इंटरनेट मानक

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Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

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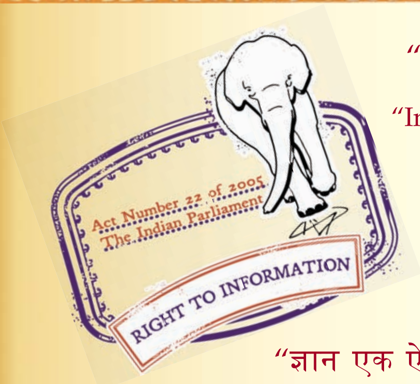
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 5571 (2009): Guide for Selection and installation of Electrical Equipment for Hazardous Areas (other than mines) [ETD 22: Electrical Apparatus for Explosive Atmosphere]

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Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”


“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

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*भारतीय मानक*

# जोखिमपूर्ण क्षेत्रों में विद्युत उपस्कर के चयन व संस्थापन की मार्गदर्शिका (खानों को छोड़कर)

*( तीसरा पुनरीक्षण )*

*Indian Standard*

# GUIDE FOR SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS (OTHER THAN MINES)

*( Third Revision )*

ICS 28.260.20



**BUREAU OF INDIAN STANDARDS**
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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## FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrical Apparatus for Explosive Atmospheres Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was first published in 1970. The first revision was carried out to remove difficulties faced during the implementation of this standard and also to take into account the latest developments in the field of electrotechnology. The second revision was published in 2000. The second revision was undertaken to include latest development taking place for updation of IEC Standards for use of electrical equipment in hazardous area.

This revision is to further align with the current international practices including the concept of 'Equipment Protection Levels'. Considerable assistance has been derived from IEC 60079-14: 2002 'Electrical apparatus for explosive gas atmosphere—Part 14: Electrical installations in hazardous areas (other than mines)' and 31J/120/ CDV 'Explosive atmospheres—Part 14: Electrical installations design, selection and erection'.

This standard is intended to provide guidance for selection of electrical equipment for use in hazardous areas, such as, petroleum refineries and petrochemical and chemical industries. In this standard, the selection of electrical equipment has been based on the classification of hazardous areas given in IS 5572 : 2008 'Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation (*third revision*)', in conjunction with which this standard shall be read and interpreted.

While formulating this standard the statutory regulations in this country have been kept in mind to see that no provision goes against such regulations. However, if there is a conflict between statutory regulations in force in any areas and this standard, the provisions of the former will prevail.

No account is taken in this standard of the toxic risks which are associated with most combustible materials in concentrations which are usually very much less than the lower explosive (flammable) limit. In locations where personnel maybe exposed to potentially toxic concentrations of combustible materials, particular precautions, which are outside the scope of this standard, should be applied.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard*

# GUIDE FOR SELECTION AND INSTALLATION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS (OTHER THAN MINES)

*( Third Revision )*

## 1 SCOPE

### 1.1 General

This standard contains the specific requirements for the design, selection and erection of electrical installations in hazardous area associated with explosive gas atmospheres.

These requirements are in addition to those as required for installations in non-hazardous areas, as per applicable codes and statutory regulations.

This standard applies to all electrical equipment and installations in hazardous areas whether permanent, temporary, portable, transportable or hand-held.

It applies to installations at all voltages.

This standard does not apply to,

a) electrical installations in mines susceptible to firedamp;
b) electrical installations in areas where the hazard is due to combustible dusts or fibres;
c) inherently explosive situations, for example explosives manufacturing and processing; and
d) rooms used for medical purposes.

NOTE — This standard may apply to electrical installations in mines where explosive gas atmospheres other than firedamp may be formed and to electrical installations in the surface installation of mines.

### 1.2 Statutory Requirements

The equipment and installations in hazardous areas shall in addition, meet the applicable statutory authority requirements/regulations, if any.

## 2 REFERENCES

The following standards are necessary adjunct to this standard:

| *IS No.* | *Title* |
|---|---|
| IS 302-1 : 2008 | Safety of household and similar electrical appliances: Part 1 General requirements (*sixth revision*) |
| IS 325 : 1996 | Three-phase induction motors (*first revision*) |
| IS 1646 : 1997 | Code of practice for fire safety of buildings (general): Electrical installations |
| IS 1885 (Part 60) : 1993/IEC 60050 (426) (1990) | International Electrotechnical Vocabulary (IEV): Part 60 Electrical equipment for explosive atmospheres |
| IS 2071 (Part 1): 1993/IEC 60060-1 (1989) | High-voltage test techniques: Part 1 General definitions and test requirements |
| IS 2148 : 2004/ IEC 60079-1 (2001) | Electrical equipment for explosive gas atmospheres — Flameproof enclosures "d" (*third revision*) |
| IS 2309 : 1989 | Protection of buildings and allied structures against lightning — Code of practice |
| IS 4691 : 1985 | Degrees of protection provided by enclosure for rotating electrical machinery |
| IS 5572 : 2008 | Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation (*second revision*) |
| IS 5780 : 2002/ IEC 60079-11 (1999) | Electrical equipment for explosive gas atmospheres — Intrinsic safety "i" (*second revision*) |
| IS 6381 : 2004/ IEC 60079-7 (2001) | Electrical equipment for explosive gas atmospheres — Increased safety "e" (*first revision*) |
| IS 7389 : 2004/ IEC 60079-2 (2001) | Electrical equipment for explosive gas atmospheres — Pressurised enclosures "p" (*second revision*) |
| IS 7689 : 1989 | Guide for the control of undesirable static electricity (*first revision*) |
| IS 7693 : 2004/ IEC 60079-6 (1995) | Electrical equipment for explosive gas atmospheres — Oil-immersion "o" (*first revision*) |
| IS 7724 : 2004/ IEC 60079-5 (1997) | Electrical equipment for explosive gas atmospheres — Powder-filling "q" (*first revision*) |

| IS No. | Title |
|---|---|
| IS 8062 : 2006 | Cathodic protection of buries pipeline/structure for transportation of natural gas, oil and liquids — Code of practice (*first revision*) |
| IS 9537 (Part 2) : 1981 | Conduits for electrical installation: Part 2 Rigid steel conduits |
| IS 10810 (Part 61) : 1988 | Method of test for cables: Part 61 Flame retardant test |
| IS 11064 : 1984 | Guide for construction and use of rooms or buildings protected by pressurization for installation of electrical apparatus for explosive gas atmospheres |
| IS 12063 : 1987 | Degrees of protection provided by enclosure (IP code) |
| IS 13252 : 2003/ ISO/IEC 60950-1 : 2001 | Information technology equipment — Safety — General requirements (*first revision*) |
| IS 13346 : 2004 | Electrical apparatus for explosive gas atmospheres — General requirements (*first revision*) |
| IS/IEC 60079-0 : 2004 | Electrical equipment for explosive gas atmospheres: Part 0 General requirements |
| IS/IEC 60079-15 : 2005 | Electrical apparatus for explosive gas atmospheres: Part 15 Construction, test and marking of type of protection "n" electrical apparatus |
| IS/IEC 60079-16 : 1990 | Electrical apparatus for explosive gas atmospheres: Part 16 Artificial ventilation for the protection of analyzer(s) houses |
| IS/IEC 60079-17 : 2002 | Electrical apparatus for explosive gas atmospheres: Part 17 Inspection and maintenance of electrical installations in hazardous areas (other than mines) |
| IS/IEC 60079-18 : 2003 | Electrical apparatus for explosive gas atmospheres: Part 18 Construction, test and marking of type of protection encapsulation "m" electrical apparatus |
| IS/IEC 60079-19 : 2006 | Explosive atmospheres: Part 19 Equipment repair, overhaul and reclamation |
| IS/IEC 60079-26 : 2006[1)] | Explosive atmospheres: Part 26 Equipment with equipment protection level (EPL) "Ga" |
| IS/IEC 60079-27 : 2005[1)] | Electrical equipment for explosive gas atmospheres: Part 27 Field bus intrinsically safe concept (FISCO) and fieldbus non-incendive concept (FNICO) |
| IS/IEC 60079-28 : 2006[1)] | Explosive atmospheres: Part 28 Protection of equipment and transmission systems using optical radiation |
| IS/IEC 61285 : 2004[1)] | Industrial process control — Safety of analyser houses |
| IS/IEC 61558-1 : 1997 | Safety of power transformers, power supply units and similar: Part 1 General requirements and tests |
| IS/IEC 61558-2-6 : 1997 | Safety of power transformers, power supply units and similar: Part 2 Particular requirements, Section 6 Safety isolating transformers for general use |

[1)] Currently, corresponding Indian Standards are under consideration.

## 3 DEFINITIONS AND TERMS

For the purposes of this standard the following definitions, in addition to those given in IS 1885 (Part 60) shall apply.

### 3.1 General

**3.1.1** *Normal Operation* — Operation of equipment conforming electrically and mechanically with its design specification and used within the limits specified by the manufacturer.

NOTES

1 The limits specified by the manufacturer may include persistent operational conditions such as stalled rotors, failed lamps and overloads.

2 Variation of the supply voltage within stated limits and any other operational tolerance is part of normal operation.

**3.1.2** *Competent Body* — Individual or organization which can demonstrate appropriate technical knowledge and relevant skills to make the necessary assessments of the safety aspect under consideration.

**3.1.3** *Cable Gland* — A device used to secure the cable entering the enclosure and provide the necessary sealing to maintain the relevant protection concept.

### 3.2 Hazardous Areas

**3.2.1** *Explosive Atmosphere* — Mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, mist or dust, which, after ignition, permits self-sustaining flame propagation.

**3.2.2** *Explosive Gas Atmosphere* — Mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour, which, after ignition, permits self-sustaining flame propagation.

**3.2.3** *Hazardous Area* — Area in which an explosive gas atmosphere is present, or may be expected to be

[1)] Currently, corresponding Indian Standards are under consideration.

present, in quantities such as to require special precautions for the construction, installation and use of equipment.

NOTE — For the purpose of this standard, an area is a three-dimensional region or space.

**3.2.4** *Non-hazardous Area* — Area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.

**3.2.5** *Group (of an Electrical Equipment for Explosive Atmospheres)* — Classification of electrical equipment related to the explosive atmosphere for which it is to be used.

NOTE — Electrical equipment for use in explosive gas atmospheres is divided into two groups:

1 *Group I* electrical equipment for mines susceptible to firedamp; and

2 *Group II* (which can be divided into subgroups): electrical equipment for places with an explosive gas atmosphere, other than mines susceptible to firedamp (*see* 5.4).

**3.2.6** *Maximum Surface Temperature* — Highest temperature which is attained in service under the most adverse operating conditions (but within recognized tolerances) by any part or surface of the electrical equipment, which would be able to produce an ignition of the surrounding explosive atmosphere.

NOTES

1 The most adverse conditions include recognized overloads and fault conditions recognized in the specific standard for the type of protection concerned.

2 The relevant surface temperature may be internal and/or external depending upon the type of protection concerned.

**3.2.7** *Type of Protection* — Specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere.

**3.2.8** *Zones* — Hazardous areas are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere.

**3.2.9** *Zone* 0 — Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.

**3.2.10** *Zone* 1 — Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

**3.2.11** *Zone* 2 — Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

**3.2.12** *Equipment Protection Level (EPL)* — The level of protection assigned to equipment based on its risk of becoming a source of ignition and distinguishing the differences between explosive gas atmospheres, explosive dust atmospheres, and the explosive atmospheres which may exist in coal mines.

NOTE — The Equipment Protection Level may optionally be employed as part of a complete risk assessment of an installation.

**3.2.13** *EPL 'Ga'* — Equipment for explosive gas atmospheres, having a very high level of protection, which is not a source of ignition in normal operation, expected malfunction or when subject to rare malfunction. Such equipment will have a form of protection which will remain effective even in the presence of two potential faults (for example, intrinsic safety, level of protection ia), or will have two independent means of protection (for example, Ex e and Ex d acting independently of each other).

**3.2.14** *EPL 'Gb'* — Equipment for explosive gas atmospheres, having a high level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

**3.2.15** *EPL 'Gc'* — Equipment for explosive gas atmospheres, having a enhanced level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).

**3.2.16** *Control of Ignition Sources Procedure* — Procedure under which the use of ignition sources in a hazardous area are controlled (*see* Annex D).

**3.2.17** *Control of Ignition Sources Permit* — Permit issued under a control of ignition sources procedure.

### 3.3 Flameproof Enclosure

**3.3.1** *Flameproof Enclosure 'd'* — Type of protection in which the parts which can ignite an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure.

**3.3.2** *Pressure-Piling* — Condition resulting from the ignition of pre-compressed gases in compartments or subdivisions other than those in which ignition was initiated.

NOTE — This may lead to a higher maximum pressure than would otherwise be expected.

### 3.4 Increased Safety

**3.4.1** *Increased Safety 'e'* — Type of protection applied to electrical equipment in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in normal service or under specified abnormal conditions.

3.4.2 *Initial Starting Current $I_A$* — Highest r.m.s. value of current absorbed by an ac motor at rest when supplied at the rated voltage and frequency.

3.4.3 *Starting Current Ratio $I_A/I_N$* — Ratio between initial starting current $I_A$ and rated current $I_N$.

3.4.4 *Time $t_e$* — Time take for an ac rotor or stator winding, when carrying the initial starting current $I_A$ to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature.

**3.5 Intrinsic Safety — General**

**3.5.1** *Intrinsic Safety 'i'* — Type of protection based upon the restriction of electrical energy within equipment and of interconnecting wiring exposed to an explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects.

NOTE — Because of the method by which intrinsic safety is achieved, it is necessary to ensure that not only the electrical equipment exposed to the explosive atmosphere but also other electrical equipment with which it is interconnected is suitably constructed.

**3.5.2** *Intrinsically Safe Apparatus* — Electrical apparatus in which all the circuits are intrinsically safe.

NOTE — Intrinsically safe apparatus should conform to IS 5780, category 'ia', 'ib' or 'ic'.

3.5.3 *Galvanic Isolation* — Arrangement within an item of intrinsically safe apparatus such that a signal is transferred from the apparatus input to the apparatus output without any direct electrical connection between the two.

NOTE — Galvanic isolation frequently utilizes either magnetic (transformer or relay) or opto-coupled elements.

3.5.4 *Associated Apparatus* — Electrical apparatus in which the circuits or parts of circuits are not all necessarily intrinsically safe but which contains circuits that can affect the safety of the intrinsically safe circuits associated with it.

NOTES

1 Associated apparatus may be either,

a) electrical apparatus which has an alternative type of protection included in this standard for use in the appropriate explosive gas atmosphere,
b) electrical apparatus not so protected and which therefore is not to be used within an explosive gas atmosphere, for example, a recorder which is not of itself in an explosive gas atmosphere but is connected to a thermocouple situated within an explosive gas atmosphere where only the recorder input circuit is energy limited.

2 For the purposes of this standard associated apparatus is also electrical apparatus which contains both intrinsically safe circuits and non-intrinsically safe circuits and is constructed so that the non-intrinsically safe circuits cannot adversely affect the intrinsically safe circuits and includes

a) electrical apparatus which has another type of protection listed in IS/IEC 60079-0 for use in the appropriate explosive gas atmosphere, or
b) electrical apparatus not so protected and which, therefore, shall not be used within an explosive gas atmosphere, for example a recorder which is not itself in an explosive gas atmosphere, but is connected to a thermocouple situated within an explosive atmosphere where only the recorder input circuit is intrinsically safe, or
c) chargers or interfaces not used in the hazardous area, but which are connected to hazardous area equipment in the safe area for charging, data downloading, etc.

3.5.5 *Simple Apparatus* — Electrical component or combination of components of simple construction with well-defined electrical parameters which is compatible with the intrinsic safety of the circuit in which it is used.

NOTE — The following apparatus is considered to be simple apparatus:

a) Passive components, for example, switches, junction boxes, resistors and simple semi-conductor devices;
b) Sources of stored energy with well-defined parameters, for example, capacitors or inductors, whose values are considered when determining the overall safety of the system; and
c) Sources of generated energy, for example thermocouples and photocells, which do not generate more than 1.5 V, 100 mA and 25 mW. Any inductance or capacitance present in these sources of energy are considered as in (b) above.

3.5.6 *Intrinsically Safe Circuit* — Circuit in which all the equipment is either intrinsically safe apparatus or simple apparatus.

NOTE — The circuit may also contain associated apparatus.

3.5.7 *Intrinsically Safe Electrical System* — Assembly of interconnected items of electrical equipment, described in a descriptive system document, in which the circuits or parts of circuits intended to be used in an explosive atmosphere are intrinsically safe.

**3.5.8** *Intrinsically Safe Sub-circuit* — Part of an intrinsically safe circuit which is galvanically isolated from another part or other parts of the same intrinsically safe circuit.

**3.6 Intrinsic Safety Parameter**

**3.6.1** *Maximum External Capacitance ($C_o$)* — Maximum capacitance in an intrinsically safe circuit that can be connected to the connection facilities of the equipment without invalidating intrinsic safety.

3.6.2 *Maximum External Inductance ($L_o$)* — Maximum value of inductance in an intrinsically safe circuit that can be connected to the connection facilities of the equipment without invalidating intrinsic safety.

3.6.3 *Maximum External Inductance to Resistance Ratio ($L_o/R_o$)* — Ratio of inductance ($L_o$) to resistance ($R_o$) of any external circuit connected to the connection facilities of the electrical equipment without invalidating intrinsic safety.

3.6.4 *Maximum Input Current ($I_i$)* — Maximum current (peak ac or dc) that can be applied to the connection facilities for intrinsically safe circuits without invalidating intrinsic safety.

3.6.5 *Maximum Input Power ($P_i$)* — Maximum input power in an intrinsically safe circuit that can be dissipated within an equipment when it is connected to an external source without invalidating intrinsic safety.

3.6.6 *Maximum Input Voltage ($U_i$)* — Maximum voltage (peak ac or dc) that can be applied to the connection facilities for intrinsically safe circuits without invalidating intrinsic safety.

3.6.7 *Maximum Internal Capacitance ($C_i$)* — Total equivalent internal capacitance of the equipment which is considered as appearing across the connection facilities of the equipment.

3.6.8 *Maximum Internal Inductance ($L_i$)* — Total equivalent internal inductance of the equipment which is considered as appearing at the connection facilities of the equipment.

3.6.9 *Maximum Internal Inductance to Resistance Ratio ($L_i/R_i$)* — Ratio of inductance ($L_i$) to resistance ($R_i$) which is considered as appearing at the external connection facilities of the electrical equipment.

3.6.10 *Maximum Output Current ($I_o$)* — Maximum current (peak ac or dc) in an intrinsically safe circuit that can be taken from the connection facilities of the equipment.

3.6.11 *Maximum Output Power ($P_o$)* — Maximum electrical power in an intrinsically safe circuit that can be taken from the equipment.

3.6.12 *Maximum Output Voltage ($U_o$)* — Maximum output voltage (peak ac or dc) in an intrinsically safe circuit that can appear under open-circuit conditions at the connection facilities of the equipment at any applied voltage up to the maximum voltage, including $U_m$ and $U_i$.

NOTES

1 Where there is more than one applied voltage, the maximum output voltage is that occurring under the most onerous combination of applied voltages.

2 $U_z$ is sometimes used to denote the output working voltage of a shunt diode safety barrier.

3.6.13 *Maximum r.m.s. ac or dc Voltage ($U_m$)* — Maximum voltage that can be applied to the non-intrinsically safe connection facilities of associated apparatus without invalidating intrinsic safety.

