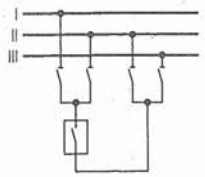
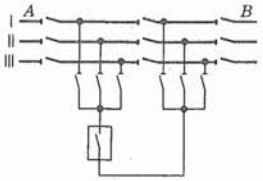
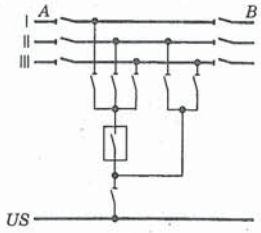
Triple busbars



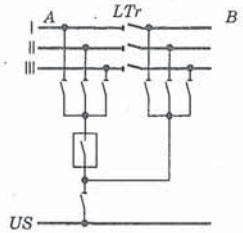
Bus coupling I/II/III



Section- and bus coupling for all possible ties between the 6 sections A-B



Bus coupling I/II/III for A or B Bypass coupling I/II/III to bypass (US) for A or B



Section coupling for A-B. Bus coupling I/II/III via LTR. Bypass coupling A I/II/III to bypass. Bypass coupling B bypass via LTR.

59

Electrical Safety

59.1. INTRODUCTION

While electricity has made life full of comfort and ease, it has also the potential to create heavy destruction if adequate precautions against its potential dangers are not taken care of. This brings into focus the safety to be exercised in the entire process of generation, transmission, distribution and the end use of electrical energy. Safety management & monitoring system has to ensure:

- Safety to self
- Safety to fellow workman
- Safety to consumer
- Safety to the public
- Safety of equipment apparatus & buildings
- Continuous and reliability of supply.

The concept of electrical safety as applied to the present day environment has taken deep roots so as to evolve as a discipline in itself in which specialists from all essential walks of life contribute towards devising ways and means to ensure safety in dealing with electrical energy. Safety includes safety of the equipment as well as the safety of the personnel. It is rather difficult to visualize any well-designed electrical system where these two aspects have not been taken into consideration. The safety of the equipment is generally provided by the use of protective devices such as switchgear and controlgear, fuses, relays etc. Safety of the personnel is ensured not only by employing protective devices but also by educating them about the safety precautions and practices that are required for installation, maintenance and operation of the electrical equipment. In addition, requirements to ensure a safe design of the equipment coupled with the reliability are specified in its product specification at the time of formulation of the relevant standard. For ensuring safety, a suitable statutory & institutional mechanism has been provided.

59.2. REQUIREMENTS FOR ELECTRICAL SAFETY

Personnel involved in the electrical work are normally called for to attend to installation and maintenance work, be it in a substation or in the factory premises or in commercial or domestic dwelling where electrical energy is being put to use. It is essential for these personnel to be conversant with Indian Standard and Codes of practices dealing with procedures for use of electricity and for various maintenance activities of electrical installations. The safety codes specify the precautions to be taken in ensuring safe use of electricity for the personnel working on them. In the Standards on personnel safety, various requirements on design and constructional details of the equipment have been laid down with a view to ensure protection from shock as well as protection from fire hazards under abnormal conditions. For ensuring a safe electrical environment, it is essential that the product conforms to these specified requirements and the instructions and guidelines laid down in Standards codes are known and practiced at all times by all concerned. The safety instructions are to be regarded as normal routine and not as involving extra and laborious efforts. Some of the important factors against which safety is ensured and requirements laid down in the Standards are:

(*i*) **Protection Against Electric Shock.** Safety against electric shock is ensured by specifying the following parameters in the Standard :

(*a*) Permissible leakage current (*b*) Insulation resistance
(*c*) Accessibility of live parts (*d*) Clearance and creepage distances
(*e*) Provision for earthing

(*ii*) **Protection Against Mechanical Hazards.** Protection against mechanical hazards to the personnel is ensured by the following requirements:

(*a*) Design and constructional features (*b*) External surfaces
(*c*) Accessibility of moving/rotating parts

(*iii*) **Protection Against Other Hazards.** Requirements for other kinds of hazards as given below are also specified:

59.3. RELEVANT INDIAN STANDARDS

The equipment used in the electrical installation should function satisfactorily not only at the time of commissioning but also it should continue to function reliably ensuring a safe working environment throughout its life period. The electrical safety requires that equipment should be able to withstand the electric stresses in normal and abnormal conditions and also at the same time providing no hazards to the persons handling the equipment. BIS has formulated Indian Standards and Codes of practices for installation and maintenance of entire range of electrical works and equipment like domestic appliances, wiring, earthing, transformers, power cables, switchgears, fuses, induction motors, motor-starters, lighting etc. A list of the same has been given at the end for reference of readers.

The scope and contents of some of the important standards is given below:

(*a*) **IS 302 Series: Safety of Household and Similar Electrical Appliances**

On the electrical safety of personnel, the most important Standard relates to general and safety requirements for household and similar electrical appliances (IS 302 series). In this Standard, constructional details of appliances have been laid down with a view to ensure protection from shock as well as protection from fire hazards under abnormal conditions beside the safety aspects. These Standards form the basis for development of more than 50 specifications dealing with the safety requirements of different electrical appliances. In addition there are about 30 specifications dealing with performance requirements for electrical appliances.

Indian Standards on electrical appliances permit a leakage current of only 300 micro amperes (Peak) against a maximum value of 700 micro amperes (peak) permitted in European countries where ambient conditions are dry and it was realized that this value may not be suitable for a tropical country like India where the ambient temperature and humidity are comparatively high. The difference in the living conditions was also taken into account to consider not only a safe current but that the level should be such that it should not cause discomfort to the user. Based on extensive study tests carried out all over the country, it was established that for India 300 microamperes (peak) should be the safe permissible leakage current. This value has been accepted by International Electrotechnical Commission also for tropical countries.

(*b*) **IS 5216 (Part 1 & 2): 1982 Guide for Safety Procedures and Practices in Electrical Work**

This is another important Standard on safety which deals with safety procedures and practices that should be followed for all major installations such as generating stations, sub-stations, industrial establishments, transmission and distribution lines and cable network. This guide also deals with safety instructions for working on low, medium, and high voltage machines and apparatus, methods to deal with accidents and fire fighting, first aid and resuscitation treatment for electric shock.

(*c*) **IS 732:1989, Code of Practice for Electrical Wiring Installations**

This Standard covers the essential requirements, which govern installations of electrical wiring in buildings with particular reference to safety and good engineering practices. It specifies the precautions to be taken regarding wiring in electric installations for ensuring efficient and safe use of electricity including safety from fire and shock. It relates to all electric installations in such locations whether the electric supply is derived from an external source or from a private generating plant.

(*d*) **IS 2309:1989, Code of Practice for the Protection of Buildings and Allied Structures Against Lightning**

This code gives the guidance on the principles and practices in protecting structures against damage from lightning. Guidance is given on how to assess the risk of being struck and in deciding if a particular structure is in need of protection.

(*e*) **IS 3043:1987, Code of Practice for Earthing**

This code gives guidance on methods that may be adopted to earth an electrical system for the purpose of limiting the potential of current carrying conductors forming part of the system.

(*f*) **IS 7689:1989, Guide for the Control of Undesirable Static Electricity**

This Standard covers the recommendations for controlling static electricity generated incidentally by processes, which may present hazards and inconvenience. This standard details the principal methods for safe control and dissipation of static electricity generated by solid objects, persons, liquids, dusts and gases. It contains information about the factors involved in the generation of the static electricity and the danger it can cause in a given environment.

