

Specification for

Flameproof enclosure of electrical apparatus

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British Railways, The British Transport Commission	Ministry of Supply
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Association of Mining Electrical and Mechanical Engineers	Institute of Petroleum
Council of Underground Machinery Manufacturers	Lloyd's Register of Shipping
Fire Offices Committee	National Coal Board
	Manufacturers of Chemicals

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Foreword

This standard makes reference to the following British Standards:

BS 31, *Steel conduits and fittings for electrical wiring.*

BS 239, *White pigments for paints.*

BS 292, *Dimensions of ball bearings and parallel-roller bearings.*

BS 410, *Test sieves.*

BS 889, *Flameproof electric lighting fittings (bulkhead and well-glass types).*

BS 970, *Wrought steels for general engineering purposes.*

BS 1387, *Steel tubes and tubulars suitable for screwing to BS 21 pipe threads.*

BS 1858, *Bitumen-base filling compounds for electrical purpose.*

BS 2474, *Recommended names for chemicals used in industry.*

BS 2558, *Tubular box spanners.*

BS 4568, *Steel conduits and fittings with metric threads of ISO form for electrical installations.*

BS 4683, *Electrical apparatus for explosive atmosphere — Part 2: The construction and testing of flameproof enclosures of electrical apparatus.*

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

BS 5501-5, *Flameproof enclosure “d”.*

This British Standard, prepared under the authority of the Electrical Industry Standards Committee, supersedes the 1946 edition.

The foreword of the 1946 edition refers to research carried out by the British Electrical and Allied Industries Research Association in collaboration with the Safety in Mines Research Establishment. The research has continued into the characteristics of a greater number of flammable¹⁾ gases and vapours and has embraced work on both one inch and half inch joint breadths. At the same time the method of assessment of the statistical maximum safe gap has been reconsidered, with the result that a more precise method of grouping the various gases and vapours has been evolved. This has resulted in a few changes of grouping. Data on gases and vapours included in any group will be extended when the results of further research are made available.

The maximum permissible gap, specified in Table 1, has a dimension which is less than that of the statistical maximum safe gap referred to above. This is to provide some margin of safety essential in respect of possible contingencies arising in course of practical use; for example, small undetected alteration or deterioration of gaps.

The requirements for large rotating machines with sleeve bearings for Group II Combustibles have been amended to make the construction and operation of such apparatus more practicable.

To simplify the presentation of the standard, supplementary data regarding the basis of the requirements specified are given in an Annex which included a revision of Appendix F of the 1946 edition to give guidance in the case of gases for which tests are not yet completed.

Although only requirements for flameproof enclosure are given it is recognized that the apparatus may have to operate in places where, for example, moisture or dust is present. It would be inappropriate to specify, in this standard, the supplementary requirements to cover such protection, but care has been taken in drafting that such requirements are not excluded provided that any additions to the enclosure itself do not impair its flameproof qualities (see Clause 7, page 4, paragraphs 8 and 9).

By way of example an accepted method of weatherproofing a flameproof enclosure is given in Figure 18.

¹⁾ The term “flammable” is synonymous with the term “inflammable” which has been used in previous editions of BS 229.

Obsolescent (by Amendment No. 9)

This standard has been declared obsolescent. It is not recommended for new designs of apparatus but is retained to provide a standard for servicing existing equipment and installations.

BS 4683-2 is a later standard which will eventually be superseded by BS 5501-5. BS 5501-5 is identical with European Standard EN 50018 which is referred to in EEC Directives 79/196/EEC and 82/130/EEC.

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 34 and a back cover.

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

Section 1. General

1 Scope

This standard prescribes the performance required from the flameproof enclosure of electrical apparatus and those features of design and construction which are considered to be essential or desirable to secure reliability of the enclosure in service.

Pending the revision of existing British Standards for particular types of flameproof apparatus to make them accord with this specification where applicable, this standard takes precedence over the individual standards for apparatus where there is any conflict as regards flameproof requirements.

For the purposes of this standard various flammable gases and vapours which constitute an explosion hazard in industry are placed in groups according to the appropriate maximum permissible dimensions of joint gaps and other openings in the enclosure of the apparatus as set out in Clause 4, Table 1.

It is intended to add to this list of gases and vapours when the necessary information is available.

