g. electric heaters.

e) The maximum acceptable inlet temperature of the protective gas.

f) The minimum operating pressure and, where applicable, the minimum rate of flow of the protective gas.

g) The free or net internal volume of the pressurized enclosure and the minimum volume of protective gas necessary for purging.

h) Any additional information relevant to the safe operation of the system including warning instruments.

The additional information may include:

1) the gross volume of the incoming and outgoing ducts used for the protective gas which, added to the volume of the pressurized enclosure, determines the volume of the protective gas under the same pressure conditions, and therefore the time required for purging;

2) the time delay (if any) following de-energization after which the pressurized enclosure may be opened for maintenance or other purposes.

12.2 The position for measuring the over-pressure should be indicated either on the pressurized enclosure or in its accompanying documents.

12.3 In cases where the pressurized enclosure cannot be assessed or tested for pressurization and effective purging until installation has been completed, the pressurized enclosure should not be marked "Ex" until the necessary assessment and tests, if any, have been carried out.

13 Records

A record should be available and kept up-to-date by the user for all installations of pressurized apparatus.

This record should include all the details covered by clause **12** together with the following information:

a) certification documents or test report;

b) installation and operating instructions;

c) the justification for the T class or the maximum surface temperature assigned to the installation;

d) the date of commissioning of the installation;

e) the drawings necessary for the safe use of the installation;

f) measurements of the enclosure pressures on the completed installation under purging and pressurized conditions;

g) measurement of the purging flow on the completed installation;

h) the justification for the minimum acceptable purging time specified for the pressurized enclosure;

i) the settings of any safety devices;

j) details of periodic examinations carried out to check that the installation is still in a satisfactory condition;

k) details of any maintenance work carried out on the apparatus or accessories;

l) details of any alterations to the "as built" installation, which should include check measurements of pressures and flow;

m) reasons for deviations from the relevant standards (see **4.1**).

Table 2 — Inspection schedule

Check that:	Inspection category[a]		Notes
	Initial	Periodic	
Apparatus is appropriate to area classification	A	B	See **12.1** of BS 5345-1:1976
Inlet temperature is below maximum specified	A	B	
Surface temperature or T class is correct	B	B	See **12.2** of BS 5345-1:1976
Electrical apparatus carries the correct circuit identification	A	B	Apparatus should be positively identified to facilitate safe isolation
There are no unauthorized modifications	A	A	
Earthing is satisfactory	A	A	See clause **22** of BS 5345-1:1976
Lamp rating and type is correct (where relevant)	A	B	
There is no obvious damage to cables	A	A	
Protective gas is substantially free from contaminants	A	A	See clause **5**
Pressure/flow is adequate	A	A	See clause **5**
Pressure/flow indicators, alarms and interlocks function correctly	A	A	See clause **11**
Pre-energizing purge period is adequate	A	A	See clause **6**
Ducting, piping and pressurized enclosures are in good condition	A	A	See clause **9**

[a] Category "A" inspections should be carried out in all cases and, where periodic, at intervals not exceeding two years. More frequent and/or more detailed inspection will be necessary where there is a corrosive or other adverse atmosphere, a high risk of mechanical damage or vibration, or where there are other onerous circumstances. The need for more frequent inspection may also be determined by operating experience.

The need for and the method and frequency of category "B" inspections are determined by the person responsible. It is not intended that periodic inspections should incur undue disturbances of apparatus unless considered necessary by the person responsible.

14 Inspection and maintenance

The procedures for inspection and maintenance should be in accordance with Part 1 of the code. However, the specific schedule shown in Table 2 is recommended for all items used in the pressurized system.

15 Operation

15.1 Any operating conditions imposed by the designer of a pressurized system should be strictly observed.

15.2 It may be necessary to gain access to the protected apparatus for maintenance or other purposes whilst the apparatus is still energized. In this circumstance precautions should be taken to ensure the absence of an explosive gas/air mixture (see Part 1 of this code) during the removal of covers and subsequent replacement. This should only be allowed under "permit-to-work" conditions.

15.3 Any changes to the installation could affect safety as provided for by the original designer and/or installer; therefore, after any change to the installation a check should be made to establish that the integrity of the protection is maintained.