(*g*) **IS 8437:1993, Effects of Current Passing Through Human Body**

This provides basic guidance on the effects of shock currents on the human body for use in the establishment of electrical safety requirements. It specifies the effects of both the types of current ac as well as dc on living organisms.

(*h*) **IS 8828:1996 Specification for Miniature Circuit Breakers**

This standard specifies the requirements of miniature circuit breakers, which ensures the tripping of circuitry in case of overload and short circuit conditions and thus preventing hazards.

(*i*) **IS 12640:1988 Specification for Residual Current Operated Circuit Breakers**

This Specification lays down the requirements of RCCBs/ELCBs which operate and separate the electrical system in the event of any leakage current and thus ensures the safety of the personnel handling the equipment.

(*j*) **IS 13703:1993 Specification for Low Voltage Fuses**

This covers the various types of fuses, which are used in breaking the circuit in the event of overload and short circuit conditions and thus reducing the risk of thermal hazards and fire.

(*k*) **SP (30) : 1986, National Electrical Code**

It is as a document on electrical practices & has been organized in the following parts :—

Part 1 General and Common Aspects
Part 2 Electrical installation in standby y Generating Stations and substations
Part 3 Electrical installation in no-industrial buildings
Part 4 Electrical installation in industrial buildings
Part 5 Outdoor installations
Part 6 Electrical Installations in agricultural premises
Part 7 Electrical Installation in hazardous area

Each part of the National Electric Code covers the requirements relating to electrical installations in specific occupancies. Special considerations & precautions are required for any electrical equipment for use in hazardous areas. Various such features and requirements are given in the next chapter.

59.4. SPECIAL PRECAUTIONS IN DESIGN, INSTALLATION MAINTENANCE OF ELECTRICAL EQUIPMENT IN HAZARDOUS LOCATIONS

The Electrical and Instrumentation equipment to be installed in hazardous locations of chemical and/or Hydrocarbon based processing, manufacturing, storage and/or transportation industry, are to be of special design to ensure that electrical equipment does not become a source of ignition/explosion of the inflammable gases/vapors or volatile liquids and/or dusts/fibers in such areas. There are many types and varieties of inflammable gases, dusts, fibers and liquids and these are grouped together based on their ignition/flash point, relative density and desired concentration of its mixture with oxygen in the air to form combustible source. The arcs/sparks at make-break contacts, and/or the hot surface temperature of electrical equipment can be source of start of ignition of such inflammable elements mixed with air in the atmosphere and which can lead to an explosion.

59.4.1. Elements for Ignition

There are three basic essential elements for ignition to start:

(A) Presence of favorable concentration of inflammable gases/vapours, dust, volatile liquids, fibers, etc.

(B) Arc/Sparks or heated surface temperature enough to ignite.

(C) Oxygen in the air to spread the combustion.

Presence of inflammable elements in Hydrocarbon and chemical process based industry and use of electrical equipment such as Panels, DBs, Junction boxes, Switchgear items, Motors, Generators, Luminaries, Fans, Telephone and Transducers, etc. is invariably required. It is not always practical to install electrical equipment away from hazardous area.) Oxygen is always present in atmosphere. Therefore, only element out of three above, which can be controlled is by the construction and design of electrical equipment to avoid start of ignition/combustion, by ensuring that no arcs/sparks come in direct contact with inflammable elements and equipment surface temperature in continuous as well as fault conditions does not exceed ignition/flash temperature point of inflammable elements. Ignition temperature of a gas/vapor is the lowest temperature at which its ignition occurs under specified condition. Flash point of a liquid is the lowest temperature at which the liquid evaporates and its vapors form inflammable mixture with oxygen in the air to start ignition.

Therefore specially designed electrical equipment have to be installed and maintained with proper care, that its explosion protected features remain always intact, to ensure safety of plant, machinery and personnel in the vicinity of such equipment.

For uniformity in design, construction and testing of such apparatus, Standards and Rules have been formulated in various countries. Independent test houses are established and recognized by statutory bodies to issue a conformity compliance test report to the manufacturer vide relevant Engineering Standards. The statutory approving authorities in each country accord approval, on the application and use of such test certified explosion protected equipment. It is mandatory to use only such test certified approved explosion protected design equipment in the hazardous areas. The development of Ex-protection methods took place around 1905. The first regulation of installation of such equipment in the hazardous areas was published in Germany and USA IN 1934-1935. The European norms for hazardous areas were published by CENELEC in 1972. The Indian Standard IS 2148 was first published in 1962. (Previously India used British Standards.)

Basic concept of explosion protection in various techniques is elimination of arcs/sparks, prompt extinguishing of arcs/sparks (if it occurs) and design the size of enclosure so as to maintain the surface temperature within the ignition limit/flash point of hazardous areas. The explosion protected design is coupled with mechanical design of joints, gaps, openings and inserts, etc. in such a fashion that environmental dust and liquids do not enter inside the enclosure. Care is also taken in the selection of material of construction and/or its painting to prevent corrosion due to acid/alkali fumes, gases and vapors in the vicinity of such apparatus. In such areas the process equipment or systems are also so designed, installed operated and maintained to minimize the release of inflammable elements during working conditions.

59.4.2. Classifications of hazardous areas & its sub-groups

As various explosion protection techniques depend on probability and risk factor of identified hazardous location, European (CENELEC series), British, Indian and standards formulated by IEC are similar on hazardous area classification and gas groups. NEC code of USA has a different classification scheme. NEC also recognizes inflammable dust and fibers as a separate class than gases (vide NEC 500-503). Recently NEC has added Part 505 to make hazardous areas classification in line with EN Series Standards. Vide NEC gases/vapors are Class I, dust as Class II and Fibers as Class III. Whereas vide most of other National standards, gases/vapors/dust/fibers are grouped into 4 Gas Groups only. The differences between NEC of USA and other major standards are—continued non-agreement on division and zone classification, differences in marking scheme on the equipment and differences in wiring and installation methods.

59.5. HAZARDOUS AREAS CLASSIFICATION-ZONES/DIVISIONS

The hazardous areas have been divided into zones take into account to different levels of dangers and likely protection schemes, which take care of both cost and safety.

A. Continuous Hazardous

Areas where Combustible Gas/Vapor/dust/fibers/volatile liquids are continuously present or present for long time. These are normally confined spaces like process vessels, storage tanks or closed containers, etc.

Known as — Zone-0 vide EN-500014, IEC79.1, IS-5572Pt.1 and IS-13346, NEC-505, BS 5501 Pt.1 for Gases/Vapours and Zone-20 vide EN, BS and IEC Standards for Dusts (It is Class-I, Division-1 vide NEC 500 to 503 for Gases and class-II, Division-1 for dusts)

B. Intermittent Hazardous

Areas where inflammable elements may exist under normal working conditions and/or under frequent repair/maintenance operations or where breakdown or faulty operation of process equipment may simultaneously cause failure of electrical equipment.

Known as-zone-1 vide EN 50014 and others as above for Gases/Vapors and zone-21 for Dusts.

(It is Class-I, Division 1 vide NEC 500-503 for Gases and Class-II, Division-1 for Dusts)

C. Hazardous Under Abnormal Condition

Areas where inflammable elements are handled within closed system/enclosures and where its concentration is prevented by the ventilation, *i.e.* areas where hazardous atmosphere occurs only during abnormal operating conditions (simultaneous occurrence of failure of some control system and sparks due to electrical failure). In such areas no danger exists in normal operating conditions. Such areas explosive gas/air mixture occurs for short time only.