It will be seen that in the Group IV are placed those gases and vapours with regard to which the maximum safe gap, as at present ascertained, is too small to be practicable for the generality of apparatus and to justify certification on the basis of type test.

NOTE It is not intended that this standard shall be applicable to apparatus certified as flameproof by the recognized Testing Authority before the date of this publication; but where provisional reports have been issued by that authority, it is to be understood that certificates when issued in substitution for such provisional reports will require compliance with the relevant dimensions in Table 1.

2 Definition of flameproof enclosure

A flameproof enclosure for electrical apparatus is one that will withstand, without injury, any explosion of the prescribed flammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith), and will prevent the transmission of flame such as will ignite the prescribed flammable gas which may be present in the surrounding atmosphere.

NOTE 1 *Flammable gases.* Flammable gas may originate within the enclosure of particular kinds of apparatus, such as gases derived from the cracking of hydrocarbon oil under the action of the electric arc in oil-immersed switch and control gear. The flammable gases within and without the enclosure may differ in such cases, and limiting dimensions appropriate to these different flammable gases are prescribed for joint surfaces and other openings in the flameproof enclosure.

NOTE 2 *Control of circuit.* As the condition of flameproofness depends upon operation of the apparatus within its rating, means should be provided so that the highest recognized overload of the apparatus or, in the case of circuit-breakers, the rated breaking capacity, is not exceeded.

The consequences of a destructive short-circuit within the apparatus should be guarded against by the provision of means to achieve automatic interruption of the short-circuit elsewhere before the risk of destruction of the enclosure supervenes.

NOTE 3 *Oil-immersed resistors.* If an oil-immersed starting resistor is left in circuit, or is operated more frequently than the design provides for, the temperature of the oil may increase dangerously and vapour may issue through openings of the prescribed dimensions in the enclosing case at such a temperature as to ignite spontaneously when mixed with air.

NOTE 4 *Normal operating temperature.* The normal operating temperature of some apparatus, in particular resistors, space heaters and lighting fittings, may cause the enclosure surface to exceed the safe temperature for certain flammable substances. For instance, the Cellulose Solutions Regulations, 1934 (S.R. and O. 1934, No. 990) put the danger point for the solid residue at 180 °F (82 °C). There may be other cases where precautions should be taken, e.g. with regard to the vapour of diethyl ether. In cases of doubt, expert advice should be sought.

NOTE 5 *Maintenance of structure.* As the condition of flameproofness depends upon maintenance of the structure in its designed condition, including the filling of spaces intended to be occupied by insulation compound or by oil, and maintenance of the latter at the correct design level, it is essential that due attention be paid to this condition at all times, and that corrosion, deformation, or wear of components be remedied before any designed openings or gaps in the enclosure are enlarged beyond the limits laid down in this standard.

The maintenance and use of flameproof apparatus so that its safety will not be impaired is the responsibility of the user.

Section 2. Apparatus to be enclosed

3 Design of apparatus

In electrical features, rating and performance, the design of the apparatus to be enclosed in flameproof enclosures shall meet the general requirements of the current British Standard, if any, for such apparatus.

Where the complete unit comprises two or more distinct pieces of electrical apparatus, the several components shall meet the general requirements of the corresponding current British Standards, if any.

Section 3. Grouping of gases and classification of gap dimensions

4 Permissible dimensions

For the purpose of this standard, flammable gases and vapours met with in industry are arranged in groups, with corresponding maximum permissible dimensions for any gaps which may exist between joint surfaces and for other openings in the structure, such as shaft glands, as set out in Table 1.

Table 1 — Grouping and corresponding gap dimensions for flammable gases and vapours