**3.7 Pressurization**

3.7.1 *Pressurization 'p'* — Technique of guarding against the ingress of the external atmosphere into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere.

3.7.2 *Continuous Dilution (Flow)* — Continuous supply of a protective gas, after purging, at such a rate that the concentration of a flammable substance inside the pressurized enclosure is maintained at a value outside the explosive limits at any potential ignition source (that is, outside the dilution area).

NOTE — The dilution area is an area in the vicinity of an internal source of release where the concentration of a flammable substance is not diluted to a safe concentration.

3.7.3 *Leakage Compensation* — Flow of protective gas sufficient to compensate for any leakage from the pressurized enclosure and its ducts.

3.7.4 *Static Pressurization* — Maintenance of an overpressure within a pressurized enclosure without the addition of protective gas in the hazardous area.

**3.8 Non-sparking**

3.8.1 *Type of Protection 'n'* — Type of protection applied to electrical equipment such that, in normal operation and in certain specified abnormal conditions, it is not capable of igniting a surrounding explosive atmosphere.

NOTES

1 Additionally; the requirements of the equipment standard are intended to ensure that a fault capable of causing ignition is not likely to occur.

2 An example of a specified abnormal condition is a luminaire with a failed lamp.

3.8.2 *Energy-Limited Apparatus* — Electrical equipment in which the circuits and components are constructed according to the concept of energy limitation.

3.8.3 *Associated Energy-Limited Apparatus* — Electrical equipment which contains both energy-limited and non-energy-limited circuits and is constructed so that the non energy limited circuits cannot adversely affect the energy limited circuits.

**3.9 Oil Immersion 'o'** — Type of protection in which the electrical equipment or parts of the electrical equipment are immersed in a protective liquid in such a way that an explosive atmosphere, which may be above the liquid or outside the enclosure cannot be ignited.

**3.10 Powder Filling 'q'** — Type of protection in which the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by filling material to prevent the ignition of an explosive atmosphere.

NOTE — The type of protection may not prevent the surrounding explosive gas atmosphere from penetrating into the equipment and components and being ignited by the circuits. However, due to the small free volumes in the filling material and due to the quenching of a flame which may propagate through the paths in the filling material, an external explosion is prevented.

**3.11 Encapsulation 'm'** — Type of protection whereby parts that are capable of igniting an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that the explosive atmosphere cannot be ignited under operating or installation conditions.

### 3.12 Electrical Supply Systems

a) *Protective Extra-Low Voltage (PELV)* — Extra-low voltage system which is not electrically separated from earth but which otherwise satisfies the requirements for SELV.

   NOTE — A 50V centre-tapped earth system is a PELV system.

b) *Safety Extra-Low Voltage (SELV)* — Extra-low voltage system (that is, normally not exceeding 50V ac or 120 V ripple-free dc) which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to an electric shock.

   NOTE — A 50V earth free system is a SELV system.

## 4 GENERAL

### 4.1 General Requirements

In order to facilitate the selection of appropriate electrical equipment and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 according to IS 5572 and based on the equipment protection level (EPL).

Electrical equipment should, as far as is reasonably practicable, be located in non-hazardous areas. Where it is not possible to do this, it should be located in a location requiring the lowest EPL.

Electrical equipment and materials should be installed and used within their electrical ratings for power, voltage, current, frequency, duty and such other characteristics where non-conformity might jeopardize the safety of the installation. In particular, care should be taken to ensure that the voltage and frequency are appropriate to the supply system with which the equipment is used and that the temperature classification has been established for the correct voltage, frequency, etc.

All electrical equipment and wiring in hazardous areas shall be selected and installed in accordance with **5** to **9** inclusive and the additional requirements for the particular type of protection (*see* **10** to **17**).

Equipment shall be installed in accordance with its documentation. Care should be taken to ensure that replaceable items, such as lamps, are of the correct type and rating. On completion of the installation, periodic inspection of the equipment and installation shall be carried out in accordance with IS/IEC 60079-17.

Installations should be designed and equipment and materials installed with a view to providing ease of access for inspection and maintenance.

NOTES

1 If luminaires with fluorescent tubes are used, then the area should be confirmed to be free from group IIC gas/vapour before tubes are transported through the area or changed, unless suitable precautions are taken to prevent tubes being broken. Low-pressure sodium lamps should not be used in any hazardous area owing to the risk of ignition from the free sodium from a broken lamp.

2 For explanation of EPLs, *see* Annex G.

### 4.2 Documentation

In order to correctly install or extend an existing installation, the following information, additional to that required for non-hazardous areas, is required, where applicable:

a) Area classification documents (*see* IS 5572);
b) Assessment of consequences of ignition;
c) Instructions for installation and connection;
d) Documents for electrical equipment with special conditions, for example, for equipment with certificate numbers which have the suffix 'X' or other suffix;
e) Descriptive system document for the intrinsically safe system (*see* **12.2.5**);
f) Necessary information to ensure correct installation of the equipment provided in a form which is suitable to the personnel responsible for this activity;
g) Information necessary for inspection, for example, list and location of equipment, spares, technical information;
h) Details of any relevant calculation, for example, for purging rates for instruments or analyzer houses; and
j) If repairs are to be carried out by the user or a repairer, information necessary for the repair of the electrical equipment (*see* IS/IEC 60079-19).

**4.3 Selection of Repaired, Second Hand or Existing Equipment**

When it is intended that existing, second hand or repaired equipment is to be installed in a new installation, it shall be only be reused if,

a) it can be verified that the equipment is unmodified and is in a condition that meets the original certification (including any repair or overhaul); and
b) any changes to equipment standards relevant to the item considered do not require additional safety precautions.

NOTES

1 The act of introducing equipment where specifications are not identical to an existing installation may cause that installation to be deemed 'new'.

2 In the situation where equipment is dual certified (for example, as intrinsically safe apparatus and independently as flameproof apparatus) care should be taken that the type of protection used for its new intended location has not been compromised by the way in which it was originally installed and subsequently maintained. Different protection concepts have different maintenance requirements. In the above example, apparatus originally installed as flameproof should only be used as flameproof unless it can be verified that there has been no damage to the safety components within the intrinsically safe circuit on which safety depends by, for example, an over-voltage at the supply terminals or if it was originally installed as intrinsically safe then a check is required to ensure that there has been no damage to the flame paths before it can be used as flameproof.

## 5 SELECTION OF ELECTRICAL EQUIPMENT (EXCLUDING CABLES AND CONDUITS)

**5.1 Specific Information**

In order to select the appropriate electrical equipment for hazardous areas, the following information is required:

a) Classification of the hazardous area;
b) Temperature class or ignition temperature of the gas or vapour involved according to **5.3**;
c) Where applicable, gas or vapour classification in relation to the group or sub-group of the electrical equipment according to **5.4**; and
d) External influences and ambient temperature.

NOTE — Of the types of protection listed in IS/IEC 60079-0, the equipment sub-group is only required for protection types 'd' (flameproof enclosures) and 'i' (intrinsic safety). The equipment sub-group is also required for certain equipment with protection types 'n' or 'o' (oil immersion) (*see* **5.4**).

**5.2 Selection According to Zones**

**5.2.1** *Equipment for Use in Zone* 0

Electrical equipment and circuits can be used in zone 0 if they are constructed in accordance with following:

**EPL 'Ga'**

a) Intrinsic safety (category 'ia') according to IS 5780/IEC 60079-11.

**5.2.2** *Equipment for Use in Zone* 1

Electrical equipment can be used in zone 1 if it is constructed in accordance with the requirements for zone 0 or one or more of the following types of protection:

**EPL 'Gb'**

a) Flameproof enclosures 'd' according to IS 2148/IEC 60079-1;
b) Pressurised enclosures 'p' according to IS 7389/IEC 60079-2;
c) Powder filling 'q' according to IS 7724/IEC 60079-5;
d) Oil immersion 'o' according to IS 7693/IEC 60079-6 (*see* Note 6 under **5.2.3**);
e) Intrinsic safety 'i' according to IS 5780/IEC 60079-11;
f) Encapsulation 'm' according to IS/IEC 60079-18; and
g) Electrical heat tracers and equipment which are certified for use in zone 1 areas.

**5.2.3** *Equipment for Use in Zone 2*

Electrical equipment can be used in zone 2 if it is constructed in accordance with the requirements for zone 0 / zone 1 or one or more of the following types of protection:

**EPL 'Gc'**

a) Non sparking 'n' according to IS/IEC 60079-15;
b) Intrinsic safety 'i' according to IS 5780/ IEC 60079-11;
c) Increased safety 'e' according to IS 6381/IEC 60079-7; and
d) Electrical heat tracers and equipment, which are certified for use in zone 2 areas.

NOTES

1 Various Indian Standards for electrical equipments for hazardous areas have been aligned with IEC Standards to facilitate manufacturers and testing bodies. However selection and installation of these equipment in hazardous areas shall follow this standard.

2 For outdoor installations, the apparatus with type of protection 'e' and 'n' should be used with enclosures providing at least the following degree of protection:

a) IP 55, where there are uninsulated conducting parts internally, and

b) IP 44 for insulated parts.

3 Annex E includes certain key features for electrical equipment meant for use in hazardous area.

4 Even though, in general, use of increased safety equipment in zone 1 area is not termitted, certain equipment having a combination of Ex i, Ex e and Ex d protection may be used in zone 1 areas, provided the Ex e protection is limited to the termination of cables / wires only.

5 Requirements of diesel engines for hazardous areas are covered in Annex F.

6 Type 'o' equipment shall not be used in zone 1 area in oil mines.

### 5.3 Selection According to the Ignition Temperature of the Gas or Vapour and Ambient Temperature

The electrical equipment shall be so selected that its maximum surface temperature will not reach the ignition temperature of any gas or vapour which may be present.

Symbols for the temperature classes which may be marked on the electrical equipment have the meaning indicated in Table 1.

**Table 1 Relationship Between Gas or Vapour Ignition Temperature and Temperature Class of Equipment**

| Sl No. | Temperature Class Required by the Area Classification | Ignition Temperature of Gas or Vapour °C | Allowable Temperature Classes of Equipment |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | T1 | >450 | T1-T6 |
| ii) | T2 | >300 | T2-T6 |
| iii) | T3 | >200 | T3-T6 |
| iv) | T4 | >135 | T4-T6 |
| v) | T5 | >100 | T5-T6 |
| vi) | T6 | >85 | T6 |

If the marking of the electrical equipment does not include an ambient temperature range, the equipment shall be used only within the temperature range -20°C to + 40 °C. If the marking of the electrical equipment includes an ambient temperature range, the equipment shall only be used within this range.

If there is an influence from an ambient temperature outside the temperature range, the process temperature or exposure to sun light, the effect on the equipment shall be verified as suitable for the application and documented.

Ambient temperatures do not consider solar radiation. Where applicable, additional factors should be applied.

Junction boxes and switches in intrinsically safe circuits, however, can be assumed to have a temperature classification of T6 because, by their nature, they do not contain heat dissipating components. Simple apparatus used within an intrinsically safe circuit shall be temperature classified in accordance with **12.2.5.2**.

Cable glands in normal service do not create a heat source and therefore do not have a temperature class or ambient operating temperature range marked on them. In general cable glands will be marked with service temperature. If no marking exists it is assumed that the service temperature is -20°C to +80°C.

NOTE — Consideration of the capability of the equipment and cables to operate in the required temperature range should include normal operating limits as well as temperature rise.

### 5.4 Selection According to Apparatus Grouping

Electrical equipment of types of protection 'e', 'm', 'p' and 'q' shall be of equipment group II. *See* Note 1 below.

Electrical equipment of types of protection 'd' and 'i' shall be of equipment group IIA, IIB or IIC and selected in accordance with Table 2.

Electrical equipment of type of protection 'n' shall normally be of equipment group II but, if it contains enclosed break devices, non-incendive components or energy limited apparatus or circuits, then the equipment shall be group IIA, IIB or IIC and selected in accordance with Table 2.

Electrical equipment of type of protection 'o' shall be of equipment group IIA, IIB or IIC for certain equipment and selected in accordance with Table 2.

**Table 2 Relationship Between Gas/Vapour Subdivision and Apparatus Subgroup**

| Sl No. | Location Gas/Vapour Subdivision | Permitted Apparatus Group or Subgroup |
|---|---|---|
| (1) | (2) | (3) |
| i) | IIA | II, IIA, IIB or IIC |
| ii) | IIB | II, IIB or IIC |
| iii) | IIC | II or IIC |

NOTES

1 There are nevertheless occasions when some of these types of protection, which are normally of equipment group II, can be allocated within subgroups IIA or IIB (to accommodate discharge of stored energy, static electricity, etc.).

2 In mixtures of hydrogen sulphide and natural gas, it is recommended that the mixture be considered as group IIA, if the hydrogen sulphide constitutes less than 25 percent of the mixture (by volume).

3 In mixtures of manufactured gases, the mixture should be considered as group IIC, if the gases contain more than 30 percent hydrogen by volume.

### 5.5 External Influences

Electrical equipment shall be selected and installed so that it is protected against external influences (for example, chemical, mechanical, vibrational, thermal, electrical and humidity), which could adversely affect the explosion protection.

Precautions shall be taken, without affecting designed ventilation conditions, to prevent foreign bodies falling vertically into the ventilation openings of vertical rotating electrical machines.

The integrity of electrical equipment may be affected, if it is operated under temperature or pressure conditions outside those for which the equipment has been constructed. In these circumstances, further advice should be sought (*see also* **5.3**).

NOTES

1 Attention is drawn to the risks that can arise when equipment subject to prolonged humidity and wide temperature variations. The equipment should be provided with suitable devices to ensure satisfactory prevention or draining of all condensate.

2 Attention is drawn to the risks that can arise when process fluids become introduced into equipment, for example, pressure switches or canned electric motor pumps. Under fault conditions, for example, a diaphragm or can failure, the fluid may be released inside the equipment under considerable pressure which may cause any or all of the following to occur:

a) rupture of the equipment enclosure;
b) risk of immediate ignition; and
c) transmission of the fluid along the inside of the cable into a non-hazardous area.

Preferably such equipment should be designed so that process fluid containment is reliably separated from the electrical equipment (for example, by use of a primary seal for the main process interface and a secondary seal internal to the equipment in case of primary seal failure). Where this is not achieved, the equipment should be vented (via a suitable explosion protected vent, drain or breather) and/or the wiring system shall be sealed to prevent the transmission of any fluid. Failure of primary seal should also be annunciated, for example, by visible leak, self-revealing failure of the equipment, audible sound or electronic detection.

Potential sealing method include, the use of a special sealing joint or a length of mineral-insulated metal-sheathed (MIMS) cable or an 'epoxy' joint should be introduced into the cable run. Venting systems should be arranged so that the occurrence of any leaks become visible.

3 Where the manufacturer has tested the enclosure to a higher degree of ingress protection (IP) than required by the type of protection (perhaps to make suitable for an adverse environment) the IP rating of the enclosure should be maintained at the IP rating requirement of the location.

**5.6 Light Metals as Construction Materials**

Particular consideration shall be given to the location of equipment that incorporate light metals in their external construction as it has been well established that such materials give rise to sparking that is incendive under conditions of frictional contact.

Light metal materials used in the construction of enclosures of electrical equipment shall be in accordance with IS/IEC 60079-0.

**5.7 Transportable, Portable and Personal Equipment**

**5.7.1** *General*

Transportable, portable and personal equipment should be used in hazardous areas only when its use cannot reasonably be avoided.

Due to the demand of the application and enhanced flexibility for use transportable, portable and personal equipment may be required to be used in differing areas. Unless the equipment is protected for the higher risk, it shall not be transferred while in operation from a hazardous area of lower risk to a hazardous area of higher risk. In practice, however, such a limitation may be difficult to enforce; particularly with respect to portable equipment. Hence it is recommended, therefore, that all portable equipment meet the requirements of the highest risk. Similarly, the equipment group and temperature classification should be appropriate for all the gases and vapours in which the equipment may be used.

Unless suitable precautions are taken, spare batteries shall not be taken into hazardous areas

**5.7.2** *Transportable and Portable Equipment*

Unless equipment which is permanently installed, transportable and portable equipment may occupy the hazardous area on a temporary basis. Such equipment may include emergency generators, electrical arc welders, industrial forklifts, air compressors, powered ventilation fans or blowers, portable electrically powered hand tools, certain type of test and inspection equipment.

Equipment that may be transported or carried into a hazardous area shall have a type of protection appropriate to the zone(s) of use. Where there is a need to use transportable or portable equipment in a hazardous area for which the required explosion protection is not obtainable, a documented programme for risk management shall be implemented. This programme shall include appropriate training, procedures and controls. A 'Control of ignition sources permit' shall be issued appropriate to the potential ignition risk created by the use of the equipment.

If plugs and sockets are present in a hazardous area, they should be suitable for use in the particular zone and have mechanical and/or electrical inter-locking to prevent an ignition source occurring during insertion or removal of the plug. Alternately, they should only be energised or connections made under a 'Control of ignition sources procedure'.

**5.7.3** *Personal Equipment*

Items of personal equipment which are battery or solar operated (for example, electronic wrist watches, hearing aids, car remote controls, key ring, torches, calculators, etc) are sometimes carried by personnel and inadvertently taken into a hazardous area.

The risk with electronic watches is small and their use in hazardous area is generally acceptable.

All other personal battery or solar operated equipment (including electronic wrist watches incorporating a calculator) should:

a) conform to appropriate type of protection or
b) be taken into the hazardous area under a 'Control of ignition sources procedure'.

NOTE — An increased risk is associated with lithium batteries which may be used to power personal electronic equipment and their use should be subjected to risk assessment.

### 5.8 Selection of Rotating Electrical Machines

**5.8.1** *General*

Rotating electrical machines are classified in accordance with IS 325 for duty cycles.

In selecting rotating electrical machines, as a minimum the following shall be considered:

a) Duty cycle;
b) Supply voltage and frequency range;
c) Heat transfer from driven equipment (for example, pump);
d) Bearing and lubricant life; and
e) Insulation class.

NOTE — For maximum motor life, the supply voltage for continuous operation should not exceed the permissible limits of variation.

**5.8.2** *Motors Fed from Converter Supply*

Selection and installations of motors supplied at varying voltage and frequency shall take into account items that may reduce the voltage at the motor terminals.

NOTES

1 A filter at the output of the converter causes a voltage drop at the terminals of the machine. The reduced voltage increases the motor current, the slip and therewith the temperature of the motor in the stator and particularly in the rotor at constant rated load conditions.

2 Major concerns on the application of motors with a converter supply include frequency spectrums of the voltage and current plus their additional losses, over-voltage effects, bearing currents and installation of high frequency earthing.

### 5.9 Luminaires

Selection of luminaires shall take account of the need to transport through, change or install lamps/tubes in a hazardous area.

NOTES

1 *Fluorescent tubes*: the area will need to be confirmed to be free from flammable concentrations of hydrogen, under a 'control of ignition sources permit', before tubes are transported through the area, changed or installed above a hazardous area, unless suitable precautions are taken to prevent tubes being broken.

2 *Low-pressure sodium lamps*: these should not be transported through a hazardous area or installed above a hazardous area owing to the risk of ignition from the free sodium from a broken lamp.

## 6 PROTECTION FROM DANGEROUS (INCENDIVE) SPARKING

### 6.1 Danger from Live Parts

In order to avoid the formation of sparks liable to ignite the explosive gas atmosphere, the possible inadvertent contact with bare live parts other than intrinsically safe parts shall be prevented.