Known as zone 2 vide EN 50014 and others as above for Gases/Vapours and Zone-22 for Dusts.

(It is Class-I, Division 2 vide NEC 500-503 for Gases Class-II, Division-2 for Dusts)

Areas adjacent to Zone 1 are also identified as Zone 2 because inflammable Gas/Vapor mixture may occassionally flow into such areas from Zone 1. It is the obligation of process know-how supplier and the process Engineering Consultant who prepare layout of equipment to identify hazardous areas of a Plant/Project in above 3 categories and earmark its boundary limits in both vertical and horizontal plane, around the equipment/area. Exhibit - I may be referred for guidance only for estimation of zones.

Extent of zones is a national division m/km a plant.

59.6. GAS/DUST/FIBRE GROUPS

Inflammable substances can be Gas, Liquid or Solid. Gases are often compound of Hydrogen and Carbon, which require little energy to react with atmospheric oxygen. Inflammable liquids are Hydrogen such as Ether, Acetone and Lighter fuel, which even at room temperature can evaporate to form explosive danger. Other liquids need higher temperature to form vapors.

When liquids are sprayed, a mist consisting of very small droplets with a large overall surface is produced. Such mist also present explosion hazards.

Inflammable solids are in form of dust, fibers and fluff that may react with atmospheric air to produce explosion. Once combustion starts the energy released produces high pressure and temperature.

Different combustible/inflammable elements have been grouped together based on its characteristics like density, flash point/ignition temperature and its lower and upper explosive limit by percentage volume (ratio with oxygen in air). This has been done to standardize the explosion protection technique for a particular gas/dust/fiber group and not design the electrical equipment for each type of gas/vapor/dust, etc. Othere important classification of hazardous areas is its temperature class based on ignition temperature of gas/dust, etc. or flash point of volatile liquids. A representative gas or dust is nominated for each group and design of equipment is based on characteristics of the representative gas/vapor, dust, etc.

Gas Groups : Representative gas name	*Gas group vide EN/IS/IEC/BS and also NEC 505*	*Class vide NEC 500 to 503*	*Group vide NEC 500 to 503*	
Methane*	I	Class I	Group D	(Underground coal mines)
Propane	IIA	Class I	Group D	
Ethylene	IIB	Class I	Group C	(Above ground plants)
Hydrogen	IIC (or IIB + H2 vide NEC 505)	Class I	Group B	
Acetylene	IIC	Class I	Group A	

*Methane in above ground plants (Sewage, LNG) falls under Gas Group II A

Representative dust/fiber name	*Class and group vide NEC 500-503*	*Group Classification vide EN/IEC/IS/BS standards*
Metal dust	Class II Group E	IIA/IIB
Coal dust	Class II Group F	IIA/IIB
Grain dust	Class II Group G	IIA/IIB
Wood/Paper/Cotton (Process fibers)	Class III No sub group	IIA/IIB

59.7. TEMPERATURE CLASS

The temperature rise of electrical products like Light Fitting, Motors, Fans, Generators, MOV, Transformer, etc. is important factor for its suitability in hazardous area. For uniformity and standardization, EN, IEC as well as NEC and IS codes have formulated 6 classes of temperature from T1 to T6, and design of any Ex-protected equipment is tested to determine its temperature class based on maximum surface temperature attained in continuous working. The selection of equipment is such that temperature class must be lower than the minimum ignition point or flash point of explosible elements in that area. The surface temperature attained of an equipment is external surface temperature for Exd type of protection and internal surface temperature for Exe type of protection. Ambient Temperature assumed is normally 40°C and they are suitable for installation in areas of ambient temperature (–) 20°C to (+) 40°C. For areas with ambient temperature higher than 40°C, the product has to be de-rated suitably. If an apparatus is combination of more than one enclosure, the temperature class of the apparatus shall be that of lowest temperature class of various enclosures.

Highest surface temperature of system: Temperature classes are $T1 - 450°C$, $T2 - 300°C$, $T3 - 200°C$, $T4 - 135°C$, $T5 - 100°C$ and $T6 - 85°C$ vide IEC/EN/IS/BS/NEC Codes. NEC 500-503 has sub-groups in T2 to T6 classes (for cost saving in size of enclosures).

Indian standard 2206 part 1 and B.S. 889 have different system of temperature class for only light fittings. These classes are, $X - 125°C$, $Y - 75°C$, and $Z - 50°C$ which is Temperature rise above ambient temperature of 35°C. Therefore temperature class vide these standards for light fittings shall be

$$X\,(125 + 35) - 160°C \mathrel{\hat{=}} T3$$
$$Y\,(75 + 35) - 110°C \mathrel{\hat{=}} T4$$
$$Z\,(50 + 35) - 85°C \mathrel{\hat{=}} T6$$

Temperature classes vide VDE (Germany) are 5 classes, G1 to G5, called ignition groups,

G1 - more than 450°C, G2 - 300 to 450°C
G3 - 200 to 300°C, G4 - 135 to 200°C
G5 - 100 to 135°C

The cable junction boxes (JBs) local and remote control stations, DBs, Panels, Receptacles, Switches and starters, etc. are in general designed for T6 class always by all manufacturers. Temperature rise in electrical apparatus may also be due to insulation failure of wires/cables, Transformers, solenoid valves, Impedance coils, etc which is a condition of temperature rise during fault/breakdown. In motors, generators, and MOV the temperature rise can also be due to overload condition. The temperature class is tested by Test House and recorded in the Type Test Certificate.

59.8. WEATHER PROTECTION

All Ex-Protected equipment design and construction also takes care of environmental protection against ingress of dust/liquids. For the design based on weatherproof protection standards (IP - degree of protection) Exhibit - III gives details of degree of protection. The metallic enclosures are epoxy powder coated to withstand corrosion. In areas where dust accumulation on electrical products cannot be controlled, design has to take care of temperature class due to smouldering temperature of the type of dust in the environment.

59.9. MATERIAL OF CONSTRUCTION, DESIGN CHARACTERISTICS AND CONFORMITY TYPE TEST REPORT

The electrical equipment when in metallic construction has to be of copper free metal alloy to ensure that it does not produce spark when stuck by a metallic tool or hardware dropped on it by accident. Normally Aluminium - Alloy-LM6 is used for above ground installation and Cast Iron for underground coalmines. New trend is to use Moulded Reinforced polypropylene enclosures. For above ground industries only (still not approved vide Indian Standard IS-2148 for zone 1 Areas), design features are according to Engineering Standard to which it is made and tested.

Tests conducted by Test House include study of Detail construction drawings evaluation of materials of construction, Type of joints, Material and size of Hardware, Number and Size of display windows and cable entries, Rating and specification of electrical components. The equipment is actually tested for Explosion test, Flame Transmission test, Over Pressure Test, and IP Test. The detail construction design of manufacturer is also studied and approved by the Test House and the drawing number is recorded in the Type Test Certificate.

The test certificate number is sometimes suffixed by letter U, B, S, or X. If there is no suffix, the product can be used in designated area. The suffix stand for -

U — Test Certificate is not for complete equipment. It is usually for Components or Conduit/Cable accessories (like P.B., I.L., Switches, Meter, Gland, Elbow and other Pipefittings and Blanking plug.

B — Special conditions for installation, which are described in test report.