1	2	3	4	5	6
Group	Name according to BS 2474 ^b (for convenience, names used in the 1946 edition of BS 229, where these are different, are given in brackets)	Maximum permissible gap dimension (inches)			
		For joints (flanges) not less than 1 in. in breadth			For joints (flanges) less than 1 in. in breadth but not less than 0.5 in. in breadth
		Class A (i)	Class A (ii)	Class B	Class A (iii)
I	Methane	0.020	0.020	0.006	0.016
II	Blastfurnace gases	0.016	0.016	0.006	0.006
	Carbon monoxide	0.016	0.016	0.006	0.006
	Propane	0.016	0.016	0.006	0.006
	Butane	0.016	0.016	0.006	0.006
	Pentane	0.016	0.016	0.006	0.006
	Hexane	0.016	0.016	0.006	0.006
	Heptane	0.016	0.016	0.006	0.006
	Iso-octane ^d	0.016	0.016	0.006	0.006
	Decane	0.016	0.016	0.006	0.006
	Benzene	0.016	0.016	0.006	0.006
	Xylene	0.016	0.016	0.006	0.006
	Cyclohexane	0.016	0.016	0.006	0.006
	Acetone	0.016	0.016	0.006	0.006
	Ethyl methyl ketone (Methyl ethyl ketone or M.E.K.)	0.016	0.016	^a	0.006
	Methyl acetate	0.016	0.016	^a	0.006
	Ethyl acetate	0.016	0.016	^a	0.006
	<i>n</i> -Propyl acetate [Propyl acetate (normal)]	0.016	0.016	^a	0.006
	<i>n</i> -Butyl acetate [Butyl acetate (normal)]	0.016	0.016	^a	0.006
	Amyl acetate	0.016	0.016	^a	0.006
	Chloroethylene (Vinyl chloride)	0.016	0.016	^a	0.006
	Methanol (Methyl alcohol)	0.016	0.016	^a	0.006
	Ethanol (Ethyl alcohol)	0.016	0.016	^a	0.006
	<i>iso</i> Butyl alcohol (Iso-butyl alcohol)	0.016	0.016	^a	0.006
	<i>n</i> -Butanol [Butyl alcohol (normal)]	0.016	0.016	^a	0.006
	Amyl alcohol	0.016	0.016	^a	0.006
	Ethyl nitrite	0.016	0.016	^a	0.006
	Buta-1 : 3-diene (Butadiene 1 : 3)	0.016	0.016	^a	0.006
III	Ethylene	0.008	0.016	^a	0.006
	Diethyl ether ^c (Ethyl ether)	0.008	0.016	^a	0.006
	Ethylene oxide	0.008	0.016	^a	0.006
	Coal gas (town gas)	0.008	0.016	^a	0.006

Table 1 — Grouping and corresponding gap dimensions for flammable gases and vapours

1	2	3	4	5	6
Group	Name according to BS 2474 ^b (for convenience, names used in the 1946 edition of BS 229, where these are different, are given in brackets)	Maximum permissible gap dimension (inches)			
		For joints (flanges) not less than 1 in. in breadth			For joints (flanges) less than 1 in. in breadth but not less than 0.5 in. in breadth
		Class A (i)	Class A (ii)	Class B	Class A (iii)
IV	Acetylene Carbon disulphide Ethyl nitrate Hydrogen Water gas	These gases and vapours are excluded, see Clause 1, Para. 5.			

Dimensions shown in heavy type are those confirmed by a full series of tests. Dimensions shown in thin type are those now permitted following examination which has been made of available data. It is expected that in further editions the dimensions in thin type in Column 6 will have confirmation following a full series of tests. In the particular cases of dimensions in thin type in Column 5 and those in Columns 3 and 4 of Group III, available data is very limited and it is possible that the experimental work in hand will lead to the specifying of smaller dimensions.

NOTE The grouping of Ammonia is under consideration. Pending the allocation of Ammonia to another group, enclosures constructed in accordance with the requirements for Group I are deemed to be appropriate where flameproof enclosures are required for situations where Ammonia may be present.

^a Excluded at present.

^b BS 2474 "Recommended names for chemicals used in industry".

^c See Note 4 to clause 2.

^d According to BS 2474 the name should be 2 : 2 : 4-Trimethyl pentane but the gas tested contained some 2 : 2 : 3 : 3-Tetramethyl pentane and the name Iso-octane has therefore been retained.

Containing not more than 57 per cent by volume of hydrogen and not more than 16 per cent by volume of carbon monoxide, the remainder being a mixture of paraffin hydrocarbons and inert gas.

Class A Dimensions apply to apparatus normally filled with air as follows:—

A (i) (Column 3). Gaps between joint surfaces (see Clause 7) and diametral clearances for operating rods and spindles (see Clause 8).

A (ii) (Column 4). Diametral clearance for shaft glands for motors and generators, other than labyrinth glands (see Clause 9).

A (iii) (Column 6). Gaps between the surfaces of joints of ½ in. breadth.