### 6.2 Danger from Exposed and Extraneous Conductive Parts

The basic principles on which safety depends are the limitation of earth-fault currents (magnitude and/or duration) in frameworks or enclosures and the prevention of elevated potentials on equipotential bonding conductors.

Although it is impracticable to cover all possible systems, the following applies to electrical systems, other than intrinsically safe circuits, for use in zones 1 and 2 up to 1 000 V ac r.m.s./1 500 V dc.

**6.2.1** *Solidly Earthed System*

The neutral and earthed conductor shall not be connected together. Protection against detection of earth fault shall be provide.

**6.2.2** *Unearthed and High Resistance Earthed System*

The system shall be protected by a residual current device.

**6.2.3** *SELV and PELV Systems*

Safety extra-low voltage systems (SELV) shall be in accordance with 3.4.2 of IS 302-1. Live parts of SELV circuits shall not be connected to earth, or to live parts or to protective conductors forming part of other circuits. Any exposed conductive parts may be unearthed or earthed (for example, for electro-magnetic compatibility).

Protective extra-low voltages systems (PELV) shall be in accordance with 3.4.4 of IS 302-1 : 2008. PELV circuits are earthed. Any exposed conductive parts shall be connected to a common earthing (and potential equalization) system.

Safety isolating transformers for SELV and PELV shall be in accordance with IS/IEC 61558-1 and IS/IEC 61558-2-6.

**6.2.4** *Above Hazardous Areas*

Equipment that may produce hot particles or hot surfaces located less than 3.5 m above a hazardous area shall be either totally enclosed or provided with suitable guards or screens, to prevent any ignition sources falling into the hazardous area.

NOTE — Such items may include:

a) Fuses that, sparks or hot particles;
b) Switches that may produce arcs, sparks or hot particles may produce arcs;
c) Motors or generators that have sliding contacts or brushes;
d) Heaters, heating elements or other equipment that may produce arcs, sparks or hot particles;
e) Auxiliary equipment such as ballasts, capacitors and starting switches for all types of discharge luminaries; and
f) All lamps.

Low pressure sodium vapour discharge lamps shall not be installed above a hazardous area.

**6.3 Potential Equalization**

**6.3.1** *General*

Potential equalization is required for installations in hazardous areas. For earthed and unearthed power systems all exposed and extraneous conductive parts shall be connected to the equipotential bonding system. The bonding system may include protective conductors, metal conduits, metal cable sheaths, steel wire armouring and metallic parts of structures, but shall not include neutral conductors. Connections shall be secure against self-loosening and shall minimize the risk of corrosion which may reduce the effectiveness of connection.

Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and are in metallic contact with structural parts or piping which are connected to the equipotential bonding system. Extraneous conductive parts which are not part of the structure or of the electrical installation need not be connected to the equipotential bonding system, if there is no danger of voltage displacement, for example frames of doors or windows.

Cable glands which incorporate clamping devices which clamp the braiding or armour of the cable can be used to provide equipotential bonding.

Metallic enclosures of intrinsically safe or energy limited apparatus need not be connected to the equipotential bonding system, unless required by the apparatus documentation or to prevent accumulation of static charge.

Installations with cathodic protection shall not be connected to the equipotential bonding system unless the system is specifically designed for this purpose.

NOTE — Potential equalization between vehicles and fixed installations may require special arrangements, for example, where insulated flanges are used to connect pipelines.

**6.3.2** *Temporary Bonding*

Temporary bonding includes earth connections that are made to moveable items such as drums, vehicles and portable equipment for control of static electricity or potential equalization.

It is recommended that the final connection of a temporary bonding connection should be made either:

a) in a non hazardous area, or
b) using a connection that meets the EPL requirements of the location, or
c) using a documented procedure which reduces the risk of sparking to an acceptable level.

For temporary bonding the resistance between the metallic parts shall be less than 1 mega-ohms. Conductors and connections shall be durable, flexible and of sufficient mechanical strength to withstand in-service movement.

**6.4 Static Electricity**

Recommendations for avoidance of ignition of risks due to static electricity are covered in IS 7689.

**6.5 Lightning Protection**

Recommendations for avoidance of ignition of risks due to lightning are covered in IS 2309. **12.3** gives details of lightning protection requirements for Ex 'ia' apparatus installed in zone 0.

**6.6 Cathodically Protected Metallic Parts**

Cathodically protected metallic parts located in hazardous areas are live extraneous conductive parts which shall be considered potentially dangerous (especially if equipped with the impressed current method) despite their low negative potential. No cathodic protection shall be provided for metallic parts in zone 0 unless it is specially designed for this application.

NOTE — Recommendations of cathodic protection system are given in IS 8062.

**6.7 Ignition by Optical Radiation**

In the design of optical installations steps shall be taken to reduce a safe level the effects of radiation in accordance with IS/IEC 60079-28.

NOTE — Optical equipment in the form of lamps, lasers, LEDs, optical fibers etc, is increasingly used for communications, surveying, sensing and measurement. In material processing optical radiation of high irradiance is used. Often the installation is inside or close to explosive atmospheres and radiation from such equipment may pass through these atmospheres. Depending on the characteristics of the radiation it might then be able to ignite a surrounding explosive atmosphere. The presence or absence of an additional absorber significantly influences the ignition.

**6.8 Interconnection of Earthing System**

The power, lightning and static earthing systems, where they exist in the same area, should be effectively connected together to ensure as far as possible that all metal work in a particular area is at same potential under all conditions.

## 7 ELECTRICAL PROTECTION

**7.1 General**

The requirements of this clause are not applicable to intrinsically safe and energy limited circuits.

Wiring shall be protected against overload and from the harmful effects of short-circuits and earth faults.

All electrical apparatus shall be protected against the harmful effects of short-circuits and earth faults. Short-circuit and earth fault protection devices shall be such that auto-reclosing under fault conditions is prevented.

Precautions shall be taken to prevent operation of multiphase electrical equipment (for example, three phase motors) where the loss of one or more phases can cause overheating to occur. In circumstances where automatic disconnection of the electrical equipment may introduce a safety risk, which is more dangerous than that arising from the risk of ignition alone, a warning device (or devices) may be used as an alternative to automatic disconnection provided that operation of warning device (or devices) is immediately apparent so that prompt redressal action can be taken.

**7.2 Rotating Electrical Machines**

Rotating electrical machinery shall additionally be protected against overload unless it can withstand continuously the starting current at rated voltage and frequency or, in the case of generators, the short-circuit current, without inadmissible heating. The overload protective device shall be,

a) a current-dependent, time lag protective device monitoring all three phases, set at not more than the rated current of the machine, which will operate in 2 h or less at 1.20 times the set current and will not operate within 2 h at 1.05 times the set current, or;
b) a device for direct temperature control by embedded temperature sensors, or; and
c) another equivalent device.

**7.3 Transformers**

Transformers shall additionally be protected against overload unless they can withstand continuously the short-circuited secondary current at rated primary voltage and frequency without inadmissible heating or where no overload is to be expected as a result of the connected loads.

**7.4 Resistance Heating Devices**

In addition to the over current protection, and in order to limit the heating effect due to abnormal earth-fault and earth leakage currents, a residual current device (RCD) with a rated residual operating current not exceeding 100 mA shall be used. Preferences should be given to RCDs with residual operating current of 30 mA.

Resistance heating devices shall be protected against excessive surface temperature, where required. Where specified, protective measures shall be applied in accordance with the requirements of the manufacturer and relevant documentation (*see* Note 1 below).

Where protection is achieved by sensing, it shall be either:

a) the temperature of the resistance heating device or if appropriate of it's immediate surroundings, or
b) the surrounding temperature and one or more of the parameters, or
c) two or more parameters other than the temperature.

Also *see* Note 2 below.

NOTES

1 The above additional protection is not required if the resistance heating device (for example, an anti condensation heater of an electric motor) is intended to be protected by the manner in which it is installed in the electrical equipment.

2 Examples of the parameters include the level, flow, current, power consumption.

Any temperature protective device, if required, shall be independent from any operating temperature control device and de-energize the resistance-heating device either directly or indirectly. It shall be a type that has to be manually reset.

## 8 EMERGENCY SWITCH-OFF AND ELECTRICAL ISOLATION (OTHER THAN INTRINSICALLY SAFE CIRCUITS)

**8.1 Emergency Switch-Off**

For emergency purposes, at a suitable point or points outside the hazardous area, there shall be single or multiple means of switching off electrical supplies to the hazardous area.

Electrical apparatus, which must continue to operate to prevent additional danger, shall not be included in the emergency switch-off circuit; it shall be on a separate circuit.

NOTES

1 The switching devices installed in the general switchgear are normally adequate with respect to emergency switch-off facilities.

2 Emergency switch-off should consider isolation of all circuit power supply conductors including the neutral.

3 Suitable points for emergency switch-off should be assessed relevant to the site distribution, personnel on site and the nature of site operations.

### 8.2 Electrical Isolation

To allow work to be carried out safely, suitable means of isolation (for example, isolators, fuses and links) shall be provided for each circuit or group of circuits, to include all circuit conductors including neutral.

Labelling shall be provided immediately adjacent to each means of isolation to permit rapid identification of the circuit or group of circuits thereby controlled.

NOTE — There should be effective measures or procedures to prevent the restoration of supply to the apparatus whilst the risk of exposing unprotected live conductors to an explosive gas atmosphere continues.

## 9 WIRING SYSTEMS

### 9.1 General

Wiring systems shall comply fully with the relevant requirements of this clause except that intrinsically safe and energy limited installations need not comply with **9.3.1** to **9.3.5**.

### 9.2 Aluminium Conductors

Where aluminium is used as the conductor material, it shall be used only with suitable connections and, with the exception of intrinsically safe installations, shall have a cross-sectional area of at least 4 $mm^2$.

Connections shall ensure that the required creepage and clearance distances will not be reduced by the additional means, which are required for connecting aluminium conductors.

NOTES

1 Minimum creepage and clearance distances may be determined by the voltage level and/or the requirements of the type of protection.

2 Special precautions against electrolytic corrosion should be considered.

### 9.3 Cables

Cables with low tensile strength sheaths (commonly known as 'easy tear' cables) shall not be used in hazardous areas unless installed in conduit.

**9.3.1** *Cables for Fixed Wiring*

Cable for fixed wiring used in hazardous areas shall be,

a) sheathed with thermoplastic, thermosetting or elastomeric material. They shall be circular, having extruded bedding and fillers, if any shall be non-hygroscopic; or
b) mineral insulated metal sheathed; or
c) special flat cables with appropriate cable glands.

The cables may be unarmoured, braid screened, braid armoured or armoured as required. All cables shall be provided with overall outer sheath.

NOTE — Where enclosures are likely to be subjected to large variations in ambient and/or service temperature conditions, a 'pumping' action can transfer the hazardous atmosphere through cables which are not substantially compact. When such cables lie between a hazardous and non-hazardous area this may result in a flammable atmosphere being transported to the inside of, for example, control room equipment. The situation is likely to be most acute with equipment installed in a zone 0 or zone 1 location (where the presence of a hazardous atmosphere has a greater likelihood and duration). If these conditions are likely to apply, a cable sealing device (which seals between the inner sheath and the individual conductors) should be used.

**9.3.2** *Cable for Transportable and Portable Equipment*

Transportable and portable electrical apparatus shall have cables with a heavy polychloroprene or other equivalent synthetic elastomeric sheath, cables with a heavy tough rubber sheath, or cables having an equally robust construction. The conductors shall have a minimum cross-sectional area of 1.0 $mm^2$. If an electrical protective conductor is necessary, it should be separately insulated in a manner similar to the other conductors and should be incorporated within the supply cable sheath.

If, for transportable and portable electrical apparatus, a metallic flexible armour or screen is incorporated in the cable, this shall not be used as the only protective conductor. The cable should be suitable for the circuit protective arrangements, for example, where earth monitoring is used, the necessary number of conductors should be included. Where the apparatus needs to be earthed, the cable may include an earthed flexible metallic screen in addition to the PE conductor.

Portable electrical apparatus with rated voltage not exceeding 250 V to earth and with rated current not exceeding 6 A may have cables,

a) with an ordinary polychloroprene or other equivalent synthetic elastomeric sheath;
b) with an ordinary tough rubber sheath, or; and
c) with an equally robust construction.

These cables are not admissible for portable electrical apparatus exposed to heavy mechanical stresses, for example hand-lamps, foot-switches, barrel pumps, etc.

**9.3.3** *Flexible Cables*

Flexible cables in hazardous areas shall be selected from the following:

a) Ordinary tough rubber sheathed;
b) Ordinary polychloroprene sheathed;
c) Heavy tough rubber sheathed;
d) Heavy polychloroprene sheathed; and
e) Plastic insulated and of equally robust construction to heavy tough rubber sheathed flexible cables.

**9.3.4** *Non-sheathed Single Core*

Non-sheathed single core cables shall not be used for live conductors, unless they are installed inside switchboards, enclosures or conduit systems.

**9.3.5** *Overhead Lines*

Where overhead wiring with uninsulated conductors provides power or communications services to equipment in a hazardous area, it shall be terminated in a non-hazardous area and the service continued into the hazardous area with cable or conduit.

NOTE — Uninsulated conductors should not be installed above hazardous areas. Uninsulated conductors include items such as partially insulated crane conductor rail systems and low and extra-low voltage track systems.

**9.3.6** *Avoidance of Damage*

Cable systems and accessories should be installed, so far as is practicable, in positions that will prevent them being exposed to mechanical damage and to corrosion or chemical influences (for example, solvents), and to the effects of heat (*see also* **12.2.2.5** for intrinsically safe circuits).

Where exposure of this nature is unavoidable, protective measures, such as installation in conduit, shall be taken or appropriate cables selected (for example, to minimize the risk of mechanical damage, armoured, screened, seamless aluminium sheathed, mineral-insulated metal sheathed or semi-rigid sheathed cables could be used).

Where cables are subject to vibration, they shall be designed to withstand that vibration without damage.

NOTES

1 Precautions should be taken to prevent damage to the sheathing or insulating materials of PVC cables when they are to be installed at temperatures below −5°C.

2 The bend radius on the cables should be in compliance with cable manufacturer's data and be at least 8 times the diameter to prevent damage to the cable. The bend radius of the cable shall at least 25 mm from the end of the cable gland.

**9.3.7** *Cable Surface Temperature*

The surface temperature of cables shall not exceed the temperature class for the installation.

NOTES

1 Where cables are identified as having a high operating temperature of (for example, 105°C), this temperature relates to the copper temperature of the cable and not the cable sheath. Due to heat losses, it is unlikely that cable temperature will exceed T6. When high temperature cables are required, this information will be included in the certification for the equipment or in the manufacturer's recommendations.

2 Where cable glands are identified as being able to operate at elevated temperature, the current certification standards do not take account of the effects of these temperatures on the gland seals, when used in their operating position.

**9.3.8** *Flame Propagation*

Cables for external fixed wiring shall have flame propagation characteristics, which enable them to withstand the tests according to IS 10810 (Part 61) unless they are laid in earth, in sand-filled trenches / ducts or are otherwise protected against flame propagation.

**9.3.9** *Connections of Cables to Equipment*

The connection of cables to the electrical equipment shall be made in accordance with the requirements of the relevant type of protection.

Where the certificate for the cable gland has 'X' condition regarding clamping and cleating of the cable, a clamp shall be provided and placed within 300 mm of the end of the cable gland (to prevent pulling and twisting of the cable transmitting the forces to the conductor terminations inside the enclosure) where the equipment is portable the cable shall be clamped to the equipment that it is supplying.

Cable glands and/or cables shall be selected to reduce the effects of 'cold flow characteristics' of the cable.

NOTES

1 Cable employ materials, which may exhibit 'cold flow' characteristics. 'Cold flow' in cables can be described as the movement of the cable sheath under the compressive forces created by the displacement of seals in cable glands where the compressive forces applied by the seal is greater than the resistance of the cable sheath to deformation. Low smoke and/ or fire resistant cables usually exhibit significant cold flow characteristics. Cold flow could give rise to a reduction in the insulation resistance of the cable and, where reasonably practical, efforts should be made to prevent this by selection of suitable cable glands. Cable glands with tapered threads shall

not be used in enclosures having gland plates with unthreaded entries.

2 Tapered threads include NPT threads.

## 9.4 Conduit Systems

Conduits shall be provided with stopping boxes or sealing devices where it enters or leaves a hazardous area and adjacent to enclosures to maintain the appropriate degree of protection (for example, IP54) of the enclosure.

Elbows of solid types may be used for the immediate connection of conduit to the apparatus.

The conduits shall be pulled up tight at all of the threaded connections. Surface mounted conduits should be supported by spacing saddles.

In the event that the conduit is installed in a corrosive area, the conduit material shall either be corrosion resistant or the conduit shall be adequately protected against corrosion. Combinations of metals that can lead to galvanic corrosion shall be avoided.

After cables are installed in the conduit, stopping boxes shall be filled in accordance with manufacturer's instructions with a compound which does not shrink on setting and is impervious to, and unaffected by, chemicals found in the hazardous area.

All bends in conduits should be machine made and rounded so as to facilitate drawing of cables. When the conduit contains three or more cables, the total cross-sectional area of the cables, shall be not more than 40 percent of the cross-sectional area of the conduit.

Long runs of wiring enclosures shall be provided with suitable draining devices to ensure satisfactory draining of condensate. In addition, cable insulation shall have suitable water resistance.

To meet the degree of protection required by the enclosure, in addition to the use of stopping boxes, it may be necessary to seal between the conduit and the enclosure (for example, by means of a sealing washer or non-setting grease).

## 9.5 Cable Systems for Zone 0

Additional requirements for cables in an 'ia' type of protection installation are defined in **12**. Additional requirements for cables used with other types of protection according to with IS/IEC 60079-26 shall comply with the relevant protection concepts identified in the documentation.

## 9.6 Cable Systems for Zones 1 and 2

Additional requirements for cables systems for zone 1 and zone 2 are given in **10** to **17**.

## 9.7 Installation Requirements

**9.7.1** *Circuits Traversing a Hazardous Area*

Where circuits traverse a hazardous area in passing from one non-hazardous area to another, the wiring system in the hazardous area shall be appropriate to the zone(s).

**9.7.2** *Protection of Stranded Ends*

If multi-stranded and, in particular, fine-stranded conductors are employed, the ends shall be protected against separation of the strands, for example by means of cable lugs or core end sleeves, or by the type of terminal, but not by soldering alone.

The creepage distances and clearances, in accordance with the type of protection of the apparatus, shall not be reduced by the method in which the conductors are connected to the terminals.

**9.7.3** *Unused Cores*

The hazardous area end of each unused core in multi-core cables shall either be connected to earth or be adequately insulated by means of suitable terminations. Insulation by tape alone is not permitted.

**9.7.4** *Unused Openings*

Unused openings for cable glands in electrical equipment shall be closed with blanking elements suitable for the relevant type of protection. Blanking elements shall comply with IS/IEC 60079-0 and be of a type that can be removed only with the aid of tools.

**9.7.5** *Fortuitous Contact*

Except for trace-heating, fortuitous contact between the metallic armouring/sheathing of cables and pipe work or equipment containing flammable gases, vapours or liquids shall be avoided. The insulation provided by a non-metallic outer sheath on a cable will usually be sufficient to avoid this.