S — A non Ex-protected apparatus. This apparatus has often Exi circuits, which may be connected, into hazardous areas or this apparatus can be part of Exi circuits.

X — It is a substitute for B and S above, only vide CENELEC standards (EN - Series).

A list of approved Test Laboratories is given in Appendix-IV.

59.10. MARKING ON EX-PROTECTED DESIGN ELECTRICAL EQUIPMENT

Explosion protected design equipment carry a Name plate on cover top to indicate Name of manufacturer, Manufacturer product type number/numbers (in case of Panel, DB, LCS, etc.), Name of Test House, Reference of Standard to which design conforms to, Test certificate Numbers or Numbers, Approval reference of Statutory bodies (as relevant to country of installation) along with type of protection, degree of IP protection and temperature class.

The explosion protection technique is symbolized by letter "Ex" suffixed by type of protection like d, e, i, P, q, O e.g., Ex-d/Ex-e/Ex-P or combination of 2 protection like Ex-ed/Ex-id, as per IS, BS, NEC Standard. Whereas vide European harmonized EN standards the symbol is "EEx" suffixed by type of protection.

This is followed by hazardous zone and Gas group to which equipment has been tested and found suitable by the test House and then by temperature class and last by IP degree of protection. For example, Ex-d IIA/B T4 IP55 or EEx-d IIA/B T4 IP55. The symbol for conformity to EN codes is Ex.

A new scheme (IEC Ex) was published by IEC in Oct'1998 acceptable to all member countries, to minimize multiple testing and certification for a product to be accepted in various countries. It has been declared operative in Sep'1999. Under the scheme a manufacturer obtains an Assessment and Test Report (ATR) from an accepted certification body (ACB) using the work of an IEC Ex Testing laboratory (Ex TL). This ATR is accepted by certification bodies in other countries, when issuing their own national certification. (ACB and Ex TL can be same in many cases) ATR shows evidence of conformity with relevant IEC standards.

Each country when joining IEC Ex scheme is required to declare the differences between its national standard corresponding to IEC standard. On manufacturer request the ATR may include testing and assessment to cover the declared differences. ATR is thus a passport to gain access to different countries. ATR is an IEC Ex certificate of conformity and an IEC Ex marking. At present 19 countries are members (Australia, Canada, China, Korea, Russia, South Africa and 13 European nations) of this schemes. The basis to become member for a country is to get its ACB AND Ex TL approved by IEC Ex scheme governing body after survey of its standards and testing laboratories.

In Europe many EC nations have accepted 'ATEX' Directive (Ref. 94/9/EG) of 1995, which is being used for Ex-protected Equipment marking for zone-2 areas only. Under 'ATEX' manufacturers have option to build and Test Ex-Protection Equipment based on performance testing and not strictly confirming to laid out Engineering Standards. Such ATEX approved equipment is marked 'CE'. Under this scheme manufacturer is responsible for documenting and certifying the equipment. ATEX allows performance testing of product, instead of testing production facilities and construction standards. The 'CE' marking means equipment meet all EC directives. This CE mark and manufacturers declaration of conformity replaces legal testing norms, for zone 2 areas equipment only. Equipment for zone 0 or zone 1 still requires test certificate of approved test lab. ATEX has fixed June 30, 2003 dead line for manufacturers who wish to use CE mark, to have their quality systems in place, before getting approval of ATEX to use 'CE' mark on zone 2 area suitable equipment.

Association of electrical manufacturers of North America (NEMA) and test laboratory 'UL' in USA have standardized enclosure construction for Ex-Protection, to 2 Types only, which are marked on the equipment as relevant (NEMA 7 or NEMA 9, refer Exhibit - III).

59.11. MAINTENANCE OF EX-PROTECTED EQUIPMENT

It is very important that plant owners and Maintenance Engineers/Technicians must know and operate Ex-Protected Equipment in their plants, as per standard Norms and Care.

1. **First principle :**

— De-Energize/Isolate power supply before any opening of cover of Ex-protected Equipment
— Avoid using hammers and sharp tools, which damage flat joint surfaces.
— Always use right size of allen-key only, for cover bolts.

2. **Types of maintenance :**

— Preventive - Routine inspection and checks
— Repairs/replacement
— Statutory audit/inspection

3. **Visual inspection (once in every 4 to 6 months) :**
   1. Check for any Mechanical Damage, Corrosion, Dust collection, Condensate collection, Loose hardware, condition of Connectors and Cables, Tightness of clamps, condition of glass display windows and glass covers of light fitting and any visible cracks on equipment.
   2. Check for Tightness of cover Bolts/Threaded joints. See no cover bolts are missing and are not loose.
   3. To clean exteriors of dust/dirt, Touch up with correct quality of paint.
   4. To Ensure earth connections tight.
   5. To Remove dust/dirt from insulating materials, Check insulators are not discolored or damaged.
   6. Check condition and connection of components in "Exi" circuits, Check and measure open circuit voltage of Exi terminals.
   7. To Check Nameplate data is legible and no deterioration of markings on tag plates. Do not temper with nameplate data.
   8. To See no unused cable entry is blank. Use proper size and test certified blanking plugs with correct type of threads. Check over pressure reading of Ex-p apparatus.
   9. To Check flexible cable of portable equipment, Hand Lamp and Extension receptacle boards, etc., to be intact, properly connected and no extra load of any kind applied on such leads.
   10. To Check dielectric strength of Exi circuits, *i.e.* IR valve between intrinsically and non-intrinsically safe terminals is within limits.
   11. To check there is no undue vibration.
   12. To check oil levels of oil filled protected enclosure and sand level of sand filled protected enclosure.

4. **Routine maintenance (once in every 6 to 12 months) :**
   1. To remove rust/corrosion from joint gaps use CTC/Brush. Do not use files/abrasives. Do not place covers on surfaces that might damage/scratch flat joints.
   2. Topping up of Oil/Sand as relevant in Ex-protection models; To check Electrical and Mechanical Interlocks in Ex-p protected apparatus.
   3. Lamp replacement, removal of condensed water (if any).
   4. Check Emergency light fitting - Check for correct connection, Indicating light, switch and its ON/OFF working.
   5. Check performance of P.B. Actuators, Switch shaft, Limit Switch rollers, MCB, ELCB and O/L relay and resetting knobs, etc., for any malfunction/deterioration etc.

6. Check condition of gaskets for any cracks/deformation. Replace with genuine material and shape of gaskets only.
7. Check condition of Bearing, for leakage, deterioration of oil/grease and replace as desired. Use specified grease only.
8. To check and measure flame-path length and joint gaps with Vernier/Feeler gauges and verify it with standard norms for Exd and/or Exi enclosures.
9. Check aluminium alloy flanges for shape and damage. Clean flange joints of dirt/dust and apply suitable grease. Check that all surfaces that form flame-path are in tact and protected from damage. Check no foreign material in joints or between cover and enclosures. Never use metal tools or abrasives to clean flame-path.
10. Always use proper size and thread type of test certified cable glands. Never try any fresh Drilling/Tapping in Ex protected enclosures OD/UAD Grommets (Bushes) in a gland must be compatible with cable data.
11. When replacing cover bolts/Screws, always use specified size and material. Always use proper size of allen-keys.
12. Always maintain standard gaps when doing re-assembly of Rotors, Shafts and Bearing, etc.
13. Check IR value with megger before assembly after maintenance jobs to maintain integrity of insulation to avoid any accidental sparking or arcs.
14. No maintenance or checking of any sort shall be ever done on live parts.
15. Always take written permission of concerned plant manager before any repair/maintenance job is done in hazardous areas.
16. Check all enclosures and non-current carrying metal parts of fixed and portable equipment is properly grounded after each repair jobs, care is taken to avoid ignition due to static electricity. Cathodic protection system shall be maintained as per standard codes and circuits.