Section 2. Electrical apparatus with no internal source of flammable gas or vapour

16 Description of technique

When individual items of apparatus are protected by the technique of pressurization, the protective gas is contained within the casing of the apparatus. In many applications apparatus that is totally enclosed may be protected in this way with little or no change to the structure.

17 Ducts and pressure distribution

17.1 Ducts should be in accordance with clause **9**.

17.2 In the case of rotating apparatus, account should be taken of the cooling arrangements so that adequate over-pressure is maintained in all parts of the enclosure where leakage can occur. Figure 1 to Figure 3 show the distribution of over-pressure in ducts and pressurized apparatus.

18 Wiring systems

Electrical connections may enter directly into the enclosure or indirectly by means of a distinct terminal compartment or enclosure. Where indirect entry is used, each terminal enclosure should be provided with a type of protection appropriate to the external zone. The terminal enclosure may be pressurized with protective gas drawn directly from the supply to the pressurized system or other types of protection may be used, such as "d" or "e" as appropriate to the apparatus and area classification.

19 Multiple enclosures

When a source of protective gas is common to a number of separate pressurized enclosures the safety arrangements may be common to several of these provided that the control system takes account of the most unfavourable conditions in the group of pressurized enclosures. If the safety devices are common the opening of a door or cover need not switch off the group or set off the alarm provided that:

a) the opening is preceded by de-energizing all electrical circuits in the pressurized enclosure, except circuits or parts of circuits that are protected by a type of protection suitable for the external zone;

b) the common safety device continues to monitor the over-pressure in all the other pressurized enclosures of the group;

c) the subsequent switching on of the electrical apparatus in the particular pressurized enclosures is preceded by purging.

20 Testing

20.1 For individual items of pressurized apparatus, it will usually be possible for assessment or certification authorities to determine that the pressurized apparatus complies with the requirements for pressurized enclosures.

This will usually be done in the manufacturer's works.

20.2 The installation of pressurized apparatus should be carried out under the control of a suitably qualified person. When pressurized apparatus that has been assessed or certified at the manufacturer's works is installed, measurements should be made on the completed installation to show that the purging and pressurizing intentions are being fulfilled.

20.3 Many pressurized systems are fabricated and assembled on site. Hence prior inspection and test for the purposes of certification or other prior assessment of compliance is not possible. In these cases, the following checks should be carried out on the completed installation.

a) Check by assessment or test, if necessary, that the pressurized apparatus design is such that the purging can be completed satisfactorily.

b) Check that the pressurized system complies with the over-pressure requirements as stated by the designer.

c) Check that the temperature classification of the completed system is correctly marked on the pressurized enclosure.

Section 3. Electrical apparatus with an internal source of flammable gas or vapour

21 Description of technique

The release of flammable material within electrical apparatus (such as gas analysers) may occur in normal operation or under abnormal conditions.

Safety may be maintained by:

a) continuous dilution in which a protective gas is supplied in sufficient quantity to ensure that the concentration of the resultant mixture is below the lower explosive limit (LEL); or

b) the use of an inert protective gas, in which case leakage compensation techniques should be used.

In a hazardous area the protective gas should also pressurize the apparatus to prevent the ingress of flammable material from the external atmosphere. Precautions should be taken to provide for safety in the event of an inadequate supply of protective gas.

NOTE When the protective gas is discharged to atmosphere this may affect the area classification.

22 Construction

The materials and methods of construction should be in accordance with BS 5501-3.

23 Internal release

When flammable gas or vapour is released within apparatus, the duration of the release and the hazard produced may be greater than that produced by the same release in the open air unless special precautions are taken. All types of internal release of flammable material are grouped into four categories.

a) *No normal release*. The apparatus will be considered to have no normal release if the flammable material is enclosed in metallic pipes, tubes, vessels or elements, such as bourdon-tubes, bellows, diaphragms or spirals. The number of joints should be minimal but when required they should be well made with threaded pipe joints, welding or metallic compression fittings and be leak-free when tested at a pressure above the rated pressure. An example of this type of apparatus is a Bourdon-tube type pressure switch.

b) *Limited normal release*. The apparatus will be considered to have a limited normal release if it does not comply with the requirements for "no normal release" (e.g. has a large number of joints) or has rotating or sliding seals, flanged joints, non-metallic tubing or fragile windows subjected to the pressure of the flammable material. Examples of this type of apparatus are chromatographs and infra-red analysers.

c) *Restricted abnormal release*. A restricted abnormal release is one in which any abnormal release of flammable material is limited by design to a value within the diluent capacity of the protective gas system. It is usually achieved by placing a restrictor in the pipes supplying flammable material to the apparatus.

d) *Unrestricted abnormal release*. An unrestricted abnormal release is one in which any abnormal release is not restricted by design to a value within diluent capacity of the protective gas system. In this case the protective gas is required to be inert.