**9.7.6** *Jointing*

Cable runs in hazardous areas should, where practicable, be uninterrupted. Where discontinuities cannot be avoided, the joint, in addition to being mechanically, electrically and environmentally suitable for the situation, shall be;

a) made in an enclosure with a type of protection appropriate to the zone, or

b) providing the joint is not subject to mechanical stress, be 'epoxy' filled, compound-filled or sleeved with heat-shrunk tubing or cold-shrunk tubing, in accordance with the manufacturer's instructions.

Conductor connections, with the exception of those in flameproof conduit systems or intrinsically safe circuits, shall be made only by means of compression connectors, secured screw connectors, welding or brazing. Soldering is permissible, if the conductors being connected are held together by suitable mechanical means and then soldered.

**9.7.7** *Openings in Walls*

Openings in walls for cables and conduits between hazardous and non-hazardous areas shall be adequately sealed, for example by means of sand seals or mortar sealing to maintain the area classification where relevant.

**9.7.8** *Passage and Collection of Flammables*

Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions shall be taken to prevent the passage of flammable gases, vapours or liquids from one area to another and to prevent the collection of flammable gases, vapours or liquids in trenches.

Such precautions may involve the sealing of trunking, ducts or pipes. For trenches, sand filling may be used. Conduits and, in special cases, cables (for example, where there is a pressure differential) shall be sealed, if necessary, so as to prevent the passage of liquids or gases.

## 10 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'd' — FLAMEPROOF ENCLOSURES

### 10.1 General

Flameproof enclosures, with only an Ex component enclosure certificate, shall not be installed. It shall always have an apparatus certificate.

Alteration of the internal components of equipment is not permitted without re-evaluation of the equipment because conditions may be created inadvertently which lead to pressure-piling, change in temperature class, or other such issues that may invalidate the certificate.

Equipments marked for a specific gas, or marked for an apparatus group plus a specific gas, and used in that specific gas atmosphere shall be installed in accordance with the requirements of the apparatus group in which the specific gas belongs. For example apparatus marked 'IIB + $H_2$' and used in hydrogen atmosphere shall be installed as IIC apparatus.

### 10.2 Solid Obstacles

When installing equipment, care shall be exercized to prevent the flameproof flange joint approaching nearer than the distance specified in Table 3 to any solid obstacle which is not part of the equipment, such as steelwork, walls, weather guards, mounting brackets, pipes or other electrical equipment, unless the equipment has been tested at a smaller distance of separation and has been documented.

**Table 3 Minimum Distance of Obstruction from the Flameproof Flange Joints Related to the Gas/Vapour Subgroup of the Hazardous Area**

| Sl No. | Gas/Vapour Subgroup | Minimum Distance mm |
|---|---|---|
| (1) | (2) | (3) |
| i) | IIA | 10 |
| ii) | IIB | 30 |
| iii) | IIC | 40 |

### 10.3 Protection of Flameproof Joints

Protection against corrosion of flameproof joints shall be maintained in accordance with manufacturer's documentation. The use of gaskets is only permissible when specified in manufacturer's documentation.

Flameproof joints shall not be painted.

Painting (by the user) of the enclosure after complete assembly is permitted. The application of grease to the flameproof joint faces will reduce, but not eliminate, the quantity of paint penetrating the gap. Where the manufacturer's documentation does not address joint protection, then only non-setting grease or anti-corrosive agents without evaporating solvents shall be used.

NOTES

1 Silicone based greases are often suitable for this purpose but care needs to be taken concerning use with gas detectors. It cannot be too strongly emphasized that extreme care should be exercised in the selection and application of these substances to ensure the retention of the non-setting characteristics and to allow subsequent separation of the joint surfaces.

2 Non-hardening grease-bearing textile tape may be employed outside of a straight flanged joint with the following conditions:

a) where the enclosure is used in conjunction with gases allocated to group IIA — the tape should be restricted to one layer surrounding all parts of the flange joint with a short overlap, new tape should be applied whenever existing tape is disturbed;

b) where the enclosure is used in conjunction with gases allocated to group IIB — the gap between the joint surfaces should not exceed 0.1 mm, irrespective of the flange width. The tape should be restricted to one layer surrounding all parts of the flange joint with a short overlap. New tape should be applied whenever existing tape is disturbed; and

c) where the enclosure is used in conjunction with gases allocated to group IIC — tape should not be applied.

### 10.4 Cable Entry Systems

**10.4.1** *General*

It is essential that cable entry systems comply with all the requirements referred to in the appropriate equipment standard and documentation, that the cable gland is appropriate to the type of cable employed, maintains the respective method of protection and is in accordance with **9**.

Where cables enter into flameproof equipment *via* flameproof bushings through the wall of the enclosure, which are part of the equipment (indirect entry), the parts of the bushings outside the flameproof enclosure will be protected in accordance with one of the types of protection listed in IS/IEC 60079-0. For example, the exposed parts of the bushings are within a terminal compartment which may either be another flameproof enclosure or will be protected by protection type 'e'. Where the terminal compartment is Ex 'd', then the cable system shall comply with **10.4.2**. Where the terminal compartment is Ex 'e', then the cable system shall comply with **11.2**.

Where cables enter into flameproof apparatus directly, the cable system shall comply with **10.4.2**.

Flameproof cable glands having cylindrically threads may be fitted with a sealing washer between the entry device and the flameproof enclosure providing that after the washer has been fitted, the applicable thread engagement is still achieved. Thread engagement shall be five full threads or 8 mm, whichever is the greater. Alternatively a threaded sealant may be used provided the sealant is non-setting and care is taken to ensure that any earthing between the two is maintained.

Where taper threads are used the connection shall be made wrench tight.

Additional holes shall not be made into flameproof enclosures.

Where the cable entry threads or hole size is different to that of the cable gland, a flameproof threaded adapter may be fitted which complies with thread engagement requirement detailed above. Not more than one adapter can be fitted into the cable entry.

Unused cable entries must be sealed with a flameproof blanking element complying with IS 2148/ IEC 60079-1. The blanking element must be fitted in the wall of the enclosure and not in any adapters and comply with thread engagement requirement detailed above.

NOTES

1 The use of aluminium conductors in Ex 'd' flameproof enclosures should be avoided in those cases where a fault leading to potentially severe arcing involving the conductors may occur in the vicinity of a plain flanged joint. Adequate protection may be afforded by conductor and terminal insulation that prevents the occurrence of faults or by using enclosures with spigot or threaded joints.

2 Gas or vapour leakage and propagation of flames may occur through the interstices between the strands of standard stranded conductors, or between individual cores of a cable. Special constructions can be employed as means of reducing leakage and preventing the propagation of flames. Examples include compacted strands, sealing of the individual strands, and extruded bedding.

**10.4.2** *Selection of Cable Glands*

The cable entry system shall comply with one of the following:

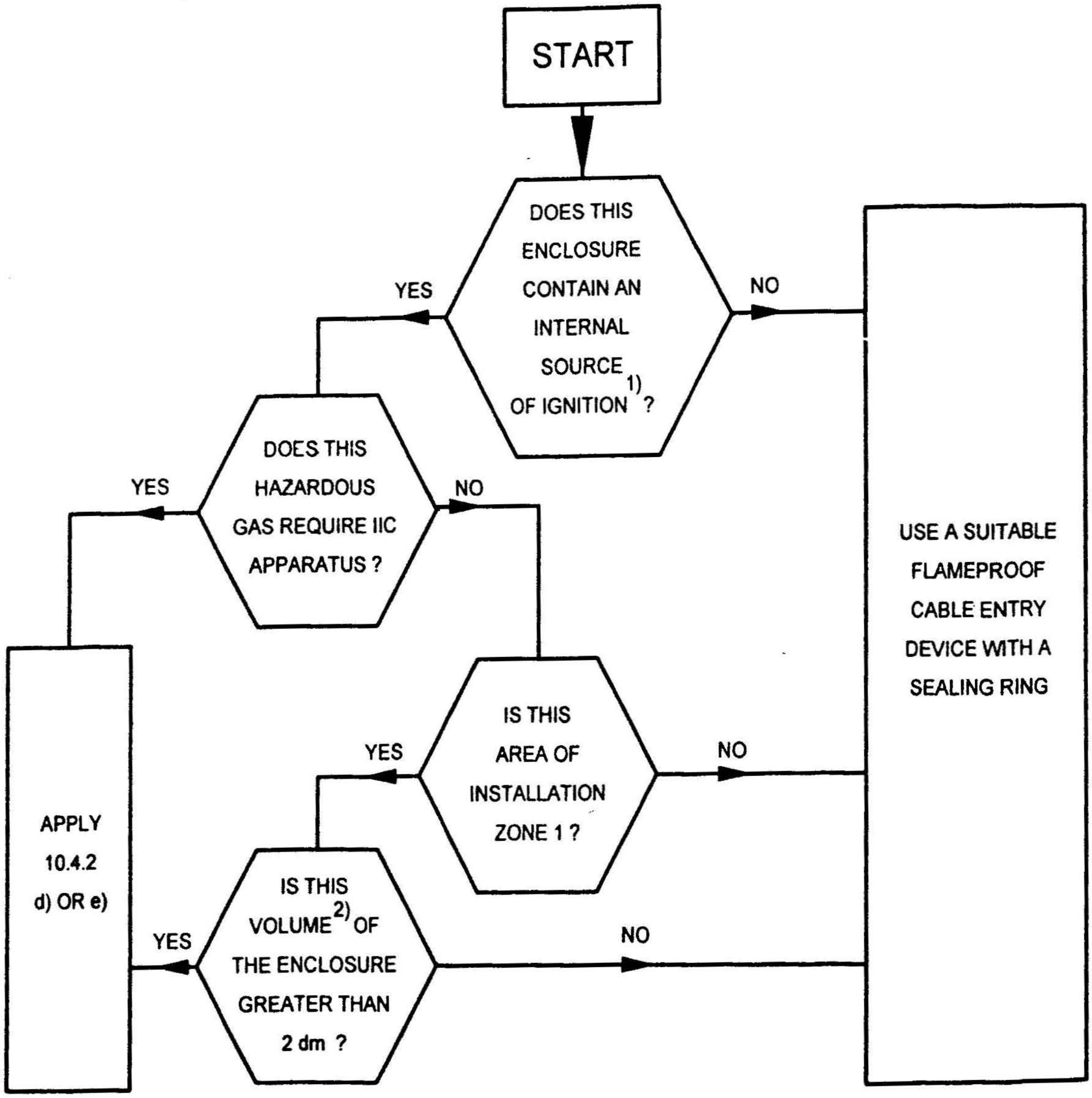
a) Cable entry device in compliance with IS 2148/IEC 60079-1 and certified as part of the equipment when tested with a sample of the particular type of cable;
b) Where a cable, in compliance with **9.3.1** is substantially compact, a flameproof cable gland may be utilised, providing this incorporates a sealing ring and is selected in accordance with Fig. 1 (*see* Note below);
c) Mineral-insulated metal sheathed cable with or without plastic outer covering with appropriate flameproof cable gland;
d) Flameproof sealing device (for example, a stopping box or sealing chamber) specified in the apparatus documentation or having component approval and employing cable entry devices appropriate to the cables used. The sealing devices such as stopping boxes or sealing chambers shall incorporate compound or other appropriate seals which permit stopping around individual cores. Sealing devices shall be fitted at the point of entry of cables to the equipment;
e) Flameproof cable gland, specific in the apparatus documentation or having a component approval, incorporating compound filled seals or elastomeric seals that seal around the individual cores or other equivalent sealing arrangements; and
f) Other means which maintain the integrity of the flameproof enclosure.

NOTE — Compliance with Fig. 1 is not necessary if the cable gland complies with IS 2148/IEC 60079-1 and has been tested with a sample specific cable and subjected to repeated ignitions of the flammable gas present in an enclosure and if these tests show no ignition.

**10.5 Conduit Systems**

Conduits where used shall be selected from the following:

a) Screwed heavy gauge steel, solid drawn or seam welded; conforming to IS 9537 (Part 2); or
b) Flexible conduit of metal or composite material construction (for example, metal conduit with




[1] Internal sources of ignition include sparks or equipment temperatures occurring in normal operation, which can cause ignition. An enclosure containing terminals only or an indirect entry enclosure (*see* **10.4.1**) is considered not to constitute an internal source of ignition.

[2] The term 'volume' is defined in IS 2148/IEC 60079-1.

FIG. 1 SELECTION CHART FOR CABLE ENTRY DEVICES INTO FLAMEPROOF ENCLOSURES FOR CABLES COMPLYING WITH ITEM (b) OF **10.4.2**

a plastic or elastomer jacket), of heavy or very heavy mechanical strength classification.

NOTE — Screwed steel conduit systems shall not be used where vibrations may cause fracture or loosening of joints or where excessive stress may be imposed as a result of its rigidity or where corrosion or excessive internal condensation of moisture is likely to occur.

A minimum of five threads shall be provided on the conduit to permit the engagement of five threads between the conduit and flameproof enclosure, or conduit and coupling. The tolerance class of the conduit thread shall be 6 g.

Stopping boxes shall be provided in the enclosure, on the wall or not more than 50 mm from the wall of flameproof enclosures to limit the pressure piling effect and to prevent hot gases from entering the conduit system from an enclosure containing a source of ignition.

Where the enclosure is specifically designed for connection to wiring in conduits but is required to be connected by cables, then a flameproof adapter, complete with bushings and terminal box, may be connected to the conduit entry of the enclosure with a length of conduit which is as short as reasonably practicable and not longer than 50 mm. The cable can then be connected to the terminal box (for example flameproof or increased safety) according to the requirements of the type of protection of the terminal box.

Blanking elements should be connected directly to the conduit entry of the enclosure.

**10.6 Motors**

**10.6.1** *Motors with a Converter Supply*

Motors supplied at varying frequency and voltage by a converter supply require either;

a) the motor has been type-tested for this duty as a unit in association with the converter specified in the descriptive documents according to IS/IEC 60079-0 and with the protective device provided, or

b) the motor has not been type-tested for this duty as a unit in association with the converter. In this case means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided. The effectiveness of the temperature control taking into account power, speed range, torque and frequency for the duty required shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTES

1 In some cases, the highest surface temperature occurs on the motor shaft.

2 A current-dependent time lag protective device in accordance with **7.2**(a) is not to be regarded as an 'other effective measure'.

3 For motors with protection type 'e' terminal boxes, when using converters with high-frequency pulses in the output, care should be taken to ensure that any over voltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

**10.6.2** *Reduced Voltage Starting (Soft Starting)*

Motors with soft start supply require either;

a) the motor has been type-tested for this duty as a unit in association with the soft start device specified in the descriptive documents according to IS/IEC 60079-0 and with the protective device provided, or

b) the motor has not been type-tested as a unit in association with the soft start device. In this case means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided or the speed control device ensures that the run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTES

1 It is considered that soft starting is under a short time period.

2 For motors with type of protection 'e' terminal boxes, when using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any over voltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

**10.7 Luminaires**

Luminaires with fluorescent lamps and electronic ballasts shall not be used where temperature class T5 or T6 is required or where the ambient temperature exceeds 60°C.

## 11 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'e' — INCREASED SAFETY

**11.1 Degree of Protection of Enclosures (IS 4691 and IS 12063)**

Enclosures containing bare live parts will have a degree of protection of at least IP54, whereas enclosures containing insulated parts only will have a degree of protection of at least IP44.

**11.2 Wiring Systems**

**11.2.1** *General*

Cables and conduits shall be installed in accordance with **9** and the following additional requirements concerning cable entries and conductor terminations.

Additional cable entry may be made into the enclosure provided; this is permitted by the manufacturer's documentation.

NOTES

1 Threaded holes in plastic enclosures should be at right angles to the face of the enclosure (due to the possible moulding methods for plastic enclosures, the wall of the enclosure may have draw angles which would not allow the gland or fitting inserted in the threaded hole to fit square to the face, resulting in ineffective sealing).

2 Taper threaded holes in plastic enclosures are not

recommended due to the high stresses created during sealing of these threads which may fracture the enclosure wall.

**11.2.2** *Cable Glands*

The connection of cables to increased safety equipment shall be effected by means of cable glands appropriate to the type of cable used. They shall comply with the requirement of IS/IEC 60079-0.

NOTES

1 To meet the ingress protection requirement it may also be necessary to seal between the cable glands and the enclosure (for example, by means of a sealing washer or thread sealant).

2 In order to meet the minimum requirement of IP54, threaded cable entry devices into threaded cable entry plates or enclosures of 6 mm or greater thickness need no additional sealing between the cable entry device and the entry plate or enclosure providing the axis of the cable entry device is perpendicular to the external surface of the cable entry plate or enclosure.

Where mineral-insulated metal-sheathed cables are used, the requirement to achieve creepage distances shall be maintained by using an Ex 'e' mineral; insulated cable sealing device.

Approved threaded adapters may be fitted into the cable entry holes to allow connection of the device or cable gland.

Unused entries in the enclosure shall be sealed by an approved stopping plug or a stopping plug, which is listed on the equipment documentation.

**11.2.3** *Conductor Terminations*

Some terminals, such as slot types, may permit the entry of more than one conductor. Where more than one conductor is connected to the same terminal, care shall be taken to ensure that each conductor is adequately clamped. Unless permitted by the documentation supplied with the equipment, two conductors of different cross-sectional area shall not be connected into one terminal unless they are first secured with a single compression type ferrule or other method specified by the manufacturer.

To avoid the risk of short-circuits between adjacent conductors in terminal blocks; the insulation of each conductor shall be maintained up to the metal of the terminal.

NOTE — Where single screw saddle clamps are used with a single conductor, the latter should be shaped around the screw in the form of a 'U' unless clamping of single conductors without 'U' is permitted in the documentation supplied with the equipment.

**11.2.4** *Combinations of Terminals and Conductors for General Connection and Junction Boxes*

Care shall be taken to ensure that the heat dissipated within the enclosure does not result in temperatures in excess of the required equipment temperature class. This can be achieved by:

a) following the guidance given by the manufacturer relating to the permissible number of terminals, the conductor size and the maximum current, or
b) checking that the calculated dissipated power, using parameters specified by the manufacturer, is less than the rated maximum dissipated power.

NOTES

1 The length of the conductors inside the enclosure should not exceed the diagonal length of the enclosure as this is the basis of calculations and type tests. Additional lengths of the conductors inside the enclosure running at maximum permitted current may give rise to increased internal temperature that may exceed the temperature class.

2 Bunching of more than 6 conductors may also give rise to high temperatures that may exceed T6 and/or damage to the insulation and should be avoided.

**11.3 Cage Induction Motors**

**11.3.1** *Mains Operated*

In order to meet the requirements of **7.2**(a), inverse-time delay overload protective devices shall be such that not only is the motor current monitored, but the stalled motor will also be disconnected within the time $t_E$ stated on the marking plate. The current-time characteristic curves giving the delay time of the overload relay or release as a function of the ratio of the starting current to the rated current shall be held by the user.

The curves will indicate the value of the delay time from the cold state related to an ambient temperature as per applicable standard and for a range of starting current ratios ($I_A/I_N$) of at least 3 to 8. The tripping time of the protective devices shall be equal to these values of delay ±20 percent.

The properties of delta wound machines in the case of the loss of one phase should be specifically addressed. Unlike star wound machines, the loss of one phase may not be detected, particularly if it occurs during operation. The effect will be current imbalance in the lines feeding the machine and increased heating of the motor. A delta wound motor with a low torque load during start-up might also be able to start under this winding failure condition and therefore the fault may exist undetected for long periods. Therefore, for delta wound machines, phase imbalance protection shall be provided which will detect machine imbalances before they can give rise to excessive heating effects.