5. **Repair jobs (when required) :**

1. Replacement parts must be genuine and identical only. (Any modification must be done with Manufacturer consent or by Manufacturer only.) Alterations done without authorization invalidate the Type Test Certificate.
2. Flame-paths/gaps are measured with Feeler gauges, Vernier and Taps after each repair jobs.
3. Check operation and function of operating Shafts, Handles, Actuator rods, etc. after reassembly.
4. Check condition of Gasket (0 or V Shape), Ensure fitting of Gasket in designated groove only after repair jobs. Replace gaskets with specified material and type only.
5. Dome glass when broken must be replaced with correct specified glass, cemented in metal ring for Exd and with rubber ring for Exe light fittings.
6. When terminating external cables, ensure cable conductors not subject to any tension. Check all connections are tight.
7. Check and measure surface temperature of Ex protected apparatus and ensure it is within specified temperature class of the area, after any repair job on Ex protected equipment.
8. Follow Sr. Nos. 9 to 16 of Routine Maintenance jobs as above after every repair job.
9. It is important, Plant owner shall keep in their records "AS BUILT" GA Drawings, conformity test certificates, Approvals of statutory bodies wiring diagrams, Reference list of comptible spare parts, Rating, Make and specification of electrical components used in assembly as well as Instruction manuals of the manufacturer. User shall also keep a log book/register to keep record of all repair jobs done as well as any incidents of Fire, Malfunctioning and of Explosion.

6. **Statutory audit/inspection (once in 1.5 to 2 years):**

It should be by chartered certified consulting engineers and/or by Inspector/Controller of explosives as per rules in the country of installation. The frequency of visual/Routine/Statutory Inspections can be revised based on process conditions and environmental conditions or after each fire and explosion.

59.12. DUTIES AND OBLIGATIONS

Manufacturer. To manufacture and sell all equipment strictly in line with certified approved detail construction drawing reference as indicated in conformity test certificates of test house. The test house approved detail construction drawing shall be shown on demand at manufacturer works to the buyer for verification of material of construction, dimensions, thickness of enclosures, special condition of test report (if any), size and openings of display windows, cable entries, Glass Type and thickness, and rating of components including glass, resin and cement/chemicals used in construction. Name plate of product shall also show relevant approval reference of statutory bodies. DIRECTOR GENERAL MINES SAFETY (coal, oil/gas mines), CHIEF CONTROLLER OF EXPLOSIVES (for all chemical and petrochemical industries), DIRECTOR GENERAL FACTORY ADVISORY SERVICES AND LABOUR INSTITUTE (for all industries) and ISI mark license Number issued by Bureau of Indian standards are the relevant approving authorities in India. Each Product shall be supplied with copy of Test house Type Test Certificate and works routine test reports (Hydraulic Test, IR Test, HV Test, Wiring circuit tests and functional tests).

Plant Owner/User. To install the equipment as per guidelines of hazardous areas and electricity rules, the equipment erection and cable termination are to be approved by statutory body in country of installation before commissioning. Copies of conformity test certificates and approvals must be available with user for reference of statutory body. Plant owner/user has to notify the approving statutory body promptly at time of any major/minor explosion or fire in hazardous areas. Routine Maintenance and inspection must be done as per factory/standard norms.

The Ex-protected equipment shall be properly serviced and maintained. A Log Book/Register shall be maintained to record all Maintenance/Repair jobs done and incidents of Sparking, Fire and Explosion, etc. for use in future audit jobs. Any special condition in conformity test certificate of recognized test house must be observed during repair jobs.

59.13. SELECTION OF RIGHT VARIETY OF EX-PROTECTED EQUIPMENT

Electrical and instrumentation equipment for hazardous areas shall be selected based on zone and gas group classification, Temperature class, Environmental protection desired and material of construction as per purchase requisition. Special consideration has to be given for non-hazardous area equipment, which is associated with hazardous area equipment of intrinsically safe design and sometimes of increased safety design also. The equipment shall be of design out of recognized Ex protection techniques with a conformity test certificate issued be a recognized test house vide standards approved and recognized in the country of installation. The explosion protection technique of equipment shall be compatible with hazardous area class, gas group (when relevant) satisfactory to thermal stability and any special condition of Conformity Test Certificate, as well as ambient Temperature, environmental protection desired and external cable sizes as per permissible cable entries in the equipment. Some equipment into which fluids may be introduced during the process (like pressure switch or canned motor pumps, where under fault condition diaphragm can fail and fluid under pressure released inside the apparatus) which is a ignition risk and its installation must be as per conditions in conformity test certificate.

Vide EN and NEC codes, user can assemble test certified enclosure with test certified components (like P.B., I.L., Meters, Switches etc.) In such cases only the test certified components vide standards acceptable in country and area of installation, shall only be selected by the user.

59.14. EXPLOSION PROTECTION TECHNIQUES

A. **Primary Ex-Protection.** It aims at substituting an inert product for inflammable substance or reduces quantity of Air/Oxygen that it does not form explosive mixture. Increase Air circulation or have equipment in open areas to reduce danger. Provide artificial ventilation and use Gas/Smoke detection, which would give alarm and/or shut down the system in case of Air/Gas mixture ratio exceeds set limits. Third element to prevent explosion is avoidance of source of ignition i.e. Electrical sparks (static discharge or when circuits are broken) friction and impact sparks (when castings or enclosure are struck) and hot surfaces (due to heat of Lamp, Brakes, Bearing and coils). Other ignition sources are flames or hot gases, lighting, ionizing, radiation, intense electromagnetic radiation, etc.

B. **Secondary Ex-Protection.** An explosion protected electrical equipment is not necessarily a totally encapsulated or totally sealed unit. There are 7 Known types of protection techniques, which revolve round principles that electrical equipment does not become a source of ignition, *i.e.* parts to which a potentially explosive atmosphere has free access do not become hot enough to ignite explosive mixture. The Protection feature, design construction details and Test acceptance norms are described in relevant Engineering standard of corresponding Ex-Protection scheme.

1. *Type M or type h - hermatically sealed.* It is totally sealed or Encapsulated design, in which parts that can ignite gases/vapors are enclosed (hermetically sealed) with a resin sufficiently resistant to environmental influences. It is mainly used for Miniature motors, Indicating Lamp, Meters, Small Compressors, Limit Switches and Electronic circuit boards. Suitable for zone 0, 1 and 2 areas, any gas group.

2. *Type q - sand filled/powder filled.* The electrical equipment is fitted in an enclosure which is filled with fine granulated sand (Quartz) of size 1.6 mm maximum and having 0.1% by weight of water, so that any arc occurring within the enclosure will not ignite the surrounding atmosphere and arc thus occurring is extinguished in sand itself, so no ignition is caused by flame or excessive temperature of surfaces of the enclosure. It is mainly used for fuse banks, Capacitor Banks, Resistance Banks, Small transformer or electronic circuit boards. The safe filling height of sand is determined by the rating of equipment and type tests. The minimum distance between bare live parts and enclosure wall shall be 5 mm to 10 mm. The enclosure must withstand over pressure test and withstand explosion within. It is suitable for zone 1 and 2 areas. The enclosures can be sheet metal fabricated or of castings.