Four combinations of normal and abnormal release are possible:

a) no normal release, restricted abnormal release;

b) no normal release, unrestricted abnormal release;

c) limited normal release, restricted abnormal release;

d) limited normal release, unrestricted abnormal release.

The recommended procedure in the event of failure of the protective gas is given in Table 3.

24 Continuous dilution systems

The protective gas rate should be determined by the magnitude of the abnormal release rate, the characteristics of the flammable material and the safety factor chosen. When pressurized enclosures contain ignition-capable apparatus and an unrestricted abnormal release can occur, an inert gas should be used. An example of the necessary calculation is shown in Appendix A.

The continuous dilution system should also pressurize the apparatus to a minimum over-pressure of 50 Pa (0.5 mbar) to prevent the ingress of the external atmosphere.

25 Inert gas systems

The protective gas rate is the minimum needed to pressurize the apparatus and maintain the required over-pressure.

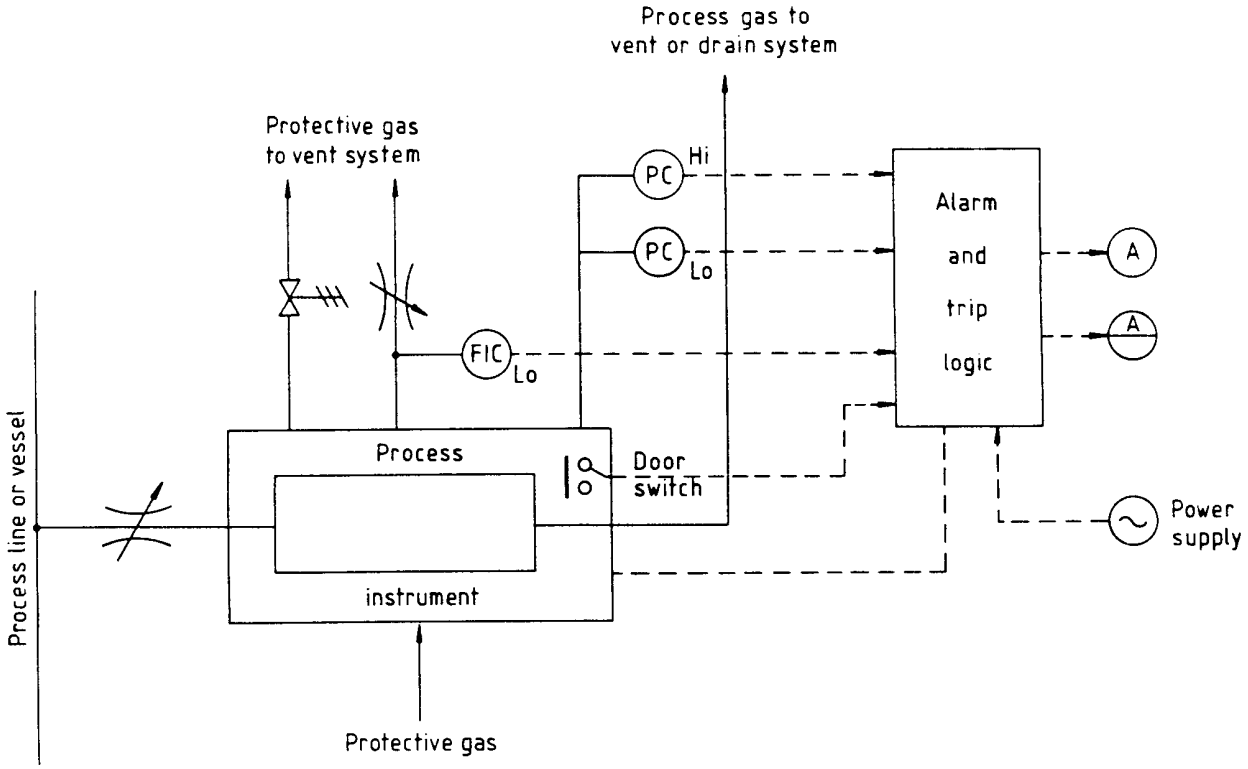
26 Safety devices and procedure

In addition to the recommendations given in clause **11** a flow switch should be connected to the duct conveying the protective gas from the pressurized enclosure. The switch should operate when the flow falls below the minimum safe value. Figure 4 shows a typical continuous dilution system. The actions initiated by this switch will depend upon the area classification and the type of apparatus, as given in Table 3.

Table 3 — Action on failure of protective gas

Internal release conditions	The enclosure is in Zone 1 and contains electrical apparatus which is normally:		The enclosure is in Zone 2 and contains electrical apparatus which is normally:	
	Suitable for Zone 2	Ignition capable	Suitable for Zone 2	Ignition capable
No normal release, restricted abnormal release	Alarm (3)	Alarm and (4)	Not applicable	Alarm (3)
No normal release, unrestricted abnormal release	Alarm (3)	Alarm and (4) (2)	Not applicable	Alarm (2) (3)
Limited normal release, restricted abnormal release	Alarm (3)	Alarm and (4)	Alarm (3)	Alarm and (4)
Limited normal release, unrestricted abnormal release	Alarm (3)	Alarm and (4) (2)	Alarm (3)	Alarm and (4) (2)

NOTE 1 Restricted abnormal release means that the maximum possible ratio of flammable gas to dilution gas is below the LEL in the vicinity of the electrical apparatus in the enclosure when dilution is proceeding.
NOTE 2 The dilution gas is required to be inert.
NOTE 3 When the alarm is operated, immediate action should be taken to restore the integrity of the system.
NOTE 4 De-energize ignition capable components.



Key

FI — Flow indicator

Variable flow restrictor

Over-pressure relief valve

FIC Lo — Low-flow indicating switch

PC Hi — High-pressure switch

PC Lo — Low-pressure switch