In general, motors designed for continuous operation, involving easy and infrequent starts which do not produce appreciable additional heating, are acceptable with inverse-time delay overload protection. Motors designed for arduous starting conditions or which are to be started frequently are acceptable only when suitable protective devices ensure that the limiting temperature is not exceeded.

Arduous starting conditions are considered to exist if an inverse-time delay overload protective device, correctly selected as above, disconnects the motor before it reaches its rated speed. Generally, this will happen if the total starting time exceeds 1.7 $t_E$.

NOTES

1 *Operation* — Where the duty of the motor is not S1 (continuous operation at constant load), the user should obtain the appropriate parameters for the determination of suitability given a definition of operation.

2 *Starting* — It is preferred that the direct on-line starting time for the motor is less than the $t_E$ time so that the motor protection device does not trip the motor during start-up. Where the starting time exceeds 80 percent of the $t_E$ time, the limitations associated with starting whilst maintaining operation within the machine certification should be ascertained from the motor manufacturer.

As the voltage dips during a direct on-line start, the starting current decreases and the run-up time increases. Although these effects may tend to cancel out for small voltage dips, for voltages less than 85 percent of $U_N$ during start-up, the motor manufacturer should declare the associated limitations on start-up.

Motors may be limited by the manufacture to a fixed number of start attempts from a running temperature condition.

3 *Protection relay* — The protection relay for machines in accordance with type of protection 'e' should, in addition to the requirements of 7,

a) monitor the current in each phase; and

b) provide close overload protection to the fully loaded condition of the motor.

Inverse-time delay overload protection relays may be acceptable for machines of duty type S1 which have easy and infrequent starts. Where the starting duty is arduous or starting is required frequently, the protection device should be selected so that it ensures limiting temperatures are not exceeded under the declared operational parameters of the machine. Where the starting time exceeds 1.7$t_E$, an inverse-time relay would be expected to trip the machine during start-up.

Under some circumstances, for example, for duty types other than S1, the motor may be certified with the temperature detection and protection. If this is the case, the $t_E$ time may not be identified (*see* **11.2.2** for additional information).

**11.3.2** *Winding Temperature Sensors*

In order to meet the requirements of **7.2**(b), winding temperature sensors associated with protective devices shall be adequate for the thermal protection of the machine even when the machine is stalled. The use of embedded temperature sensors to control the limiting temperature of the machine is only permitted if such use is specified in the machine documentation. The type of built-in temperature sensors and associated protective device will be identified on the machine.

**11.3.3** *Machines with Rated Voltage More Than 1 kV*

Machines with rated voltage exceeding 1kV shall be selected taking into account the 'potential stator winding discharge risk assessment — ignition risk factors' in IS 6381/IEC 60079-7. If the total sum of the risk factors is greater than 6.

a) anti-condensation space heaters shall be employed, and
b) either the machine is tested in accordance with IS 6381/IEC 60079-7 or special measures shall be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

NOTES

1 If the machine is intended to operate under special measures, the certificate shall have the symbol 'x' in accordance with IS/IEC 60079-0.

2 Special measures may include pre-start ventilation, the application of fixed gas detection inside the machine or other methods specified in manufacturer's instructions.

**11.3.4** *Motors with Converter Supply*

Motors supplied at varying frequency and voltage by a converter shall have been type tested for this duty as a unit in association with the converter specified in the descriptive documents according to IS/IEC 60079-0 and with the protective device provided or shall be evaluated in accordance with IS 6381/IEC 60079-7.

**11.3.5** *Reduced Voltage Starting (Soft Starting)*

Motors with soft start supply require either;

a) the motor has been tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) the motor has not been tested as a unit in association with the soft start device. In this case means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor shall be provided or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTES

1 It is considered that soft starting is used for a short time period.

2 When using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any over voltage

spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

### 11.4 Luminaires

Luminaires with fluorescent lamps and electronic ballasts shall not be used where temperature class T5 or T6 is required or where the ambient temperature exceeds 60°C.

Lamps (for example, bi-pins, screw connections on tungsten lamps) using non-conductive materials with a conductive coating shall not be used unless tested with the equipment.

NOTE — This requirement is intended to apply to recently designed lamps where the pins or end caps may be plastic or ceramic with a conductive film coating.

## 12 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'i' — INTRINSIC SAFETY

### 12.1 Introductory Remark

A fundamentally different installation philosophy has to be recognized in the installation of intrinsically safe circuits. In comparison with all other types of installations, where care is taken to confine electrical energy to the installed system as designed so that a hazardous environment cannot be ignited, the integrity of an intrinsically safe circuit has to be protected from the intrusion of energy from other electrical sources so that the safe energy limitation in the circuit is not exceeded, even when breaking, shorting or earthing of the circuit occurs.

As a consequence of this principle, the aim of the installation rules for intrinsically safe circuits is to maintain separation from other circuits. Unless otherwise stated, requirements for intrinsically safe circuits shall apply to all levels of protection ('ia', 'ib' and 'ic').

Energy-limited circuits 'nL' shall comply with all the requirements for intrinsically safe circuits 'ic'.

### 12.2 Zone 1 and Zone 2 Installations

**12.2.1** *Equipment*

In zone 1 installations, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IS 5780/IEC 60079-11, at least to level of protection 'ib'.

In Zone 2 locations, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IS 5780/IEC 60079-11, at least to level of protection 'ic'.

Simple apparatus need not be marked, but shall comply with the requirements of IS/IEC 60079-0 and IS 5780/ IEC 60079-11 in so far as intrinsic safety is respectively is dependent on them.

Associated apparatus should preferably be located outside the hazardous area or, if installed inside a hazardous area, shall be provided with another appropriate type of protection in accordance with **5.2** which is suitable for the ignition sources which the associated apparatus may present.

Electrical equipment connected to the non-intrinsically safe terminals of an associated apparatus shall not be fed with a voltage supply greater than $U_m$ shown on the label of the associated apparatus. The prospective short-circuit current of the supply shall not be greater than 1 500 A.

Where $U_m$ marked on the associated apparatus is less than 250V it shall be installed in accordance with one of the following:

a) Where $U_m$ does not exceed 50 V ac or 120 V dc, in an SELV or PELV system, or
b) *Via* a safety isolating transformer complying with the requirements of IS/IEC 61558-2-6 or technically equivalent standard, or
c) Directly connected to apparatus complying with IS 13252 or a technically equivalent standard, or
d) Fed directly from cells or batteries.

NOTE — Limitation of the prospective short circuit current, where higher fault levels exist, may be achieved by appropriate upstream fusing or protection.

In order to protect against unauthorized interference and damage, the components and wiring of intrinsically safe apparatus and associated apparatus (for example, barriers) should normally be mounted in enclosures offering a degree of protection of at least IP20 unless a higher IP rating is required by the apparatus documentation. Alternative methods of mounting may be used, if they offer similar integrity against interference and damage (for example, mounted in racks in a normally locked switch-room).

All apparatus forming part of an intrinsically safe system should, where reasonably practicable, be identifiable as being part of an intrinsically safe system. This recommendation may be met by conformity with **12.2.2.6**.

**12.2.2** *Cables*

**12.2.2.1** *General*

Only insulated cables whose conductor-earth, conductor-screen and screen-earth test voltages are at least 500 V ac or 750 V dc shall be used in intrinsically safe and energy limited circuits.

The diameter of individual conductors within the area subject to explosion hazards shall be not less than

0.1 mm. This applies also to the individual wires of a finely stranded conductor.

**12.2.2.2** *Electrical parameters of cables*

The electrical parameters ($C_c$ and $L_c$) or ($C_c$ and $L_c/R_c$) for all cables used (*see* **12.2.5**) shall be determined according to the following:

a) The most onerous electrical parameters provided by the cable manufacturer;
b) Electrical parameters determined by measurement of a sample; and
c) 200 pF/m and either 1 µH/m or 30 µH/Ω where the interconnection comprises two or three cores of a conventionally constructed cable (with or without screen).

NOTE — Annex C details a satisfactory method of determining the relevant parameters.

Where FISCO or FNICO system is used, the requirements for cable parameters shall comply with IS/IEC 60079-27.

**12.2.2.3** *Earthing of conducting screens*

Where a screen is required, except as in (a) through (c) below, the screen shall be electrically connected to earth at one point only, normally at the non-hazardous area end of the circuit loop. This requirement is to avoid the possibility of the screen carrying a possibly incendive level of circulating current in the event that there are local differences in earth potential between one end of the circuit and the other.

If an earthed intrinsically safe circuit is run in a screened cable, the screen for that circuit should be earthed at the same point as the intrinsically safe circuit, which it is screening.

If an intrinsically safe circuit or sub-circuit which is isolated from earth is run in a screened cable, the screen should be connected to the equipotential bonding system at one point.

Special cases:

a) If there are special reasons (for example, when the screen has high resistance, or where screening against inductive interference is additionally required) for the screen to have multiple electrical connections throughout its length, the arrangement of Fig. 2 may be used, provided that
   1) insulated earth conductor is of robust construction (normally at least 4 mm$^2$ but 16 mm$^2$ may be more appropriate for clamp type connections),
   2) arrangement of the insulated earth conductor plus the screen is insulated to withstand a 500 V insulation test from all other conductors in the cable and any cable armour,
   3) insulated earth conductor and the screen are only connected to earth at one point which shall be the same point for both the insulated earth conductor and the screen, and would normally be at the non-hazardous end of the cable,
   4) insulated earth conductor complies with **9.1.2**, and
   5) inductance/resistance ratio (L/R) of the cable, installed together with the insulated earth conductor, shall be established and shown to conform to the requirements of **12.2.5**.
b) If the installation is effected and maintained in such a manner that there is a high level of assurance that potential equalisation exists between each end of the circuit (that is, between the hazardous area and the non-hazardous area), then, if desired, cable screens may be connected to earth at both ends of the cable and, if required, at any interposing points.
c) Multiple earthing through small capacitors (for example, 1 nF, 1 500 V ceramic) is acceptable provided that the total capacitance does not exceed 10 nF.

**12.2.2.4** *Cable armour bonding*

Armour should normally be bonded to the equipotential bonding system *via* the cable entry devices or equivalent, at each end of the cable run. Where there are interposing junction boxes or other equipment, the armour will normally be similarly bonded to the equipotential bonding system at these points. In the event that armour is required not to be bonded to the equipotential bonding system at any interposing point, care should be taken to ensure that the electrical continuity of the armour from end to end of the complete cable run is maintained.

Where bonding of the armour at a cable entry point is not practical, or where design requirements make this not permissible, care should be taken to avoid any potential difference which may arise between the armour and the equipotential bonding system giving rise to an incendive spark. In any event, there shall be at least one electrical bonding connection of the armour to the equipotential bonding system. The cable entry device for isolating the armour from earth shall be installed in the non-hazardous area or zone 2.

**12.2.2.5** *Installation of cables and wiring*

Installations with intrinsically safe circuits shall be

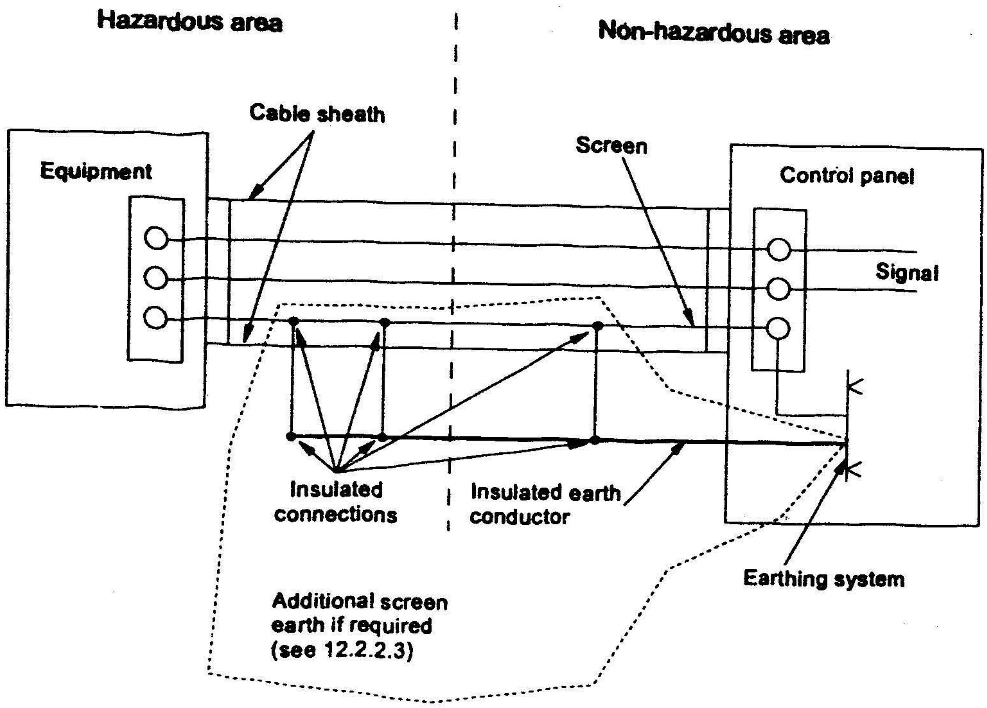



FIG. 2 EARTHING OF CONDUCTING SCREENS

erected in such a way that their intrinsic safety is not adversely affected by external electric or magnetic fields such as from nearby overhead power lines or heavy current-carrying single core cables. This can be achieved, for example, by the use of screens and/or twisted cores or by maintaining an adequate distance from the source of the electric or magnetic field.

In addition to the cable requirements of **9.3.6**, cables in both hazardous and non-hazardous areas shall be installed so as to ensure that intrinsically safe circuit cables cannot be inadvertently connected to circuit cables, which are not intrinsically safe.

This may be achieved by,

a) Separating the different type of circuit cables; or
b) Placing the cables so as to protect against the risk of mechanical damage; or
c) Using cables which are armoured, metal sheathed or screened for specific type of circuits (for example, all circuits which are not intrinsically safe are run in armoured cables).

Conductors of intrinsically safe circuits and non-intrinsically safe circuits shall not be carried in the same cable (*see* **12.4**).

Conductors of intrinsically safe and non-intrinsically safe circuits except as permitted in **12.2.2.7**, shall not be in the same bundle or duct as conductors of circuits which are not intrinsically safe, unless separated by an intermediate layer of insulating material or by an earthed metal partition. No separation is required, if metal sheaths or screens are used for the intrinsically safe circuits or circuits which are not intrinsically safe.

Each unused core in a multi-core cable should either,

a) be adequately insulated from earth and from each other at both ends by the use of suitable terminations, or
b) if other circuits in the multicore have an earth connection (for example, *via* the associated apparatus), be connected to the earth point used to earth any intrinsically safe circuits in the same cable, but should be adequately insulated from earth and from each other by the use of suitable terminations at the other end.

**12.2.2.6** *Marking of cables*

Cables containing intrinsically safe circuits shall be marked (except as below) to identify them as being a part of an intrinsically safe circuit. If sheaths or coverings are marked by a colour, the colour used for cable containing intrinsically safe circuits shall be light blue. Where intrinsically safe circuits have been identified by the use of light blue covered cable, then light blue covered cable shall not be used for other purposes in a manner or location which could lead to confusion or detract from the effectiveness of the identification of intrinsically safe circuits.

If all intrinsically safe circuit cables or all cables of circuits which are not-intrinsically safe are armoured, metal sheathed or screened, then marking of intrinsically safe cables is not required.

Alternative marking measures shall be taken inside measuring and control cabinets, switchgear, distribution equipment, etc, where there is a risk of confusion between cables of intrinsically safe and non-intrinsically safe circuits, in the presence of a blue neutral conductor. Such measures include,

a) combining the cores in a common light blue harness;
b) labelling; and
c) clear arrangement and spatial separation.

**12.2.2.7** *Multi-core cables containing more than one intrinsically safe circuit*

The requirements of this sub clause are in addition to those of **12.2.2.1** to **12.2.2.6**.

Multi-core cables may contain more than one intrinsically safe circuit but intrinsically safe 'ia' or 'ib' circuit. Intrinsically safe 'ic' circuits may only be run in a multicore cables if the multicore cable is Type A or Type B. Circuits which are not intrinsically safe shall not be carried in the same multicore as intrinsically safe circuit (*see* **12.4**).

The radial thickness of the conductor insulation shall be appropriate to the conductor diameter and the nature of the insulation. The minimum radial thickness shall be 0.2 mm.

The conductor insulation shall be such that it will be capable of withstanding an r.m.s. ac test voltage of twice the nominal voltage of the intrinsically safe circuit with a minimum of 500 V.

Multi-core cables shall be of a type capable of withstanding a dielectric test of at least

a) 500 V r.m.s. ac or 750 V dc applied between any armouring and/or screen(s) joined together and all the cores joined together, and
b) 1 000 V r.m.s. ac or 1 500 V dc applied between a bundle comprising one half of the cable cores joined together and a bundle comprising the other half of the cores joined together. This test is not applicable to multi-core cables with conducting screens for individual circuits.

The voltage tests shall be carried out by a method specified in an appropriate cable standard. Where no such method is available, the tests shall be carried out in accordance with IS 5780/IEC 60079-11.

**12.2.2.8** *Fault considerations in multi-core cables*

The faults, if any, which shall be taken into consideration in multi-core cables used in intrinsically safe electrical systems depend upon the type of cable used.

a) *Type A*

   For cables complying with the requirements of **12.2.2.7** and, in addition, with conducting screens providing individual protection for intrinsically safe circuits in order to prevent such circuits becoming connected to one another, coverage of such screens shall be at least 60 percent of the surface area. No faults between circuits are taken into consideration.
b) *Type B*

   Cable which is fixed, effectively protected against damage, complying with the requirements of **12.2.2.7** and, in addition, no circuit contained within the cable has a maximum voltage $U_o$ exceeding 60 V. No faults between circuits are taken into consideration.
c) *Others*

   For cables complying with the requirements of **12.2.2.7** but not the additional requirements of Type A or Type B, it is necessary for 'ia' and 'ib' to take into consideration up to two short-circuits between conductors and, simultaneously, up to four open circuits of conductors. In the case of identical circuits, failures shall not be taken into consideration provided that each circuit passing through the cable has a safety factor of four times that required for category 'ia' or 'ib'.

**12.2.3** *Termination of Intrinsically Safe Circuits*

Terminals for intrinsically safe circuits shall be separated from terminals of circuits which are not intrinsically safe by one of the methods given below:

a) When separation is accomplished by distance, then the clearance between terminals shall be at least 50 mm. Care shall be exercised in the layout of terminals and in the wiring method used so that contact between circuits is unlikely, if a wire becomes dislodged.
b) When separation is accomplished by use of an insulating partition or earthed metal partition, the partitions used shall extend to within 1.5 mm of the walls of the enclosure,

or alternatively provide a minimum measurement of 50 mm between the terminals when taken in any direction around the partition.

The minimum clearances between the bare conducting parts of external conductors connected to terminals and earthed metal or other conducting parts shall be 3 mm.

The clearance between the bare conducting parts of terminals of separate intrinsically safe circuits shall be such that there is at least 6 mm between the bare conducting parts of connected external conductors.

The terminals of the intrinsically safe circuits shall be marked as such.

NOTES

1 This marking may be by the use of colour, in which case it shall be light blue.

Plugs and sockets used for connection of external intrinsically safe circuits shall be separate from, and non-interchangeable with, those of circuits which are not intrinsically safe. Where the apparatus is fitted with more than one plug and socket for external connections and interchange could adversely affect the type of protection, such plugs and sockets shall either be arranged so that interchange is not possible, for example, by keying, or mating plugs and sockets shall be identified, for example, by marking or colour coding, to make interchange obvious (*see* **12.4**).