3. *Type O - oil immersion.* Similar to Type q above, here sand is replaced by Mineral Oil, Minimum oil immersion height is determined by the rating and type tests. The maximum oil temperature shall remain within temperature class of area. High and Low oil level limits are mentioned on the enclosure. It is mainly used for Switching units, Circuit breakers and Transformers. Oil is a fire hazard, so special attention in maintenance and operation of such apparatus. Suitable for zone 2 areas.

4. *Type P - pressurized apparatus.* In this the whole electrical apparatus such as large size Motor, Generator, Instrument Banks, the room itself where DCS system or Power Control Center or MCC is installed is made safe by Pressurization of the enclosure of Motor/Generator or MCC/PCC room with a protective gas at higher pressure than surrounding atmosphere to prevent entry of surrounding gas/vapors into the enclosure. Over pressure can be maintained with or without continuous flow of protective gas (inert gas like N2 or air.) When flow is continuous, it is called purged gas technique, normally used when whole room is protected. In such a case the access door of the room are mechanically/electrically interlocked with power input to electrical apparatus. Also the operation of pressure control valve of the circulating air/N2 is electrically interlocked with power supply input to the electrical apparatus. The enclosure can be of sheet steel or cast metal. This technique is used where it works out economical compared to Ex-d technique or where electrical equipment is used temporarily for short period only. It is suitable for zone 1 or 2 areas.

5. *Type i - intrinsically safe.* It is a circuitry only and not an enclosure for electrical equipment. Concept is based on circuit design such that current and voltage input to the electrical equipment,

like Sensor, Transducer, Pilot Valve, Control instruments, Communication equipment, etc. in the hazardous areas shall be within limit of ignition energy (MIC - Minimum ignition current) required to ignite inflammable gases/vapors and Air mixture, under normal or anticipated fault condition either having usable power of the order of one watt, open circuit voltage less than 30 volts and short circuit current up to 200 milliamperes. Open circuit voltage is limited by proper selection of cable capacitance and short circuit current by cable inductance. (V and I limits above are in relation to Ethane gas.) There are 2 categories in design, Ex-ia for connection of equipment in zone 0, 1 or 2 areas up to 2 components and up to 2 concurrent faults, and Ex-ib for connection in zone 1 or 2 areas for up to 1 component and 1 fault only.

Interconnection wiring between hazardous and safe areas is through test certified zener barriers/isolators to ensure cutting off of power input when input V and I limit exceed the design limit of Ex-i circuit. Care is taken to ensure Ex-i wires are not electro-statically and magnetically induced by Non Ex-i wires and proper earth connection are always maintained. Ex-i circuit is test certified for specified condition of a hazardous area and cannot be automatically used in any other location.

Advantages of Ex-i design circuits are - Maintenance and Calibration can be done in 'Hot' circuits and it is very economical compared to other techniques which require a suitable design enclosure to assemble electrical apparatus. It is good even for zone 0 areas and Suitable for zone 1 and 2 areas.

6. *Type e - increased safety design.* It is a technique used for zone 2 areas only (any gas group). In this, electrical apparatus is assembled inside a cast metal (CI or LM-6) or Mould Polypropylene (GRP) enclosure, or fabricated sheet metal. Safety features of Electrical component, like terminals, lamp holders, rotating machines (squirrel cage motors) are enhanced to minimize chances of sparking. It is assumed here that no explosion shall take place inside the enclosure. The enclosure size is determined such as to limit the surface temperature within the planned temperature class under maximum rating and fault conditions. Safety is increased by making lamp holder as enclosed Break Type, cable terminals as vibration-proof anti loosening type and added thermal protection devices in rotating machine to cut-off power if temperature exceeds the limit. The enclosure is made sturdy enough to avoid impact effect and mechanical damage. The enclosure is also designed for specified IP degree of weather protection.

This protection is economical compared to Ex-d protection. The joint lengths, Flame-path and Clearances of enclosure and cover are determined by test and standardized in relevant Engineering standards. Ex-e design light fitting is also complete with Restrictive breathing design for entries and joint gaps. This ensures that influences of external environment is minimum inside the enclosure and explosive atmosphere is unlikely to occur in normal working condition. This technique normally used for light fitting and meters and for cable terminal boxes, etc. Ex-e enclosures can be used with test certified Ex-d components in combined type of protection, Ex-ed suitable for zone 1 areas.

7. *Type d - flameproof (explosion proof) design.* This is most widely used technique. It is suitable for zone 1 areas. In this also the electrical equipment is assembled inside a cast metal (CI or LM-6) or moulded reinforced polypropylene (GRP) enclosure. Concept is that enclosure is sturdy enough to withstand an explosion, if it occurs inside the enclosure and its gaps and joints are such that flame gets cooled and extinguished when it travels within the enclosure, before getting out from the gaps and joints of enclosure. The transmission of flame outside is prevented by toleranced flame-paths, based on maximum emission safe gap (MESG) test for different varieties of gases/vapors. The enclosure design is different for gas group IIA/IIB and for gas group IIC. However, an equipment approved for zone 1, IIC group can be used also in zone 1, IIA/IIB, but vice versa is not true. The enclosure size is determined by planned temperature class of application. The enclosure design is coupled with IP degree of protection and impact resistance as desired for proposed application.

The thickness of enclosure, flame path length, gap width and length, type of joint (Bolted or Threaded or flanged types), the openings for display windows and for Shaft, Bearings, Spindles, etc. are maintained as per standard limit and norms determined by laboratory tests and stand-

ardized in relevant Engineering Standards. The Exd design is used for almost all type of electrical equipment, like light fitting, control station, motors, fans, telephones, MOV, solenoid valves, junction boxes, cable conduit accessories, etc. Flameproof concept shall not be related in any way however with fireproof. Also to be noted that Exd or Exe enclosures are not Gas/Air tight. Engineering Standards associated with the various types of protection techniques.

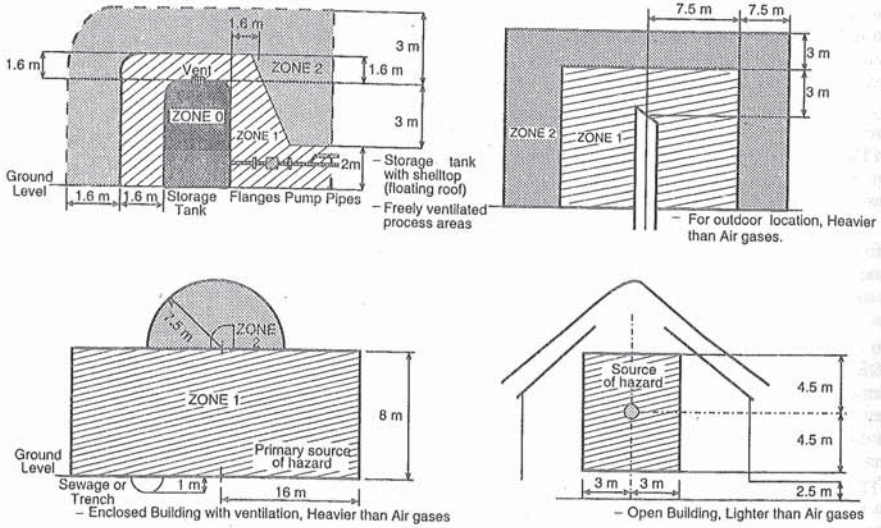


Fig. 59.1. Classification of hazardous area.