Class B Dimensions (Column 5) apply to apparatus normally containing hydrocarbon oil or parts of apparatus in gaseous communication therewith for gaps between joint surfaces (see Clause 7) and diametral clearance for operating rods and spindles (see Clause 8).

Section 4. Construction of the enclosure

5 Precautions against internal insulation failure

In view of the risk of damage to the flameproof enclosure which might result from an internal short-circuit or other failure of insulation, adequate attention to relevant details of design and manufacture is necessary.

As a precaution against the opening of a flameproof compartment, for examination or for any other purpose while the contents are live whereby the risk of arcing at exposed contacts may be introduced, warning inscriptions upon doors or cover plates giving access to the contents are required, as follows:

- Switchgear, control gear or fuse gear without an associated isolating switch:* an inscription warning against opening the cover of the switchgear, control gear or fuse gear unless the circuit is isolated elsewhere.

ii) *Switchgear, control gear or fuse gear with an associated isolating switch contained in a separate compartment of the enclosure:* an interlock between the isolator and the cover of the protected gear and an inscription warning against opening the cover of the isolating switch unless the circuit is isolated elsewhere.

6 Mechanical strength of the enclosure

The containing case shall be of metal, except inspection windows and cover glasses where necessary, but insulating materials carrying terminals for the electrical circuit may be used as barriers to cover openings in the wall of the structure, provided that the insulating materials are of adequate quality and thickness.

The structure as a whole shall be designed to withstand rough usage without fracture or such deformation as might imperil the enclosure.

In particular, projecting parts or attached accessories, unless adequately shielded, shall be so designed.

The enclosure shall be capable of withstanding an internal explosion as described in Clause 2, with an adequate factor of safety as required by Clause 26.

Inspection windows shall also be capable of withstanding such impact and other tests as may be provided for in this or other relevant British Standards, as required by Clause 10.

7 Joints

All joints in a flameproof enclosure between compartments or components, or between covers and compartments, shall be either flanged joints, spigoted joints or screwed joints, or a combination of such joints, without the intervention of any loose or perishable packing, except as provided for later in this clause.

The breadth of all joints, or the minimum length of flameproof path between the inside and outside of the flameproof enclosure through any joints or openings in that enclosure, shall be one of two minimum dimensions:

- a) The length of path shall be not less than 1 in. with gap dimensions as prescribed in Columns 3 and 5 and with diametral clearances as prescribed in Column 4 of Table 1.
- b) The length of path may be less than 1 in. but not less than $\frac{1}{2}$ in. with gap dimensions as prescribed in Column 6 of Table 1.

Exceptions to the requirements of this clause are referred to in Sub-clause 10 b) which deals with windows.

Exceptions to the requirements of this clause are referred to in sub-clause 10 b) which deals with windows, that part of Clause 17 which deals with cable glands and sealing boxes complying with Clause 5.1 in BS 4683-2:1971 and that part of Clause 21 which deals with conduit stopper boxes complying with Clause 5.1 in BS 4683-2:1971.

For operating rods and spindles see Clause 8; for shafts and bearings of motors and generators see Clause 9; for requirements regarding cable sealing and dividing boxes and conduit stopper boxes see Clauses 20 and 21.

For compound-filled compartments where, for technical reasons, joint packing is necessary, such may be accepted, provided that any conductors in the compartment are completely covered with compound applied during the process of manufacture and that the structure is capable of withstanding an internal pressure of 50 lb/sq. in. above atmospheric pressure.

For other compartments, e.g. oil-filled compartments, where, for technical reasons, joint packing is necessary, such may be accepted, provided that the packing is not relied on to complete the flameproof joint.

For all joints, the spacing of bolts and other types of cover fastening shall be consistent with good mechanical design for the structure in relation to its size and purpose.

For close joints the presence of bolt-holes, where these exist, may be ignored in determining the breadth of the joint, provided that the edge of the hole is not less than $\frac{3}{8}$ in. from the inner edge of the joint surface for external screws, and the outer edge for internal screws.

For spigot joints, the length of the path may be measured over the spigot and flange together, provided that both spigot and flange portions are continuous.

The length of the path of a screwed joint shall be taken as the threaded (axial) length. In the case of screwed conduit forming part of the enclosure, the minimum lengths of engaged thread shall be in accordance with Table 2.