A — Alarm, local

A — Alarm remote, panel mounted

NOTE Symbols are in accordance with BS 1553 and BS 1646.

Figure 4 — Typical continuous dilution system

Section 4. Pressurized rooms with no internal source of flammable gas or vapour

27 Description of technique

The general principles of pressurization are described in section 1 but there are additional considerations for pressurized rooms to take account of the possible presence of personnel. Where the presence of personnel has to be taken into account, it is essential that flammable, polluting and toxic compounds are either eliminated or reduced in concentration to an acceptable level.

28 Construction

28.1 In the absence of a specific British Standard, pressurized rooms should be constructed in accordance with BS 5501-3, where relevant. The additional recommendations given in **28.2** to **28.9** also apply.

28.2 The protective gas will be air. This may be conditioned and filtered to provide satisfactory working conditions for people in addition to its primary purpose of pressurization. In determining the quantity and flow of air the following factors should be taken into account.

a) The air requirements for the number of people expected to be present in the pressurized room.

b) The type and heat dissipation characteristics of any apparatus in the pressurized room.

c) The requirements of any air consuming device in the pressurized room.

28.3 Where practicable, exits and entrances should be positioned so that they do not face the sources of flammable material. The number of exits and entrances should be adequate to provide safe exit for people.

28.4 Exits and entrances should be clearly marked both internally and externally, emergency doors should be provided and clearly marked and all emergency doors should open outwards.

28.5 In order to maintain adequate pressurization it may be necessary to provide an airlock at each entrance and exit. Airlocks may not be necessary if the system of supply of air is capable of maintaining an adequate over-pressure with all doors and other apertures fully open.

28.6 Drains and ducts with connection to the external atmosphere or between equipment cubicles within the room and external atmosphere should be sealed against ingress of gas or vapour.

28.7 All service and utility connections should be provided with suitable seals to prevent ingress of flammable gas or vapour.

28.8 Suitable precautions should be taken to prevent the unauthorized opening of apertures for pressurized rooms in which people may be present. Consideration should be given to sealing doors, windows, and possibly the walls, floor and ceiling. Inadequate precautions in this respect may result in a substantial outflow of air that would, in turn, affect the heating requirements of the building and could result in uncomfortable streaming velocities in the internal atmosphere.