59.15 LIGHTNING PROTECTION OF STRUCTURES WITH EXPLOSIVE OR HIGHLY FLAMMABLE CONTENTS

(This is only for information of students - for field application codes & Practices to be followed)

The presence of explosives or highly flammable materials in a structure may increase the risk to persons or to the structure and the vicinity in the event of a lightning stroke. For this reason higher degree of protection is essential for these structures. Protection of a different degree may be secured in the case of both self-protecting and other structures by installation of various types of protection equipment, such as vertical and horizontal air terminations and other means. The recommendations given below should be followed for structures in which explosive or highly flammable solids, liquids, gases, vapours or dusts are manufactured, stored or used or in which highly flammable or explosive gases, vapours or dusts may accumulate.

PRECAUTIONS. Following precautions should be taken for the protection of structures and their contents from lightning.

(*a*) Storage of flammable liquids and gases in all-metal structures, essentially gas-tight,

(*b*) Closure or protection of vapour or gas openings against entrance of flames,

(*c*) Maintenance of containers in good condition, so far as potential hazards are concerned,

(*d*) Avoidance, so far as possible, of the accumulation of flammable air-vapour mixtures about such structures.

(*e*) Avoidance of spark gaps between metallic conductors at points where there may be an escape or accumulation of flammable vapours or gases.

(*f*) Location of structures not inherently self-protecting in positions of lesser exposure with regard to lightning, and

(*g*) For structures not inherently self-protecting, the establishment of zones of protection through use of earthed rods, masts, or the equivalent.

59.16. GENERAL PRINCIPLES OF PROTECTION

For the protection of structures with explosives or highly flammable contents an air termination network should be suspended at an adequate height above the area to be protected. If one horizontal conductor only is used, the protective angle adopted should not exceed 30°. If two or more parallel horizontal conductors are installed, the protective angle to be applied may be as much as 45° within the space bonded by the conductors, but it should not exceed 30° outside that space. The height of the horizontal conductor should be sufficient to avoid all risk of flashover from the protective system to the structure to be protected. The supports of the network should be adequately earthed.

Where this method may be expensive and where no risk is involved in discharging the lightning current over the surfaces of the structure to be protected, a network of horizontal conductors with a spacing of 3 m to 7.5 m, according to the risk, should be fixed to the roof of the structure. If the vertical conductor is separate from the structure to be protected, the minimum clearance between it and the protected structure shall be not less than 2 m; this clearance should be increased by 1 m for every 10 m of structure height above 15 m to prevent side flashes. Also the minimum clearance between the suspended horizontal air termination and the highest projection on the protected structure shall be 2 m.

A structure which is wholly below ground and which is not connected to any services above ground may be protected by an air termination network since soil has an impulse breakdown strength which can be taken into account when determining the risk of flashover from the protective system to the structure to be protected, including its services. Where the depth of burying is adequate, the air termination network may be replaced by a network of earthing strips arranged on the surface.

59.17. TYPES OF LIGHTNING PROTECTION SYSTEM

These are generally of the integral mounted system with the horizontal air terminals running along the perimeter of the roof in all cases except for buildings containing highly sensitive explosives & very small buildings. The following types of protection have been given in various Codes :-

Type of Building	*Recommended Type of Protection*
Building with explosives dust or flammable vapour risk	Integrally mounted system with vertical air terminals 1.5 m high and horizontal air terminals spaced 3 to 7.5 m from each other depending on the type of storage and processes involved
Explosives storage building and explosives workshops	Integrally mounted system with vertical air terminals 0.3 m high and horizontal air terminals spaced 7.5 m.
Small explosives storage buildings	Vertical pole type
Buildings storing more dangerous types of explosives, for example, nitroglycerine (NG) and for initiatory explosives manufacturing	Suspended horizontal air terminations at least 2 m higher than the structure and with a spacing of 3 m.

The earth terminations of each protective system should be interconnected by a ring conductor. This ring conductor should preferably be buried to a depth of at least 0.5 m unless other considerations, such as the need for bonding other objects to it, testing, or risk of corrosion make it desirable to leave it exposed in which case it should be protected against mechanical damage. The resistance value of the earth termination network should be maintained permanently at 10 ohms or less.

59.18. BONDING

All major members of the metallic structure, including continuous metal reinforcement and services, should be bonded together and connected to the lighting protective system. Such connections should be made at least in two places and should, so far as is possible, be equally spaced round the perimeter of the structure at intervals not exceeding 15 m. Major metalwork inside the structure should be bonded to the lightning protective system. Electrical conductors entering a structure of this category should be metal-cased. This metal casing should be electrically continuous within the structure. It should be earthed at the point of entry outside the structure on the supply side of the service and bonded directly to the lightning protective system. Where the electrical conductors are connected to an overhead electric supply line, a length of buried cable with metal sheath or armouring should be inserted between the overhead line and the point of entry to the structure and a surge protective device, for example, of the type containing voltage-dependent resistors, should be provided at the termination of the overhead line. The earth terminal of this protective device should be bonded direct to the cable sheath or armouring. The sparkover voltage of the lightning protective device should not exceed one-half the breakdown withstand voltage of the electrical equipment in the structure. Metallic pipes, electrical cable sheaths, steel ropes, rails or guides not in continuous electrical contact with the earth, which enter a structure of this kind, should be bonded to the lightning protective system. They should be about 75 m away and the other a further 75 m away.

59.19. OTHER CONSIDERATIONS

For a buried structure or underground excavation to which access is obtained by an adit or shaft, extra earthing should be followed for the adit or shaft at intervals not exceeding 75 m.

The metal uprights, components and wires of all fenes, and of retaining walls in close proximity to the structure, should be connected in such a way as to provide continuous metallic connection between themselves and the lightning protective system. Discontinuous metal wire fencing on non-conducting supports or wire coated with insulating material should not be employed.

The vents of any tanks containing flammable gas or liquid and exhaust stacks from process plants emitting flammable vapours or dusts should either be constructed of non-conducting material or be filled with flame traps.

Structures of this category should not be equipped with a tall component, such as spire or flagstaff or radio aerials on the structure or within 15 m of the structure. This clearance applies also to the planting of new trees.

59.20. GROUP CLASSIFICATION OF INFLAMMABLE GAS/VAPOR

(Figure in Brackets is Auto Ignition Temperature in °C)

(A) *Gas Group D of NEC or Group I vide EN/IS/BS/IEC*

1. Methane (537)

(B) *Gas Group C and D of NEC or Group - IIA/IIB vide EN/IS/BS/IEC*

1. Acetaldehyde (175)
2. Amyl Acetate (360)
3. Butadiene (175)
4. N-Butylvaldehyde (218)
5. Carbon Monoxide (609)
6. Isoprene (220)
7. Acetone (465)
8. Ammonia (498)
9. Ethyl chloride (405)
10. ChloraEthylene (350)
11. Butane (288)
12. Benzene (498)
13. Naphtha (288)
14. Ethanol (363)
15. Ethyl Acetate (427)
16. Hexane (225)
17. Methyl Acetate (454)
18. Ethane (472)

19. Methanol (385)
20. Propane (450)
21. Pentane (243)
22. Xylene (464)
23. Di-ethyl Ether (160)
24. Ethylene (450)
25. Ethylene (340)
26. Gaselene (260 - 471)
27. Coke oven gas (250)
28. LPG (Propane+Butane) (205)
29. Hydrazine (23 to 270)
30. Marsh gas (methane) (515)
31. Water gas (H2 + CO) (415)
32. Producer Gas (CO + N2) (455)
33. Ethylene Glycol (238)
34. Natural gas (Methane + Hydrocarbons) (426)
35. Hydrogen Sulphide (260)
36. Town Gas (350 - 500)
37. Ethylamine (380)
38. Ether (60)
39. Toulene (480)
40. Acetic Acid (464)
41. Carbon Disulphide (90)

(C) *Gas Group A and B of NEC or Group IIC vide EN/IS/BS/IEC*

1. Hydrogen (520)
2. Acetylene (305)
3. Ethylene oxide (429)
4. Formaldehyde gas (428)
5. Fuel and Combustible process containing > 20% H2 by volume (200 to 400)

(2) Group classification of Dust

(A) Group E of NEC: Metal dusts (Aluminium Alloy, Boron, Calcium, Silicate, Chromium, Magnesium, Thorium, and Titanium.)