Table 2 — Minimum lengths of engaged thread for screwed conduit used on flameproof enclosures

1	2	3
Diameter of conduit	Relevant British Standard	Minimum length (axial) of engaged thread
Up to ¾ in. (internal)	BS 1387	¾ in. 19 mm
Up to 1 in. (external)	BS 31	
Up to 25 mm (external)	BS 4568	
1 in. to 2½ in. (internal)	BS 1387	1 in. 25 mm
1¼ in. to 2½ in. (external)	BS 31	
32 mm (external)	BS 4568	
3 in. to 3½ in. (internal)	BS 1387	1¼ in.
4 in. to 6 in. (internal)	BS 1387	1½ in.

8 Operating rods and spindles

Where an operating rod or spindle passes through the wall of a flameproof enclosure it shall be of metal and it shall enter through a hole such that the effective length of the flameproof path is not less than 1 in., fitting as closely as operating conditions permit. In no case shall the clearances of the flameproof path exceed the dimensions given in Table 1 for the group and class for which the apparatus is intended.

If a sleeve or bushing gland is provided for the passage of the rod or spindle, it shall be of metal and shall be attached to the wall of the enclosure so that it cannot readily become detached, and if subject to wear it shall be arranged so that it may be replaced.

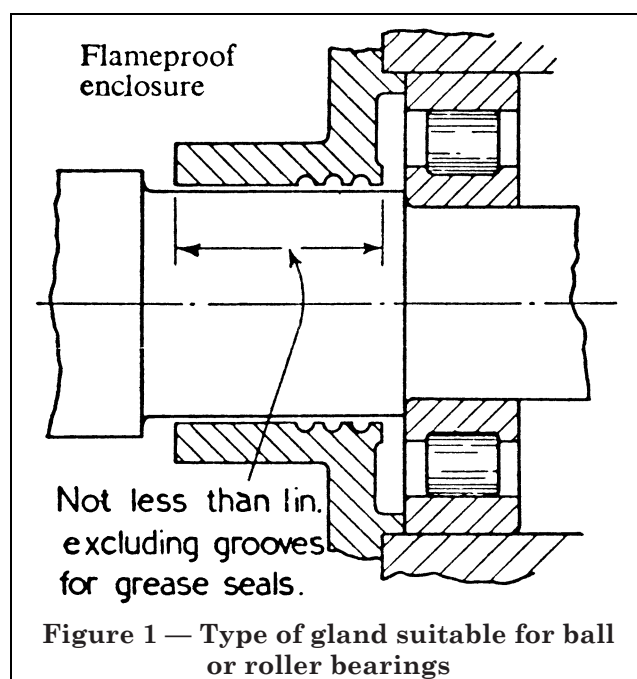
If an operating rod or spindle is intended for such continuous or repeated use as would be likely to result in rapid wear of a plain spindle or of the bushing, special means shall be provided to prevent such wear, or the requirements of Clause 9 [except 9 d)] shall be substituted for the requirements of this clause. In the case of Class B (oil-filled apparatus) the specified gap dimensions for Class B apparatus shall not be exceeded.

Where a stuffing box or packed gland is required, this shall be provided in addition to, and not in substitution for, the plain hole or sleeve, or bushing gland.

9 Shafts and bearings for motors or generators

Where the shaft of a motor or generator passes through the end shield, a flameproof gland shall be provided, and where practicable shall be designed so that it will not be subjected to wear by decentralizing or by wear of the bearings up to the limit that can occur in practice. Typical glands are shown in Figure 1, Figure 2 and Figure 3.

a) For machines having ball or roller bearings either a plain fixed gland (as shown in Figure 1) or a labyrinth gland (as shown in Figure 2) or a floating gland (as shown in Figure 3) shall be used.



This drawing is intended to illustrate basic principles and does not purport to show actual constructional details.