2 Where a connector carries earthed circuits and the type of protection depends on the earth connection, then the connector shall be constructed in accordance with the requirements given in IS 5780/IEC 60079-11 relating to earth conductors, connections and terminals.

**12.2.4** *Earthing of Intrinsically Safe Circuits*

Intrinsically safe circuits may be either;

a) isolated from earth, or
b) connected at one point to the equipotential bonding system, if this exists over the whole area in which the intrinsically safe or energy limited circuits are installed.

The installation method shall be chosen with regard to the functional requirements of the circuits and in accordance with the manufacturer's instructions.

More than one earth connection is permitted on a circuit, provided that the circuit is galvanically separated into sub circuits, each of which has only one earth point.

In intrinsically safe circuits which are isolated from earth, attention shall be paid to the danger of electrostatic charging. A connection to earth across a resistance of between 0.2MW and 1MW, for example for the dissipation of electrostatic charges, is not deemed to be earthing.

Intrinsically safe circuits shall be earthed, if this is necessary for safety reasons, for example in installations with safety barriers without galvanic isolation. They may be earthed if necessary for functional reasons, for example with welded thermocouples. If intrinsically safe apparatus does not withstand the electrical strength test with at least 500V ac r.m.s. to earth according to IS 5780/ IEC 60079-11, a connection to earth for the apparatus is to be assumed.

Where the equipment is earthed (for example, by the method of mounting) and a bonding conductor is used between the equipment and the point of earth connection of the associated apparatus, conformity with (a) or (b) is not required. Such situations should receive careful consideration by a competent person and in any case should not be used for circuits without galvanic isolation entering zone 0. If bonding conductors are employed, they should be adequate for the situation, have a copper cross-sectional area of no less than 4 $mm^2$, be permanently installed without the use of plugs and sockets, adequately mechanically protected, and have terminations which, with the exception of the IP rating, conform to the requirements of type of protection 'e'.

In intrinsically safe circuits, the earthing terminals of safety barriers without galvanic isolation (for example, Zener barriers) shall be;

1) connected to the equipotential bonding system by the shortest practicable route, or
2) for earthed power systems only, connected to a high-integrity earth point in such a way as to ensure that the impedance from the point of connection to the main power system earth point is less than 1 W. This may be achieved by connection to a switch-room earth bar or by the use of separate earth rods. The conductor used shall be insulated to prevent invasion of the earth by fault currents which might flow in metallic parts with which the conductor could come into contact (for example, control panel frames). Mechanical protection shall also be provided in places where the risk of damage is high.

The cross-section of the earth connection shall consist of;

i) at least two separate conductors each rated to carry the maximum possible current, which can continuously flow, each with a minimum of 1.5 $mm^2$ copper, or
ii) at least one conductor with a minimum of 4 $mm^2$ copper.

If the prospective short-circuit current of the supply system connected to the barrier input terminals is such that the earth connection is not capable of carrying such current, then the cross-sectional area shall be increased accordingly or additional conductors used.

If the earth connection is achieved via junction boxes, special care should be taken to ensure the continued integrity of the connection.

NOTE — The provision of two earthing conductors should be considered to facilitate testing.

**12.2.5** *Verification of Intrinsically Safe Circuits*

**12.2.5.1** *General*

Unless a system certificate is available defining the parameters for the complete intrinsically safe circuit, then the whole of this sub clause shall be complied with.

A descriptive documentation shall be prepared by the system designer in which the items of the electrical equipment of the system and the electrical parameters as well as those of interconnecting wiring are included.

When installing intrinsically safe circuits, including cables, the maximum permissible inductance, capacitance or L/R ratio and surface temperature shall not be exceeded. The permissible values shall be taken from the associated apparatus or associated energy limited apparatus documentation or the marking plate.

NOTE — The form in which information in the descriptive system document necessary to ensure safety should be kept is not stated precisely and may not be covered by a number of sources such as drawings, schedules, maintained manual and similar documents. The document should be prepared and maintained such that all the information relevant to a particular installation can be easily accessed.

**12.2.5.2** *Intrinsically safe circuits with only one associated apparatus*

Where a circuit contains significant amounts of energy stored in both capacitance and inductance the capacitve stored energy may reinforce the effect of the power source feeding the inductor. The distributed inductance and capacitance of cables is known to be less incendive than that of an inductive or capacitive component. The following method of assessment of cable parameters, which is only applicable to linear (resistive current limited) circuits, takes these factors into account.

Determine the output voltage ($U_0$), output current ($I_0$), maximum external capacitance ($C_0$), maximum external inductance ($L_0$), and the maximum external inductance to resistance ratio ($L_0/R_0$) of the power source from the label or documentation of that source.

Determine the effective total inductance and capacitance of all the apparatus connected in the circuit by adding together the input capacitances ($C_i$) and input inductances ($L_i$) of the connected apparatus plus the total capacitance and inductance of any simple apparatus included in the system.

Where either or both the effective total inductance and capacitance is not greater than 1 percent of $L_0$ and $C_0$ respectively then the permitted inductance or capacitance of the interconnected cable is determined by subtracting these effective values from the $C_0$ and $L_0$ of the source of power. The use of the $L_0/R_0$ ratio as a cable parameter is permitted, provided that the effective total capacitance is greater than or equal to 1 percent of $C_0$. If the effective total inductance is greater than 1 percent of $L_0$ then the permitted $L/R$ ratio of the cable must be recalculated in accordance with IS/IEC 60079-25. Where the use of the $L_0/R_0$ ratio is permitted, then if the cable has an $L/R$ ratio less than, or equal to the permitted value, it is not necessary to satisfy the $L_0$ requirement.

Where both the total inductance and capacitance are greater than 1 percent of $L_0$ and $C_0$ respectively then the values of $C_0$ and $L_0$ should be divided by two. The cable inductance and capacitance should then be calculated by subtracting the effective total inductance from these reduced values. The use of the $L_0/R_0$ parameter for the cable is not permitted in these circumstances.

Guidance on the determination of cable parameters is given in **12.2.2.2**.

The values of permissible input voltage $U$, input current $I_i$ and input power $P$ of each intrinsically safe apparatus shall be greater than or equal to the values $U_0$, $I_0$ and $P_0$ respectively of the associated apparatus.

For simple apparatus the maximum temperature can be determined from the values of $P_0$ of the associated apparatus to obtain the temperature class. The temperature class can be determined by;

a) reference to Table 4, or
b) calculation using the formula:

$$T = P_0 R_{th} + T_{amb}$$

where

$T$ = surface temperature;

$P_0$ = power marked on the associated apparatus;

$R_{th}$ = thermal resistance (K/W) (as specified by the component manufacturer for the applicable mounting conditions); and

$T_{amb}$ = ambient temperature (normally 40°C) and reference to **5.3**.

In addition, components with a surface area smaller than 10 $cm^2$ (excluding lead wires) may be classified as T5, if their surface temperature does not exceed 150°C.

The apparatus group of the intrinsically safe circuit is the same as the most restrictive grouping of any of the items of electrical equipment forming that circuit (for example a circuit with IIB and IIC equipment will have a circuit grouping of IIB).

In addition, components with a surface area smaller than 10 cm$^2$ (excluding lead wires) may be classified as T5 if their surface temperature does not exceed 150°C.

The apparatus group of the intrinsically safe circuit is the same as the most restrictive grouping of any of the items of electrical equipment forming that circuit (for example, a circuit with IIB and IIC apparatus will have a circuit grouping of IIB).

NOTE — Where the Intrinsically safe apparatus contains effective inductance and the associated apparatus is marked with an inductance/resistance L/R-value, reference should be made to IS/IEC 60079-25, intrinsically safe systems, Annex D: Verification of inductive parameter.

**Table 4 Assessment for T4 Classification According to Component Size and Ambient Temperature**

(*Clause* 12.2.5.2)

| Sl No. | Total Surface Area Excluding Lead Wires | Requirement for T4 Classification (based on 40°C Ambient Temperature) |
|---|---|---|
| (1) | (2) | (3) |
| i) | <20 mm$^2$ | Surface temperature ≤275°C |
| ii) | ≥20 mm$^2$ ≤10 cm$^2$ | Surface temperature ≤200°C |
| iii) | ≥20 mm$^2$ | Power not exceeding 1.3 W[1)] |

[1)] Reduced to 1.2 W with 60°C ambient temperature or 1.0 W with 80°C ambient temperature.

**12.2.5.3** *Intrinsically safe circuits with more than one associated apparatus*

If two or more intrinsically safe circuits are interconnected, the intrinsic safety of the whole system shall be checked by means of theoretical calculations or a spark ignition test in accordance with IS 5780/ IEC 60079-11. The apparatus group, temperature class and level of protection shall be determined.

Account shall be taken of the risk of feeding back voltages and currents into associated apparatus from the rest of the circuit. The rating of voltage and current-limiting elements within each associated apparatus shall not be exceeded by the appropriate combination of $U_0$ and $I_0$ of the other associated apparatus or associated energy limited apparatus.

NOTES

1 For associated apparatus with linear current/voltage characteristics, the basis of calculation is given in Annex A. For associated apparatus with non-linear current/voltage characteristics, expert guidance should be sought.

2 If the internal resistances $R_i = U_0/I_0$ are known for intrinsically safe circuits of the associated apparatus under consideration output characteristics according to Fig. C-1a of the IS/IEC 60079-25 shall be used as an alternative.

**12.2.6** *Junction Boxes and Cable Glands*

Where junction boxes (containing only terminals) share intrinsically safe circuits 'ia', 'ib' or 'ic' only, the enclosure and cable glands need only maintain IP 20.

When there are non-intrinsically safe circuits within the enclosure containing intrinsically safe circuits then, either,

a) the covers of the enclosure permitting access to energised non-intrinsically safe circuits shall have a label with the wording " DO NOT OPEN WHEN NON-INTRINSICALLY SAFE CIRCUITS ARE ENERGIZED; or
b) all live parts not protected by type of protection 'i' shall have a separate internal cover providing at least the degree of protection IP30 when the enclosure or the equipment is open, and in addition the internal cover shall have a label with the wording 'DO NOT OPEN WHEN ENERGIZED' or other wording that would otherwise be required by IS/IEC 60079-0 to be the cover of the enclosure; and the cover of the enclosure shall have a label with the wording 'NON-INTRINSICALLY SAFE CIRCUITS PROTECTED BY INTERNAL IP-30 COVER'.

NOTE — The purpose of the internal cover, when fitted, is to provide a minimum acceptable degree of protection against the access to energised non-intrinsically safe circuits, when the enclosure is opened for short periods to permit checking or adjustment of energised intrinsically safe circuits.

### 12.3 Installations for Zone 0

Intrinsically safe circuits shall be installed in accordance with **12.2** except where modified by the following special requirements.

In installations with intrinsically safe circuits for zone 0, the intrinsically safe apparatus and the associated apparatus shall comply with IS 5780/IEC 60079-11, level of protection 'ia'. Associated apparatus with galvanic isolation between the intrinsically safe and non-intrinsically safe circuits is preferred. Since only one fault in the equipotential bonding system, in some cases, could cause an ignition hazard, associated apparatus without galvanic isolation may be used only if the earthing arrangements are in accordance with item 2 of **12.2.4** and any mains-powered apparatus connected to the safe area terminals are isolated from the mains by a double wound transformer, the primary winding of which is protected by an appropriately rated fuse of adequate breaking capacity. The circuit (including all simple components, simple electrical apparatus, intrinsically safe apparatus, associated apparatus and the maximum allowable electrical parameters of inter-connecting cables) shall be of level of protection 'ia' (*see* Notes 1 and 2).

Simple apparatus installed outside zone 0 shall be referred to in the system documentation and shall comply with the requirements of IS 5780/IEC 60079-11, level of protection 'ia'.

If earthing of the circuit is required for functional reasons, the earth connection shall be made outside zone 0, but as close as is reasonably practicable to the zone 0 equipment (*see* Note 3).

If part of an intrinsically safe circuit is installed in zone 0 such that the equipment and the associated equipment are at risk of developing hazardous potential differences within zone 0, for example, through the presence of atmospheric electricity, a surge protection device shall be installed between each non-earth bonded core of the cable and the local structure as near as is reasonably practicable, preferably within 1 m, to the entrance to zone 0. Examples of such locations are flammable liquid storage tanks, effluent treatment plants and distillation columns in petrochemical works. A high risk of potential difference is generally associated with a distributed plant and/or exposed apparatus location, and the risk is not alleviated simply by using underground cables or tank installation.

The surge protection device shall be capable of diverting a minimum peak discharge current of 10 kA (8/20 µs impulse) according to IS 2071 Part 1/IEC 60060-1, 10 operations). The connection between the protection device and the local structure shall have a minimum cross-sectional area equivalent to 4 mm² copper.

The cable between the intrinsically safe apparatus in zone 0 and the surge protection device shall be installed such that it is protected from lightning (*see* Note 4).

NOTES

1 If the intrinsically safe circuit is divided into sub-circuits, the zone 0 sub-circuit(s) including the galvanically isolating elements shall be level of protection 'ia' but sub-circuits not in zone 0 need only be level of protection 'ib'.

2 Galvanic isolation may be achieved via the associated apparatus or via galvanically isolating apparatus within an intrinsically safe circuit in zone 1 or zone 2.

3 If earthing of the circuit is inherent in the circuit operation, as for example with a grounded tip thermocouple or a conductivity probe, this should be the only connection to earth, unless it can be demonstrated that no fault condition can arise as a result of the presence of more than one earth connection.

4 The use of a surge protection device with spark-over voltage below 500 V ac 50 Hz may require the intrinsically safe circuit to be regarded as being earthed.

### 12.4 Special Applications

For some special applications, such as the monitoring of power cables, circuits using the principles of intrinsic safety are included in the same cable as power circuits. Such installations require a specific analysis of the risks involved.

For special applications, intrinsically safe circuits are permitted in the same plug and socket assembly as circuits which are not intrinsically safe, provided that it meets the requirements of IS 5780/IEC 60079-11 and other Indian Standards appropriate to the type of protection used to protect the non-intrinsically safe circuits and that intrinsic safety is not required when the other circuits are energized.

## 13 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'p' — PRESSURIZED ENCLOSURES

### 13.1 Enclosures

#### 13.1.1 *General*

Unless it has been assessed as a whole, the complete installation shall be checked by an expert for compliance with the requirements of the documentation and this standard.

The required level of protection 'X', 'Y', or 'Z' is determined by zone requirement and where the enclosure contains an ignition-capable source of ignition in accordance with Table 5.

NOTES

1 The fitting of a certified pressurisation control system onto an uncertified pressurized enclosure does not confer certification on the pressurized enclosure or its contents.

2 An empty pressurized enclosure may or may not have a separate component certificate. Electrical equipment installed inside even a component certified pressurized enclosure is not fully certified unless a separate certificate of conformity refers to the actual content fitted.

**Table 5 Determination of Protection Type (With no Flammable Release within the Enclosure)**

| Sl No. | Area Classification | Enclosure Contains Ignition-Capable Equipment | Enclosure does not Contain Ignition-Capable Equipment |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Zone 1 | Type px | Type py |
| ii) | Zone 2 | Type px or pz | No pressurization required |

NOTE — IS 7389/IEC 60079-2 requires that type 'py' equipment will only contain equipment to type of protection 'd', 'e', 'i', 'm', 'nA', 'nC', 'o' or 'q'.

**13.1.2** *Ducting*

All ducts and their connecting parts shall be able to withstand a pressure equal to;

a) 1.5 times the maximum over-pressure, specified by the manufacturer of the pressurized apparatus, for normal operation, or

b) the maximum over-pressure that the pressurizing source can achieve with all the outlets closed where the pressurizing source (for example, a fan) is specified by the manufacturer of the pressurized apparatus with a minimum of 200 Pa (2 mbar).

The materials used for the ducts and connecting parts shall not be adversely affected by the specified protective gas nor by the flammable gas or vapours in which they are to be used.

The points at which the protective gas enters the supply duct(s) shall be situated in a non-hazardous area, except for cylinder supplied protective gas.

Ducting should be located in a non-hazardous area as far as is reasonably practicable. If ducting passes through a hazardous area and the protective gas is at a pressure below atmospheric then the ducting shall be free from leaks.

Ducts for exhausting the protective gas should preferably have their outlets in a non-hazardous area. Consideration shall otherwise be given to the fitting of spark and particle barriers (that is, devices to guard against the ejection of ignition-capable sparks or particles) as shown in Table 6.

**Table 6 Use of Spark and Particle Barriers**

| Sl No. | Zone of Exhaust Duct Outlet | Equipment | |
|---|---|---|---|
| | | A | B |
| (1) | (2) | (3) | (4) |
| i) | Zone 2 | Required | Not required |
| ii) | Zone 1 | Required[1)] | Required[1)] |

A — Equipment which may produce ignition-capable sparks or particles in normal operation.

B — Equipment which does not produce ignition-capable sparks or particles in normal operation.

[1)] If the temperature of the enclosed equipment constitutes a hazard upon failure of pressurization, a suitable device shall be fitted to prevent the rapid entry of the surrounding atmosphere into the pressurized enclosure.

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

NOTE — During the purge period a small hazardous area may exist at the duct outlet.

**13.1.3** *Action to be Taken on Failure of Pressurization*

**13.1.3.1** *General*

Pressurization control systems are sometimes fitted with override devices or 'maintenance switches' which are intended to allow the pressurized enclosure to remain energized in the absence of pressurization, for example, when the enclosure door has been opened.

Such devices should be used in a hazardous area only, if the specific location has been assessed to ensure that potentially flammable gas or vapour is absent during the period of use ('gas-free' situation). The enclosure should be de-energized at once, if flammable gases are detected while operating under these conditions and re-purged before it is put back into service.

NOTE — It is only necessary to re-purge the enclosure after pressurisation has been re-established if flammable gas was detected in the area while the manual override was in operation.

**13.1.3.2** *Equipment without an internal source of release*

An installation comprising electrical equipment without an internal source of release shall comply with Table 7 when the pressurization with the protective gas fails.

NOTE — Pressurized enclosures protected by static pressurization should be moved to a non-hazardous area for refilling if pressurization is lost.

The pressure monitoring devices lock out, if pressure is lost and should only be reset after pressure has been restored following refilling.

**13.1.3.3** *Equipment with an internal source of release*

Equipment with an internal source of release shall be installed in accordance with the manufacturer's instructions.

In particular, any containment system safety devices that are required for safety but which were not actually supplied with the equipment, for example, sample flow limiters, pressure regulators or in-line flame arrestors, should be fitted by the user.

Where the pressurized enclosure has an internal containment system that allows process fluids or gases to be taken into the enclosure, the likelihood and effect of the pressurizing gas leaking into the process system should be considered. For example, if a low-pressure process gas in a containment system is at a lower pressure than the pressurizing air, any leakage path into the containment system will allow air into the

**Table 7 Action to be Taken When the Pressurization with the Protective Gas Fails for Electrical Equipment Without an Internal Source of Release**

(*Clause* 13.1.3.2)

| Sl No. | Area Classification | Enclosure Contains Equipment not Meeting Zone 2 Requirements Without Pressurization | Enclosure Contains Equipment Meeting Zone 2 Requirements Without Pressurization |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Zone 1 | Alarm and switch-off [1] | Alarm [2] |
| ii) | Zone 2 | Alarm [2] | No action |

NOTE — Restoration of pressurization should be completed as soon as possible, but in any case within 24 h. During the time that the pressurization is inoperative, action should be taken to avoid the entry of flammable material into the enclosure.