(B) Group F of NEC: Coal dusts (Asphalt, Charcoal, lignite coal coke dust)

(D) Group G of NEC: Grain dusts, (cork, almond, cellulose, citrus peel, cocoa, corn, rice bran, sugar, powdered walnut shell, wheat starch, wood flour yeast, drugs, dyes, pigments, intermediate, pesticide, thermoplastic resins and moulding compound, nylon resins, epoxy resins.

(3) Group classification of Volatile liquids - vide IS-5572 Part-1 and Petroleum code of CCE, India, divided into 3 classes based on flash point. It is the lowest temperature at week sufficient quantity of vapors will advise to permit its ignition under laboratory condition.

1. Class A — for Flash Point up to 25°C
   Aviation fuel, Gasoline, Benzene, Low F.P. Naphtha, Chlorobenzene
2. Class B — for Flash Point from 26 to 60°C
   Kerosene, Diesel, Edible Oil, High Flash Point Naphtha, Styrene, Turpentine
3. Class C — for Flash Point from 61 to 94°C
   Furnace oil, Fuel oil, Phenol and heavy petroleum

Notes : (1) The above is not complete exhaustive list of all inflammable elements.

(2) Group 2 above are Gas Group IIA and IIB vide EN/IS standards, class III Group fibers and fluff vide NEC have further no sub groups.

(3) Please refer Engineering Standards, Hand Books or manufacturers manuals for characteristics like Density ignitions point flash point and maximum and minimum gas/air mixture limits of various inflammable elements.

Table

First Digit	*Degree of protection against contact and foreign bodies*	*Second Digit*	*Degree of protection against water*
0	No special protection	0	No special protection
1	No protection against conscious entry, however exclusion of large body surfaces, protected against foreign bodies over 50 mm diameter.	1	Protection against drops of water falling vertically.
2	Exclusion of finger and similar parts protected against foreign bodies over 12-mm diameter.	2	Protection against drops of water falling at 15° to vertical.
3	Exclusion of wires, etc. over 2.5 mm diameter, protected against foreign bodies over 2.5 mm diameter.	3	Protection against water spray falling at 45 to 60° to vertical.
4	Exclusion of wires, etc. over 1 mm diameter, protected against foreign bodies over 1 mm diameter.	4	Protection against water spray from any direction.
N5	Complete protection against contact, protection against harmful dust deposits (Dust Protected).	5	Protection against jets of water from any direction at specified force (size of sets and distance as per standards).
6	Complete protection against contact, protection against the entry of dust (Dust tight).	6	Protection against heavy seas or strong jets of water.
		7	Protection against harmful entry of water when dipped in (submerged in water for long time).
		8	Protected against entry of water when submerged (indefinite immersion).

QUESTIONS

1. Name three important IS related to electrical safety ?
2. The IS which deals with the requirement of Residual Current operated circuit breakers is ?
   (*a*) 13703 (*b*) 12640 (*c*) 8828 (*d*) 732,
   Ans. (*b*)
3. What are the three basic essential elements for ignition to start ?
4. What is the importance of operating temperature limit of electrical equipment in hazardous areas.
5. Discuss (*a*) Primary Ex-Protection (*b*) Secondary Ex-Protection
6. What is meant by Ex-Protected design of Electrical/Electronic Products.
7. What is degree of Protection.
8. N5 degree of protection ensures.
9. Discuss briefly the type of lightning protection of structures/buildings with Explosive or Highly flammable contents.

Appendix-A

Recent Trends and Advances Towards 21st Century

Introduction — Standards and Organisations for Quality Management (QM) — ISO 9000 Certification — BVQI Certificate of Quality Management — Feedback Loop of Site Quality and Interfaces — Interaction between Power Systems, Load, Equipment and Protection/Control/Monitoring/Dignostics — Fault Investigations — Event Recorders — Expert Systems — SCADA — Modern Control Room Facilities for Fault Investigations — *Intelligent Circuit Breakers. Electrical Safety Management* and *Safety Aspects* — Unsafe conditions and acts — Safety Procedures. *Intelligent Air Insulated Substations,* (IAIS) Control and Protection Systems with Fiber Optic Cables — Fiber Optic Cables for Data Transmission, Measurement, Protection, Monitoring Systems — Fiber Optic Cables with Transmission Lines — *Digital Optical Instrument Transducer* (DOIT) — Fiber Optic CT — Communication in Power System — *Satellite Communication.*

A.1. INTRODUCTION

The electric power systems, switchgear protection and power system automation have undergone significant advancements during the last quarter of the twentieth century. *Trends* are set for new, versatile, maintenance-free, compact, reliable, safe, user-friendly, automatic equipment. The *reliability* and *availability* of power systems, plants and equipments has gained significance. The power systems, market trends, manufacturing trends are undergoing intense restructing as a result of privatization, economic reforms, energy crisis and market pressures on cost. The significant trends have been reviewed in this concluding chapter*.

A.2. STANDARDS AND ORGANISATIONS FOR QUALITY MANAGEMENT (QM)

Quality certification for plants, equipment and services has gained importance. The following organisations publish the standards related with specifications and quality of equipment, plants and services.

— International Standards Organisations (ISO) Head Quarters : Geneva, Switzerland.

— Indian Bureau of Standards (Former Indian Standards Institution), New Delhi.

— Bureau Veritas Quality International (BVQI).

The list of ISO and IS Standards on Quality is given below. These standards are followed by Manufacturers, Consultants and Customers (users) of electrical plants and equipment.

ISO	*IS*	*Title*
ISO : 9000	IS : 14000	Quality Management and Quality Assurance Standard. Selection and Use : 20 Systems Elements
ISO : 9001	IS : 14001	Level 1 : Design/Development Prodution, Testing in Factory Installation and Servicing
ISO : 9002	IS : 14002	Level 2 : Production and Installation all elements, some less stringent.
ISO : 9003	IS : 14003	Level 3 : Final Inspection and Tests – half the elements, low stringent.
ISO : 9004	IS : 14004	Guidelines : Maximising benefits and minimising costs.

A.3. ISO 9000 CERTIFICATION

ISO 9000 Certification is given to a manufacturer or an organisation as a recognisation of the Quality. The duration of the certificate is 3 years.

* Also refer : Ch. 52, Table 52.2 ; Ch. 43-C, Ch. 46-A Ch. 47, Ch. 48, Ch. 50, Ch. 52 and Ch. 53 for recent advances.