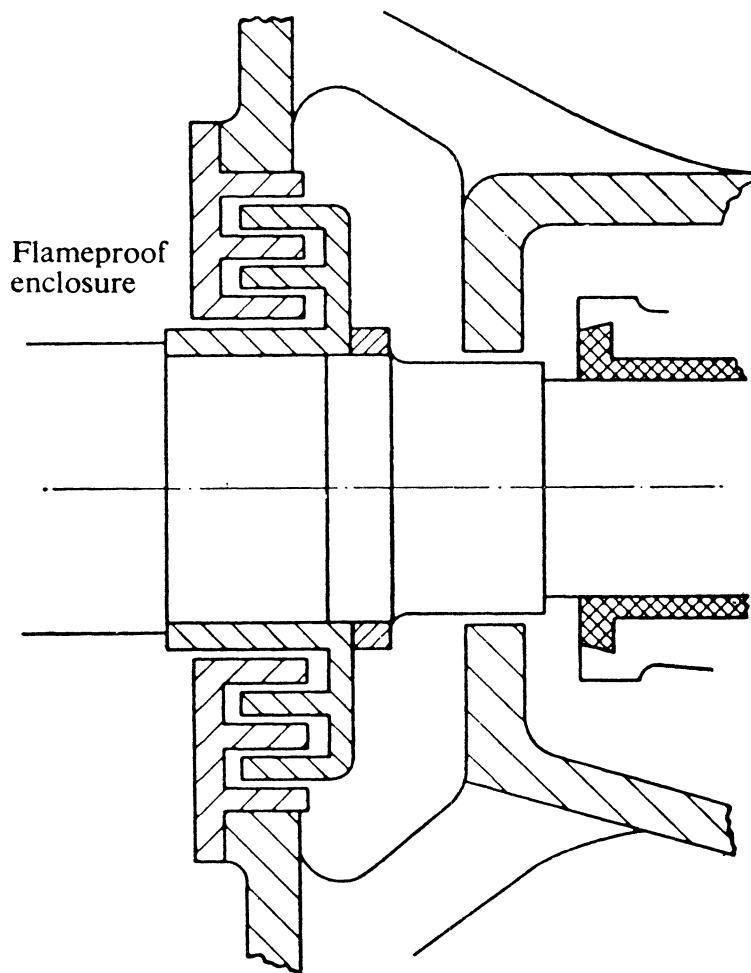
b) For machines having sleeve bearings, either a plain fixed gland, or a labyrinth gland or a floating gland shall be used, but in those cases where the radial clearance between rotor and stator is greater than the radial movement permitted by the flameproof gland, the use of a plain fixed gland or a labyrinth gland is subject to the following additional requirements:

- 1) The gland shall be of metal arranged for easy access so that the radial clearance of the gland can be measured directly.
- 2) A permanent instruction plate prominently mounted shall call the user's attention to the need for regular and frequent checking of the radial clearance of the gland.

3) The plate shall plainly state the maximum decentralization allowed and shall state that the motor will remain flameproof only if the specified conditions are maintained.

In the case of the plain, fixed gland, pending the results of further research, the maximum diametral clearance between the shaft and gland of sleeve bearing flameproof motors may be 0.02 in. for Group II combustibles. The instruction plate mentioned above shall plainly state that the maximum radial clearance as measured at any point shall never be allowed to exceed 0.016 in. The value of the minimum permissible clearance shall also be stated on the plate.

c) Where a plain gland, either fixed or floating, is used, the length of the gland, exclusive of grease seals, shall be not less than 1 in. The diametral clearance shall not exceed the dimensions given in Table 1 for the group for which the apparatus is intended, except for the special conditions already referred to in b). In no case shall the diametral clearance be less than 0.0075 in. In assessing the length of the gland, the lands between the grease grooves may be included at the discretion of the testing authority.



This drawing is intended to illustrate basic principles and does not purport to show actual constructional details.

Figure 2 — Labyrinth type of gland; suitable for both sleeve bearings and ball and roller bearings

d) Where a plain gland, either fixed or floating, is used in apparatus intended for Group III in Table 1, the eccentricity and/or looseness of fit of all parts, which may affect the clearance between the shaft and the gland, shall not in the aggregate be sufficient to cause the gland to be eccentric with the shaft to such an extent that the radial gap can exceed 0.012 in. at one side or can be less than 0.003 in. on the opposite side when all the parts are finally assembled. The eccentricity and the clearance, if any, in the bearing shall be included for this purpose. An adequate and approved method of gauging the parts concerned shall be used to ensure that these requirements are complied with.

e) Where a labyrinth gland is used (see Figure 2), the dimensions shall be such as may be approved by the recognized testing authority for the particular application.

f) Ball bearings and parallel roller bearings shall comply with the requirements of BS 292, "Dimensions of ball bearings and parallel-roller bearings", as regards permissible error due to eccentricity.