Provided that pressurized equipment is switched off automatically upon pressurization failure, an additional alarm may not be necessary for safety, even in an zone 1 location. If power is not switched off automatically, for example, in an zone 2 location, an alarm is the minimum action that is recommended if combined with immediate action by the operator to restore the pressurization or switch off the equipment.

Equipment within the pressurized enclosure suitable for the external zone need not be switched off when pressure fails. However, care should be taken to ensure that there is no trapped flammable material inside the enclosed equipment which may leak out into the larger pressurized enclosure where work involving the creation of ignition capable sparks may occur.

[1] If automatic switch-off would introduce a more dangerous condition, other precautionary measures should be taken, for example duplication of protective gas supply.

[2] If the alarm operates, immediate action should be taken, for example to restore the integrity of the system.

process and produce a potentially adverse or dangerous effect on the process.

In the event of failure of the protective gas, an alarm shall be given and corrective action taken to maintain the safety of the system.

The action to be taken on pressure or flow failure should be decided by the user, taking into account at least the following considerations:

a) Manufacturer's recommendations;
b) Nature of the release from the containment system (for example, 'none', 'limited' or 'unlimited');
c) Constituents of the internal release, for example, liquid or gas, and their flammability limits;
d) Whether or not the flammable substance supply is automatically shut off upon pressure/flow failure;
e) Nature of the equipment inside the enclosure, for example, incendive, suitable for zone 1 or suitable for zone 2, and it's proximity to the source of release;
f) External area classification, for example, zone 1 or zone 2;
g) Type of protective gas used, for example, air or inert gas. In the latter case, the enclosure should always be re-purged after pressure has been lost to restore the high concentration of inert gas (and low concentration of oxygen) required to provide adequate protection; and
h) Consequences of unannounced automatic shutdown of the apparatus.

Where the sample gas has a high upper explosive limit (UEL) for example, >80 percent, or where the gas is capable of reacting exothermically even in the absence of air, for example, ethylene oxide, it is not possible to protect the enclosure with inert gas using leakage compensation techniques. The use of the continuous flow technique with air or inert gas is suitable if the flow rate is high enough to dilute the release to a concentration below 25 percent of the lower explosive limit (LEL), or to a level below which decomposition cannot take place.

**13.1.4** *Multiple Pressurized Enclosures with a Common Safety Device*

Requirements for the use of a common safety device with more than one pressurized enclosure are given in IS 7389/IEC 60079-2.

**13.1.5** *Purging*

The minimum purge time, specified by the manufacturer, for the pressurized enclosure shall be increased by the minimum additional purging duration per unit volume of ducting, specified by the manufacturer, multiplied by the volume of the ducting.

In zone 2 locations, providing that it is established that the atmosphere within the enclosure and associated ducting is well below the lower flammable limit (for example, 25 percent LEL) purging may be omitted. Additionally, gas detectors may be used to check whether the gas in the pressurized enclosure is flammable.

**13.1.6** *Protective Gas*

The protective gas used for purging, pressurization and continuous dilution shall be non-combustible and non-toxic. It shall also 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. It will usually be air, although an inert gas may be used. The protective gas shall not contain more oxygen by volume than that normally present in air.

Where air is used as the protective gas, the source shall be located in a non-hazardous area and usually in such a position as to reduce the risk of contamination. Consideration shall be given to the effect of nearby structures on air movement and of changes in the prevailing wind direction and velocity.

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 will be marked on the pressurized enclosure).

WARNING — WHERE INERT GAS IS USED, PARTICULARLY IN LARGE ENCLOSURES, GREAT CARE SHOULD BE TAKEN TO PREVENT ASPHYXIATION. PRESSURIZED ENCLOSURES USING INERT GAS AS PROTECTIVE GAS SHALL BE MARKED AS FOLLOWS:

WARNING — THIS ENCLOSURE CONTAINS INERT GAS MAY BE ASPHYXIATION HAZRD. THIS ENCLOSURE ALSO CONTAINS A FLAMMABLE SUBSTANCE THAT MAY BE WITHIN FLAMMABLE LIMITS WHEN EXPOSED TO AIR.

**13.1.7** *Wiring Systems*

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

NOTES

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

Cabling and cable glands shall comply with the requirements of 9 and be in accordance with the apparatus documentation.

2 Compact cables, barrier glands and/or conduit seals should be considered as sealing methods.

## 13.2 Rooms

**13.2.1** *Pressurized Rooms and Analyzer Houses*

**13.2.1.1** *Pressurized rooms*

Requirements for electrical installations in pressurized rooms are given in IS 11064.

**13.2.1.2** *Analyzer houses*

Requirements for electrical installations in analyzer houses are given in IS/IEC 60079-16 and IS/IEC 61285.

## 13.3 Motors

**13.3.1** *Motors with Converter Supply*

Motors supplied at varying frequency and voltage by a converter supply require that either;

a) the motor has been type tested for this duty as a unit in association with the converter specified device specified in the descriptive documents according to IS/IEC 60079-0 and with the protective device provided, or

b) the motor has not been type tested for this duty as a unit in association with the converter. In this case means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided. The effectiveness of the temperature control taking into account power, speed range, torque and frequency for the duty required shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTES

1 In some cases, the highest surface temperature occurs on the motor shaft.

2 A current-dependent time lag protective device (in accordance with 7.2. (a) is not to be regarded as an 'other effective measure'.

3 For motors with protection type 'e' or type' n' terminal boxes, when using converters with high-frequency pulses in the output, care should be taken to ensure that any over voltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

**13.3.2** *Reduced Voltage Starting (Soft Starting)*

Motors with soft start supply require either;

a) the motor has been tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or

b) the motor has not been tested as a unit in association with the soft start device. In this case means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor shall be provided or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE — It is considered that soft starting is under a short time period.

## 14 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'n'

### 14.1 General

Type of protection 'n' is divided into 4 sub-types:

a) nA is for non-sparking apparatus;
b) nC is for sparking apparatus in which the contacts are suitably protected other than by a restricted-breathing enclosure, energy limitation and simplified pressurization;
c) nR is for restricted breathing enclosures; and
d) nL is for energy-limited apparatus (*see* **12**).

The energy-limited apparatus 'nL' and the energy-limited parts of associated energy-limited apparatus, shall comply with IS/IEC 60079-15:

Equipment for connection into energy-limited (nL) circuits should be installed in accordance with the requirements of equipment to type of protection 'ic', as specified in **12**.

Equipment to type of protection 'nL' may be used in an intrinsically safe 'ic' circuit in accordance with **12**.

Equipment which contains energy-limited circuits, the circuits shall be terminated in accordance with the requirements of the type of protection of the terminal enclosure (for example, Ex 'nA', Ex 'd', Ex 'e').

### 14.2 Degree of Protection of Enclosures (IS 12063 and IS 4691)

Enclosures containing bare live parts and enclosures containing only insulated parts require a degree of protection of at least IP54 and IP44, respectively.

When used in locations providing adequate protection against the entry of solid foreign bodies or liquids capable of impairing safety (for example indoors), enclosures containing bare live parts and enclosures containing only insulated parts require a degree of protection of IP4X and IP2X, respectively.

Equipment which would not be impaired by contact with solid foreign bodies or liquids (for example, strain gauges, resistance thermometers, thermocouples, energy-limited apparatus, etc) need not comply with the above requirements.

### 14.3 Wiring Systems

**14.3.1** *General*

Cables and conduits shall be installed in accordance with **9**, with the following additional requirements concerning cable entries and conductor terminations.

Additional cable entry holes may be made into the enclosure provided this is permitted by the manufacturer's documentation.

NOTES

1 Threaded holes in plastic enclosures should be at right angles to the face of the enclosure (due to the possible moulding methods for plastic enclosures the wall of the enclosure may have draw angles which would not allow the gland or fitting inserted in the threaded hole to fit square to the face and result in ineffective sealing).

2 Taper threaded holes in plastic enclosures are not recommended due to the high stresses created during sealing of these threads, which may fracture the enclosure wall.

**14.3.2** *Cable Glands*

**14.3.2.1** *General*

The connection of cables to non sparking equipment shall be effected by means of cable glands appropriate to the type of cable used. They shall comply with the requirements of IS/IEC 60079-0.

NOTES

1 To meet the ingress protection requirement, it may also be necessary to seal between the cable glands and the enclosure (for example, by means of a sealing washer or thread sealant).

2 In order to meet the minimum requirement of IP 54, threaded cable entry devices into threaded cable entry plates or enclosures of 6 mm or greater thickness need no additional sealing between the cable entry device and the entry plate or enclosure, providing the axis of the cable entry device is perpendicular to the external surface of the cable entry plate or enclosure.

Where mineral insulated metal sheathed cables are used, the requirement to achieve creepage distances shall be maintained by using a mineral insulated cable sealing device complying with IS/IEC 60079-0.

Approved threaded adapters may be fitted into the cable entry holes to allow connection of the device or cable gland.

Unused entries in the enclosure shall be sealed by an approved stopping plug or a stopping plug, which is listed on the equipment documentation.

**14.3.2.2** *Cable glands for 'nR' equipment*

The sealing of restricted-breathing enclosures shall be such as to maintain the restricted-breathing properties of the enclosure.

NOTES

1 Where the cable used is not part of the certification and is not effectively filled, that it may be necessary to use a cable gland or other method (for example, epoxy joint, shrinking tube) which seals around the individual conductors of the cable to prevent leakage from the enclosure.

2 A suitable sealing washer shall be fitted between the cable gland and the enclosure. Tapered threads shall require the use of threaded sealant (*see* **9.4**).

**14.3.2.3** *Conductor terminations*

Some terminals, such as slot types, may permit the entry of more than one conductor. Where more than one conductor is connected to the same terminal, care shall be taken to ensure that each conductor is adequately clamped. Unless permitted by the documentation supplied with the apparatus, two conductors of different cross-sections shall not be connected into one terminal unless they are first secured with a single compression type ferrule.

Where there is a risk of short-circuits between adjacent conductors in terminal blocks, the insulation of each conductor shall be maintained up to the metal of the terminal.

NOTE — Where single screw saddle clamps are used with a single conductor, the latter should be shaped around the screw in the form of a "U" unless clamping of single conductors without "U" is permitted in the documentation supplied with the equipment.

## 14.4 Motors

**14.4.1** *Machines with Rated Voltage More than 1 kV*

Machines with rated voltage exceeding 1 kV shall be selected taking into account the 'potential stator winding discharge risk assessment — ignition risk factors' in IS 6381/IEC 60079-7. If the total sum of the risk factors is greater than 6,

a) anti-condensation space heaters shall be employed, and
b) either the machine is tested in accordance with IS/IEC 60079-15 or special measures shall be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

NOTES

1 If the machine is intended to operate under special measures, the certificate shall have the symbol 'x' in accordance with IS/IEC 60079-0.

2 Special measures may include pre-start ventilation, the application of fixed gas detection inside the machine or other methods specified in manufacturer's instructions.

**14.4.2** *Motors with Converter Supply*

Motors supplied at varying frequency and voltage by a converter supply require that either:

a) the motor has been tested, in accordance with IS/IEC 60079-15 with the specific converter or with a comparable converter in reference to the output voltage and current specification, or
b) the motor has not been type-tested for this duty as a unit in association with the converter. In this case, means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the temperature of the motor shall be provided. The effectiveness of the temperature control taking into account power, speed range, torque and frequency for the duty required shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected, or
c) the motor has had its temperature class determined by calculation in accordance with IS/IEC 60079-15.

**14.4.3** *Reduced Voltage Starting (Soft Starting)*

Motors with soft start supply require either;

a) the motor has been tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) the motor has not been tested as a unit in association with the soft start device. In this case means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor shall be provided or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE — It is considered that soft starting is under a short time period.

## 14.5 Luminaires

Luminaires with fluorescent lamps and electronic ballasts shall not be used where temperature class T5 or T6 is required or where the ambient temperature exceeds 60°C.

Lamps (for example, bi-pins, screw connections on tungsten lamps) using non-conductive materials with a conductive coating shall not be used unless tested with the equipment.

NOTE — This requirement is intended to apply to recently designed lamps where the pins or end caps may be plastic or ceramic with a conductive film coating.

# 15 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'o' OIL IMMERSION

Oil immersed equipment shall be installed in accordance with manufacture's documentation.

## 16 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'q' — POWDER FILLING

Powder filled equipment shall be installed in accordance with manufacture's documentation.

## 17 ADDITIONAL REQUIREMENTS FOR TYPE OF PROTECTION 'm' — ENCAPSULATION

Encapsulated equipment shall be installed in accordance with manufacture's documentation.

# ANNEX A

(*Clause* 12.2.5.3)

## VERIFICATION OF INTRINSICALLY SAFE CIRCUITS (AND ENERGY-LIMITED CIRCUITS) WITH MORE THAN ONE ASSOCIATED APPARATUS (OR ASSOCIATED ENERGY-LIMITED APPARATUS) WITH LINEAR CURRENT/VOLTAGE CHARACTERISTICS

### A-0 GENERAL

The capacitance and inductance parameters for the system of intrinsically safe circuits shall be determined from the ignition curves of IS 5780/IEC 60079-11 using the system values of $U_0$ and $I_0$ under fault conditions and at each point in the system. The faults in accordance with IS 5780/IEC 60079-11 shall be applied to the electrical system as an entity and not to each item of electrical equipment.

A similar process is required for the energy limited circuits except that no faults shall be applied.

The above requirements can be met by using the following calculation procedure.

### A-1 INTRINSIC SAFETY WITH LEVEL OF PROTECTION 'ib'

The level of protection shall be deemed to be 'ib' even if all the associated apparatus is level of protection 'ia'. *See* Note below.

a) Determine the highest voltage and current in the system using the $U_0$ and $I_0$ values stated on the associated apparatus (*see* Annex B).
b) Check that the highest system current ($I_0$) multiplied by a safety factor of 1.5 does not exceed the current obtained from the ignition curves for resistive circuits, for the appropriate apparatus group in IS 5780/IEC 60079-11 for the maximum system voltage ($U_0$).
c) The maximum permissible inductance ($L_0$) is obtained from the ignition curves for inductive circuits, for the appropriate apparatus group in IS 5780/IEC 60079-11, using the highest system current ($I_0$) multiplied by a safety factor of 1.5.
d) The maximum permissible capacitance ($C_0$) is obtained from the appropriate ignition curve for capacitive circuits in IS 5780/IEC 60079-11, using the highest system voltage ($U_0$) multiplied by a safety factor of 1.5.
e) Check that the maximum permissible values of $C_0$ and $L_0$ conform to the requirements of **12.2.5.1**.
f) Check that $U_0$, $I_0$ and $P_0$ (where $P_0 = I_0U_0/4$) conform to the requirements of **12.2.5.1**.
g) Determine the apparatus group of the system, in accordance with **12.2.5.1**, taking into account the apparatus group of the ignition curves used.
h) Determine the temperature class of the system in accordance with **12.2.5.1** (where $P_0 = I_0U_0/4$).

NOTE — This level of protection reduction takes account of the fact that the assessment is by calculation only without any test.

### A-2 INTRINSIC SAFETY WITH LEVEL OF PROTECTION 'i' AND ENERGY-LIMITED 'nL'

A similar calculation method may be used for 'ic' and 'nL' circuits. The safety factor used shall be unity.

# ANNEX B

(*Clause* A-1)

## METHODS OF DETERMINING THE MAXIMUM SYSTEM VOLTAGES AND CURRENTS IN INTRINSICALLY SAFE CIRCUITS WITH MORE THAN ONE ASSOCIATED APPARATUS WITH LINEAR CURRENT/VOLTAGE CHARACTERISTICS

### B-1 INTRINSICALLY SAFE CIRCUITS

In the case of two or more associated apparatus in an intrinsically safe circuit (*see* **12.2.5.2**), the following practical method can be used to determine the new maximum system voltages and currents under fault conditions in the intrinsically safe circuit using the values $U_o$, $I_o$ of each item of associated apparatus taken from the documentation or from the marking plate.

Dependent on the interconnection of the intrinsically safe terminals of the associated apparatus, the values of $U_o$ and $I_o$ should be determined, in the case of normal operation and also under fault conditions, taking into account;

a) Summation of voltages only,
b) Summation of currents only, or
c) Summation of both voltages and currents.

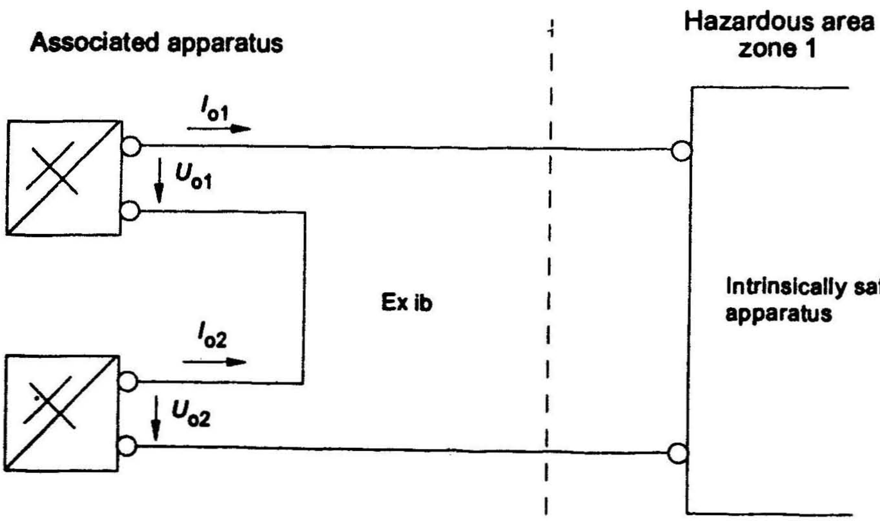
In the case of series connection of the associated apparatus with galvanic isolation between intrinsically safe and non-intrinsically safe circuits (*see* Fig. **B-1**) only the summation of voltages is possible, irrespective of the polarity of the circuits.

In the case of parallel connection of both poles of the sources (*see* Fig. **B-2**) only the summation of currents is necessary.

In all other cases, where any interconnection of the poles of the sources is possible (*see* Fig. **B-3**) series or parallel connections have to be taken into account, dependent on the fault under consideration. In this situation, both the summation of voltages and the summation of currents have to be considered separately.

### B-2 ENERGY-LIMITATION

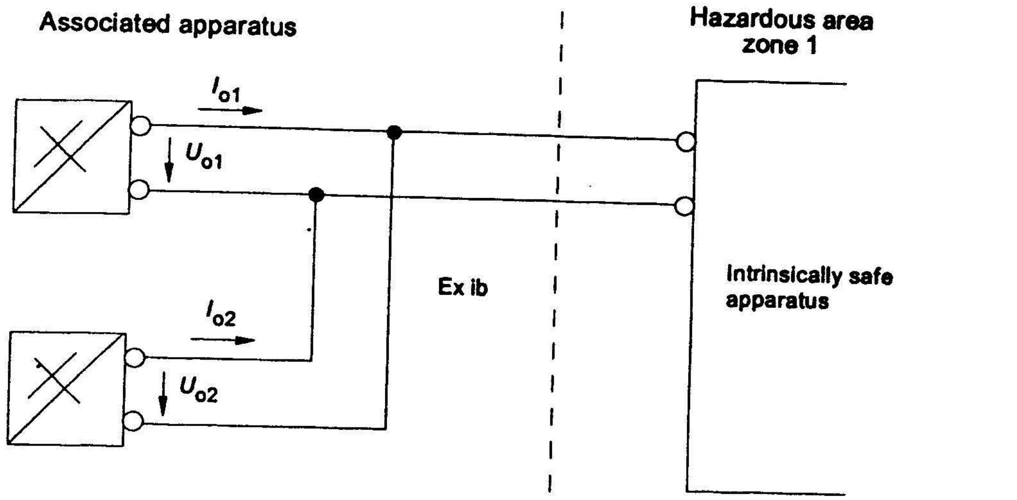
A similar procedure may be used for energy-limited circuits.