28.9 Apparatus, such as emergency lighting that has to remain in operation when the pressurization is inoperative, should have a type of protection suitable for the zone in which the pressurized room is situated.

29 Safety assessment

Pressurized rooms are often constructed on site where inspections and tests for certification purposes are not possible. In all circumstances an assessment of safety should be made which should include a check of the following.

a) That the recommendations in this Part of the code have been observed.

b) That the design is such that purging can be completed satisfactorily.

c) That the temperature classification of the pressurized room and of any apparatus inside the pressurized room that has to remain in operation when the pressurization is inoperative (see **28.9**) is correct.

d) That the safety devices installed are of suitable design and location.

e) That the pressurized room is protected against impacts and that exits and entrances are adequately and clearly marked.

30 Marking

The pressurized room should be clearly marked to enable the records (see clause **13**) to be identified.

The following additional marking is also recommended:

a) a notice worded “Warning — Pressurized Room”;

b) a warning at both the control switch for the source of pressurization and at the relevant points of isolation indicating the time “*T*” minutes for which purging is to operate before the electrical supply can be switched on or restored;

c) a warning at all entrances to the pressurized room or system against the introduction of any flammable materials.

NOTE All warning notices should be in accordance with BS 5378.

Appendix A Calculation of protective gas rate for continuous dilution

The protective gas rate depends upon the following factors.

a) The maximum rate of flow of flammable gas or vapour into the apparatus enclosure in the event of a leak.

b) The composition of the flammable gas or vapour and the LEL of its components.

c) The safety factor chosen.

d) The assumption, in the case of volatile liquids, that all the released liquid vaporizes, unless there is evidence to the contrary.

The protective gas rate, Q_1, (in m^3/h) is given by the expression

$$Q_1 = Q_2 \times \frac{Y_1}{100} \times \frac{100}{Y_2} \times F$$

where

Q_2 is the maximum release rate of vapour or gas (in m^3/h), or in the case of liquids the vaporized volume (in m^3/h);

Y_1 is the percentage concentration of the flammable component in the release;

Y_2 is the LEL percentage in the protective gas of the flammable component in the release;

F is the safety factor, the value of which should be selected to dilute any release of flammable material to, for example, 20 % of the LEL.

Example

The maximum possible flow of flammable material is 0.6 m^3/h but release is limited by a restrictor in the sample line to 0.06 m^3/h.

Sample composition: Hydrogen 20 % (LEL = 4.1 %)
Methane 10 % (LEL = 5.0 %)
Nitrogen 70 %
Total 100 %

For hydrogen, $Q_1 = 0.06 \times \frac{20}{100} \times \frac{100}{4.1} \times 5$ m^3/h

$= 1.5$ m^3/h

For methane, $Q_1 = 0.06 \times \frac{10}{100} \times \frac{100}{5.1} \times 5$ m^3/h

$= 0.6$ m^3/h

It is assumed that the flammable materials have an additive effect, so the required protective gas rate is $1.5 + 0.6 = 2.1$ m^3/h.

In this calculation, it has been assumed that the protective gas is air. If air is not used for any reason, then an inert gas should be used (see clause **21**). The required rate is then the minimum needed to pressurize the apparatus and give satisfactory operation of safety devices.

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Publications referred to

BS 1553, *Specification for graphical symbols for general engineering.*

BS 1646, *Symbolic representation for process measurement control functions and instrumentation.*

BS 5345, *Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture).*

BS 5345-1, *Basic requirements for all Parts of the code.*

BS 5378, *Safety signs and colours.*

BS 5501, *Electrical apparatus for potentially explosive atmospheres.*

BS 5501-1, *General requirements.*

BS 5501-3, *Pressurized apparatus "p".*

CP 1003, *Electrical apparatus and associated equipment for use in explosive atmospheres of gas or vapour other than mining applications.*

CP 1003-1, *Choice, installation and maintenance of flameproof and intrinsically-safe equipment.*

CP 1003-2, *Methods of meeting the explosion hazard other than by the use of flameproof or intrinsically-safe electrical equipment.*

CP 1003-3, *Division 2 areas.*

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