New maximum system values: $U_o = \Sigma U_{oi} = U_{o1} + U_{o2}$

$I_o$ = maximum ($I_{oi}$)

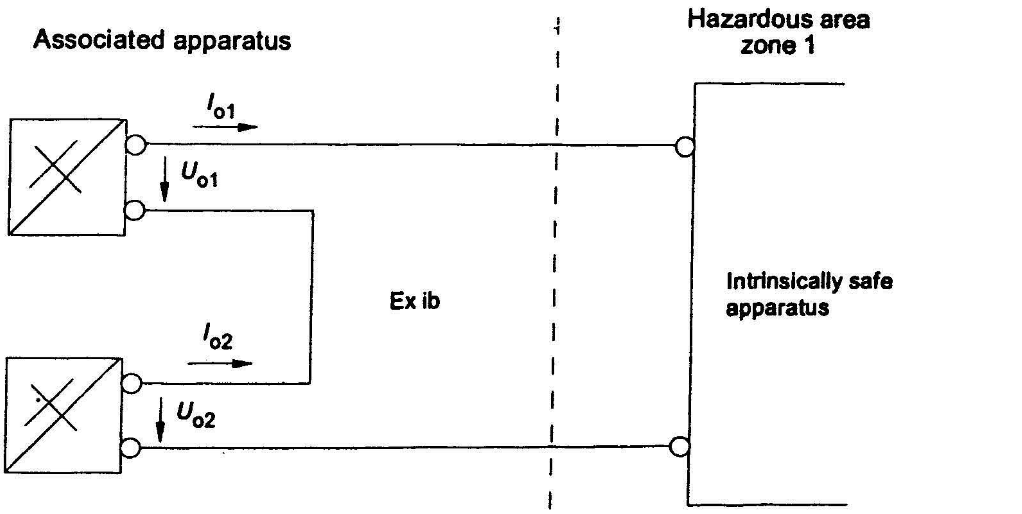
FIG. B-1 SERIES CONNECTION — SUMMATION OF VOLTAGE




New maximum system values: $U_o$ = maximum ($U_{oi}$)

$I_o = \Sigma I_{oi} = I_{o1} + I_{o2}$

FIG. B-2 PARALLEL CONNECTION — SUMMATION OF CURRENTS




New maximum system values: $U_o = \Sigma U_{oi} = U_{o1} + U_{o2}$ $\qquad$ $U_o$ = maximum ($U_{oi}$)

or

$I_o$ = maximum ($I_{oi}$) $\qquad$ $I_o = \Sigma I_{oi} = I_{o1} + I_{o2}$

FIG. B-3 SERIES AND PARALLEL CONNECTIONS — SUMMATION OF VOLTAGES AND SUMMATION OF CURRENTS

# ANNEX C

(*Clause* 12.2.2.2)

## DETERMINATION OF CABLE PARAMETERS

(Informative)

### C-1 MEASUREMENTS

The inductance and capacitance of a cable should be measured using equipment operating at a frequency of 1 kHz ± 0.1 kHz and an accuracy of ±1 percent. The resistance of the cable should be measured using dc equipment with accuracy of ±1 percent. Results taken from a representative sample of cable with a minimum length of 10 m are acceptable. Measurements should be taken at an ambient temperature of 20 °C to 30 °C (*see* Note).

Where practicable, measurements of all the possible combinations of the cores which can result from open-circuiting and short-circuiting the separate ends of the cables should be made. The maximum measured values of capacitance, inductance and the L/R ratio should be used as the cable parameters. Where there are a large number of cores, measurements should only be made utilizing a representative sample of the combination of cores which will create the largest values of inductance and capacitance.

The maximum capacitance of the cable should be determined by open-circuiting the remote end of the cable and measuring the capacitance of the combinations of the wires and screens which give the maximum value. For example, if a twin-pair screened cable is being measured, then the highest value will probably be measured between one core connected to the screen and the other core. That this is the highest value of capacitance should be confirmed by measuring the other combination of cores and screen.

The maximum inductance should be measured by connecting together the remote ends of the two cores, which are spaced furthest from one another. The dc resistance of this path is the resistance used in calculating the L/R ratio of the cable.

Where the cable is loosely constructed, bending and twisting the cable a minimum of ten times should not cause the cable parameters to vary by more than 2 percent.

For the purpose of these measurements, the combination of faults which could connect separate conductors in series to effectively increase the length of cables should not be considered. When measuring capacitance, any screens or unused cores should be joined together and connected to one side of the circuit being measured.

NOTE — The equipment for the measurement of inductance should be able to operate satisfactorily when measuring low inductance in the presence of significant resistance.

### C-2 MULTI-CORE CABLES

Where the conductors utilised by a particular intrinsically safe or energy limited circuit are readily identifiable within a multi-core, only the cable parameters related to those specific conductors should be considered.

#### C-2.1 Type A Multi-core Cables

When all the conductors utilised in a circuit are within one screen, only the interconnections of the conductors within that screen and to that screen should be considered. Where the conductors are within more than one screen, measurement should be made utilising all the relevant conductors within the relevant screens.

#### C-2.2 Type B Multi-core Cables

When the conductors utilised for a particular circuit can be clearly identified, measurement should be made only on those conductors. Where a clear identification cannot be made, all the possible combinations of the conductors used in that particular intrinsically safe circuit should be considered.

#### C-2.3 Other Multi-core Cables

Measurement should be made on all conductors and any screens associated with the intrinsically safe systems which can be interconnected by the two short-circuit faults which have to be considered.

Where relevant conductors are not clearly identifiable, the testing should be extended to the possible combinations of the total number of conductors and screens associated with the three interconnected circuits.

### C-3 FISCO

The effective capacitance of the bus cable results from the capacitance per meter $C'$ which is valid for the capacitance between the two conductors. If the cable contains as screen, and additional capacitance per meter will be effective.

The calculation of the capacitance depends on the electrical connection of bus cable and screen. If the bus circuit is isolated from the earthed screen or if the screen is arranged symmetrically between the plus and minus of the supply unit (Fieldbus balanced about ground), not only the capacitance conductor/conductor but also the series capacitance from the conductor/screen and screen/conductor is to be allowed for. The following is obtained:

$$C' = C'\text{conductor/conductor} + 0.5C'\text{conductor/screen}$$

If the screen is connected with one pole of the supply unit, the following relation will result:

$$C' = C'\text{conductor/conductor} + C'\text{conductor/screen}$$

## ANNEX D

(*Clauses* 3.2.16 *and* 12.2.5.2)

### CONTROL OF IGNITION SOURCES PROCEDURE

(Informative)

**D-1** A control of ignition sources procedure can be implemented to permit ignition sources to be used in a hazardous area under prescribed conditions.

A 'control of ignition sources permit' (gas-free) can be issued when a specific location has been assessed to ensure that gas or vapour is not present and is not expected to be present, in quantities which may give rise to flammable concentrations, during a specified period. The permit may prescribe continuous or periodic gas monitoring and/or detailed actions to be taken in the event of a release.

Considerations for the issue of a control of ignition sources permit may include,

a) Specifying the start date/time of the permit;
b) Defining the location of the activity;
c) Specifing the nature of the permitted activity (for example, Diesel generator, drilling);
d) Taking and recording measurements to confirm the absence of an ignitable concentration of any flammable gas or vapour;
e) Specifing sampling requirements to confirm the continued absence of a flammable gas or vapour;
f) Specifing contingency plans for emergencies; and
g) Specifing the expiry date/time of the permit.

NOTE — Important aspects associated with documentation, training, controls, and use required for an effective application of a 'control of ignition sources permit' are beyond the scope of this standard.

# ANNEX E

(*Clause* 5.2.3)

## FEATURES OF ELECTRICAL EQUIPMENT FOR HAZARDOUS AREAS

(*Informative*)

| *Sl No.* | *Equipment* | *Zone* 0 | *Zone* 1 | *Zone* 2 |
|---|---|---|---|---|
| i) | Motors | No motor shall be used in this area | a) Motor with type of protection '*d*'.<br>b) Motors with type of protection '*p*'. | a) Motor suitable for zone 1 area.<br>b) Motors with type of protection '*n*' and '*e*'. However, all normally sparking parts such as slip-rings and brushes shall be provided with type of protection '*d*' or '*p*'.<br>Motors provided with a combination of the above forms of protection. For example, slip-ring motors in which the main enclosures and windings are of type '*e*' but the normally sparking parts of type '*d*' protection. |
| ii) | Transformers and capacitors | No transformer or capacitor shall be used in this area | a) All power and distribution transformers and capacitors with type '*d*' protection.<br>b) Type '*i*' protection for control and instrumentation, with transformers and capacitors forming part of flameproof or intrinsically safe equipment. | Transformers and capacitors suitable for zone 1 area. Transformers and capacitors that are dry type or containing liquids need not have any special enclosure provided that the following requirements are satisfied:<br>a) Cable boxes shall be suitable for specified level of current and fault clearing time.<br>b) Only off-circuit manually operated tap changers shall be allowed with provision for locking the operating handle in position.<br>c) Auxiliary devices shall be intrinsically safe or if they have sparking contacts, these shall be:<br>1) type '*d*'.<br>2) under adequate head of oil.<br>3) of mercury in glass type with adequate mechanical protection.<br>4) of enclosed break type or, alternatively, auxiliary devices may be deleted or installed in a safe zone.<br>d) Any other sparking accessories or switches shall comply with the requirements for zone 1 area. Where oil filled transformers are used, necessary precautions against spread of fire (*see* IS 1646) shall be complied with. |
| iii) | Lighting fittings (*see* Notes 1 and 2) | No lighting fitting shall be used | All switches, circuit breakers, fuses and other equipment shall be housed in an enclosure with type '*d*' protection. | a) Lighting fittings for zone 1.<br>b) Lighting fittings with type of protection '*e*' or '*n*'. |

| *Sl No.* | *Equipment* | *Zone* 0 | *Zone* 1 | *Zone* 2 |
|---|---|---|---|---|
| iv) | Switchgear and control gear | No switchgear and control gear shall be used. When not practicable use type '*i*' protection | All switches circuit breakers, fuses and other equipment, the enclosure together with the enclosed apparatus shall be type '*d*' protection. | All equipment where arcing may occur under normal conditions of operating shall be of type '*d*', unless the current interrupting contacts are oil-immersed, or the switches are enclosed break type with flameproof breaking chamber or having mercury in glass switches or enclosed break micro switches. |
| v) | Generators | No generator shall be used | Generators with Type '*d*' and '*p*' protection | Equipment suitable for zone 1 areas Generators with type '*n*' protection or '*e*' and having brushless excitation system and sparking parts, if provided shall comply with zone 1 requirements. |
| vi) | Diesel engines | Unaccept-able | The use of permanently installed diesel engines to be avoided. Where necessary, they shall satisfy the requirements as given in Annex F. | a) The use of permanently installed diesel engines to be avoided. b) Equipment suitable in zone 1 areas. |
| vii) | Storage batteries | Shall not be used | Storage batteries shall not be installed in zone 1 areas, except those in portable torches where the enclosures housing the bulb, switch and battery shall be flameproof type. | Storage batteries shall be of type '*e*' protection. |

NOTES:

1 Low-pressure sodium lamps shall not be used in a hazardous area owing to the risk of ignition from the free sodium from a broken lamp.

2 If luminaires with fluorescent lamps are used in a hazardous area, then the area should be confirmed to be freefrom group IIC gas / vapour before lamps are transported through the area or changed, unless suitable precautions are taken to prevent tubes being broken.

# ANNEX F

(*Clause* 5.2.3 and *Annex* E)

## RECOMMENDATIONS FOR THE PROTECTION OF DIESEL ENGINE FOR PERMANENT INSTALLATION IN HAZARDOUS AREAS

(*Normative*)

**F-0** To ensure a maximum degree of safety in the event of a permanently installed diesel engine being necessary in zone 1 or zone 2 it is recommended that it should have the following protection.

**F-1** The starter shall be either of flameproof electrical type (usually operated from the mains supply) or of the following non-electric types:

a) Pneumatic,
b) Hydraulic,
c) Spring recoil,
d) Inertia, or
e) Hand start.

Any other electrical equipment associated with the engine shall be flameproof, Electrical equipment shall be effectively earthed and bonded.

**F-2** Cooling fan blades shall be made from non-metallic materials, which do not accumulate electrostatic charge.

**F-3** All belts shall be of antistatic fire resistant type.

**F-4** In order to contain discharge of sparks or flames from the exhaust system; a gas conditioner box and a flame trap shall be installed. Alternatively, the exhaust should be designed to discharge to a location within a safe area.

**F-5** To prevent flash back through induction system, wherever possible, air intakes for engines shall be located in a safe area. Alternatively, a flame trap should be installed.

**F-6** The surface temperature of the engine and exhaust system shall not exceed 250°C, when tested under full load conditions. In some situations cooling of the exhaust manifold and piping may be necessary, using water-jacketing or finned coolers and/or high temperature cut outs or alarms should be provided.

However, when either the free movement of air is restricted by thermal or acoustic shielding or the ignition temperature of the surrounding flammable atmosphere is below 200°C, exposed surface temperature of engine shall not exceed the minimum ignition temperature of the gases involved.

**F-7** To prevent over speeding of the engine due to induction of flammable gases or vapours, means shall be provided to stop the engine. It can be either:

a) a valve to close the air intake, or
b) a system to inject carbon dioxide into the air intake.

**F-8** Alarms or automatic shutdown devices shall be provided, activated by excessive water temperature and low lube oil pressure.

**F-9** A system using an alarm or trip device to protect the engine from excessive vibration should be considered.

**F-10** An engine having a crankcase volume of over 0.5 $m^3$ shall be provided with relief devices. Relief valves or breathers on engines shall be fitted with flame traps or discharge into the induction system downstream of the flame trap, if fitted, and upstream of the shut-off valve, if fitted, as specified in **F-7**. Dipsticks and/or filler caps should be screwed or effectively secured by other means.

**F-11** Intake and exhaust system design shall meet the following minimum requirements:

a) The length of the flame path through or across any joint shall be not less than 13 mm,
b) Suitable metal-clad or other acceptable jointing material shall be interposed between all joint faces to ensure that leakage does not occur,
c) Where valve spindles pass through the walls of any component of the induction system. The diametrical clearance shall not exceed 0.13 mm for an axial length of not less than 25 mm unless end caps are fitted, and
d) No screw, stud or bolt hole shall pass through the wall of any component of the system.

**F-12** De-compression system should not normally be provided. However, if they are essential, then the decompression parts should be provided with flame traps and ducted away to safe area.

**F-13** The fuel injection pump land governor, where fitted, should be so designed that reverse running of the engine is not possible.

# ANNEX G

(*Clause* 4.1)

## INTRODUCTION TO 'EQUIPMENT PROTECTION LEVELS' FOR EX EQUIPMENT

(*Informative*)

### G-1 HISTORICAL BACKGROUND

Historically, it has been acknowledged that not all types of protection provide the same level of assurance against the possibility of an incendive condition occurring. This standard allocates specific types of protection to specific zones, on the statistical basis that the more likely or frequent the occurrence of an explosive atmosphere, the greater the level of security required against the possibility of an ignition source being active.

Hazardous areas (with the normal exception of coal mining) are divided into zones, according to the degree of hazard. The degree of hazard is defined according to the probability of the occurrence of explosive atmospheres. Generally, no account is taken of the potential consequences of an explosion, nor of other factors such as the toxicity of materials. A true risk assessment would consider all factors.

Acceptance of equipment into each zone is historically based on the type of protection. In some cases the type of protection may be divided into different levels of protection which again historically correlate to zones. For example, intrinsic safety is divided into Levels of Protection 'ia' and 'ib'. The Encapsulation 'm' standard includes two levels of protection 'ma' and 'mb'.

In the past, the equipment selection standard has provided a solid link between the type of protection for the equipment and the zone in which the equipment can be used. As noted earlier, nowhere in the IS system of explosion protection is there any account taken of the potential consequences of an explosion, should it occur.

However, plant operators often make intuitive decisions on extending (or restricting) their zones in order to compensate for this omission. A typical example is the installation of 'Zone 1 Type' navigation equipment in zone 2 areas of offshore oil production platforms, so that the navigation equipment can remain functional even in the presence of a totally unexpected prolonged gas release. In the other direction, it is reasonable for the owner of a remote, well secured, small pumping station to drive the pump with a 'Zone 2 Type' motor, even in zone 1, if the total amount of gas available to explode is small and the risk to life and property from such an explosion can be discounted.

Traditionally the suitability of products for zone 0 was through the marking of the protection technique, with Ex 'ia' being the only technique to be accepted in zone 0.

It has been recognised that it is beneficial to identify and mark all products according to their inherent ignition risk. This would make equipment selection easier and provide the ability to better apply a risk assessment approach, where appropriate.

### G-2 INTRODUCTION

A risk assessment approach for the acceptance of Ex equipment has been introduced as an alternative method to the current prescriptive and relatively inflexible approach linking equipment to zones. To facilitate this, a system of 'Equipment Protection Levels' has been introduced to clearly indicate the inherent ignition risk of equipment, no matter what type of protection is used.

The system of designating these equipment protection levels is as follows.

#### G-2.1 EPL Ga

Equipment for explosive gas atmospheres, having a 'very high' level of protection, which is not a source of ignition in normal operation, expected malfunction or when subject to rare malfunction. Such equipment will have a form of protection which will remain effective even in the presence of two potential faults (for example, intrinsic safety, category ia), or will have two independent means of protection.

NOTE — An example of two independent means of protection is where Ex e and Ex d are acting independently of each other.

#### G-2.2 EPL Gb

Equipment for explosive gas atmospheres, having a 'high' level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

NOTE — The majority of the standard protection concepts bring equipment within this equipment protection level.

#### G-2.3 EPL Gc

Equipment for explosive gas atmospheres, having a 'enhanced' level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example, failure of a lamp).

NOTE — Typically this will be Ex n equipment.

For the majority of situations, with typical potential consequences from a resultant explosion, it is intended that the following would apply for use of the equipment in zones.

**Traditional Relationship of EPLs to Zones (No Additional Risk Assessment)**

| *Equipment Protection Level* | *Zone* |
|---|---|
| Ga | 0 |
| Gb | 1 |
| Gc | 2 |

**G-3 RISK OF IGNITION PROTECTION AFFORDED**

The various levels of protection of equipment must be capable of functioning in conformity with the operational parameters established by the manufacturer to that level of protection.

**Description of Risk of Ignition Protection Provided**

| *Protection Afforded* | *Equipment Protection Level* | *Performance of Protection* | *Conditions of Operation* |
|---|---|---|---|
| Very high | Ga | Two independent means of protection or safe even when two faults occur independently of each other | Equipment remains functioning in zones 0, 1 and 2 |
| High | Gb | Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account | Equipment remains energised in zones 1 and 2 |
| Enhanced | Gc | Suitable for normal operation | Equipment remains energised in zone 2 |



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