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Safety standards for electrical installations

UN SaferGuard
Securing ammunition, protecting lives

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Warning

The International Ammunition Technical Guidelines (IATG) are subject to regular review and revision. This document is current with effect from the date shown on the cover page. To verify its status, users should consult www.un.org/disarmament/ammunition

United Nations Office for Disarmament Affairs (UNODA)
United Nations Headquarters, New York, NY 10017, USA

E-mail: conventionalarms-unoda@un.org

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Foreword

Ageing, unstable and excess conventional ammunition stockpiles pose the dual risks of **accidental explosions at munition sites** and **diversion to illicit markets**.

The humanitarian impact of ammunition-storage-area explosions, particularly in populated areas, has resulted in death, injury, environmental damage, displacement and disruption of livelihoods in over 100 countries. Accidental ammunition warehouse detonations count among the heaviest explosions ever recorded.

Diversion from ammunition stockpiles has fuelled armed conflict, terrorism, organized crime and violence, and contributes to the manufacture of improvised explosive devices. Much of the ammunition circulating among armed non-State actors has been illicitly diverted from government forces.[1] In recognition of these dual threats of explosion and diversion, the General Assembly requested the United Nations to develop **guidelines for adequate ammunition management**.[2] Finalized in 2011, the International Ammunition Technical Guidelines (IATG) provide voluntary, practical, modular guidance to support national authorities (and other stakeholders) in safely and securely managing conventional ammunition stockpiles. The UN SaferGuard Programme was simultaneously established as the corresponding knowledge-management platform to oversee and disseminate the IATG.

The IATG also ensure that the United Nations entities consistently deliver high-quality advice and support – from mine action to counter-terrorism, from child protection to disarmament, from crime reduction to development.

The IATG consist of 12 volumes that provide practical guidance for 'through-life management' approach to ammunition management. The IATG can be applied at the guidelines' **basic, intermediate, or advanced levels**, making the IATG relevant for all situations by taking into account the diversity in capacities and resources available. Interested States and other stakeholders can **utilize the IATG for the development of national standards and standing operating procedures**.

The IATG are reviewed and updated at a minimum every five years, to reflect evolving ammunition stockpile-management norms and practices, and to incorporate changes due to changing international regulations and requirements. The review is undertaken by the UN SaferGuard Technical Review Board composed of national technical experts with the support of a corresponding Strategic Coordination Group comprised of expert organizations applying the IATG in practice.

The latest version of each IATG module can be found at www.un.org/disarmament/ammunition.

[1] S/2008/258.

[2] See also the urgent need to address poorly-maintained stockpiles as formulated by the United Nations Secretary-General in his Agenda for Disarmament, *Securing Our Common Future* (2018).

Introduction (LEVEL 2)

This IATG module[3] describes the requirements and standards for electrical installations, lightning protection, electrostatic protection and electrical/electronic equipment in above ground and underground sites containing or likely to contain explosives. These sites include ammunition storage, processing and handling buildings as well as related facilities and airfields.

[3] Due to the complexity of this issue and the depth of information required this IATG has been primarily adapted from UK JSP 482 (replaced by DSA03.OME part 2 provides for the safe storage and processing of Ordnance, Munitions and Explosives (OME). UK MOD. November 2020).

Safety standards for electrical installations

1 Scope

This IATG module describes the electrical safety standards that should be used in explosives facilities of various types. This module does not apply to non-explosives facilities even if they are in an explosives area. However, the electrical installation and any equipment used in these buildings should comply with national technical authority statutory requirements and specifications to ensure that they are not a risk to explosives facilities. These regulations should be read in conjunction with relevant national technical authority laws and regulations and with international standards.

This IATG module has been written using European standards, against which national standards can be compared to produce equivalent national guidelines. A list of the European Union regulations is provided for reference at Annex D.

2 Normative references

A list of normative references is given in Annex A. These documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

A further list of informative references is given in Annex B in the form of a bibliography, which lists documents that contain additional information related to the contents of this IATG module. .

3 Terms and definitions

For the purposes of this module the following terms and definitions, as well as the more comprehensive list given in IATG 01.40 *Glossary of terms, definitions and abbreviations,* shall apply.

The term 'national technical authority' refers to *the government department(s), organisation(s) or institution(s) charged with the regulation, management, co-ordination and operation of conventional ammunition storage and handling activities.*

The term ‘electrical category’ refers *to the standard of electrical installations and equipment required in an explosive building. The electrical category is the same as the category allocated to the building or area.*

The term ‘explosives facility’ refers to *an area containing one or more potential explosion sites.*

In all modules of the International Ammunition Technical Guidelines, the words 'shall', 'should', 'may' and 'can' are used to express provisions in accordance with their usage in ISO standards.

a) **'shall' indicates a requirement**: It is used to indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

b) **'should' indicates a recommendation**: It is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form, 'should not') a certain possibility or course of action is deprecated but not prohibited.

c) **'may' indicates permission**: It is used to indicate a course of action permissible within the limits of the document.

d) **‘can’ indicates possibility and capability**: It is used for statements of possibility and capability, whether material, physical or casual.

4 Electrical categories (LEVEL 2)

Areas within buildings or facilities should be divided into categories according to the type of explosives that are stored or handled and the processes to be undertaken. Electrical installations and equipment should be of the same category as the area in which they are installed or used. The category of an area or building shall be displayed at the entrance (see example sign at appendix 1 to annex E).

4.1 Mixed category areas (LEVEL 2)

As a result of the processes carried out, some facilities may have rooms, cells or areas that require different explosive categories. A physical barrier should be used to define the different categories. As a minimum, the barrier should be a door and possess sufficient measures to control the migration of dusts or vapours.

4.2 Sublimating explosives (LEVEL 3)

Special measures are necessary when explosives are liable to sublimation. Electrical equipment should not be installed in the building unless it is absolutely essential. In such circumstances, suitable standards shall be specified in conjunction with an explosives chemist who will need to advise on the properties of the explosive in the process.

4.3 Selection of electrical category (LEVEL 2)

Annex E provides an example of a selection algorithm, which may be employed in the selection of the most suitable electrical category. The algorithm should be matched to national legislation and regulations covering explosives atmospheres, degrees of protection against ingression and maximum surface temperatures.

4.4 Category A and associated electrical standards (LEVEL 3)

Category A areas are explosives buildings in which explosives gases and vapours may be present. There may also be a dust hazard and this is covered at Clause 4.8. Category A areas may be further sub-divided into three zones that codify the differing degrees of probability with which explosive concentrations of gases and vapours may arise in terms of both the frequency of occurrence and the probable duration of their existence. These zones are shown in Table 1:

Category A Zones	Definition
Category A Zone 0	An area in which an explosive gas/vapour atmosphere is continuously present or is present for long periods.
Category A Zone 1	An area in which a flammable atmosphere is likely to occur during normal operation.
Category A Zone 2	An area in which a flammable atmosphere is not likely to occur in normal operation but, if one does occur, it will exist for a short time only.

Table 1: Category A electrical zones

4.4.1. Buildings and installations near to Category A areas

Electrical installations and equipment located on the outside of the building or in an adjacent and separate room should be of Category A standard if the gas or vapour hazard extends outside the building. The zone allocated should address the risk of the type of flammable atmosphere occurring. A degree of protection giving additional weather proofing may be necessary.

4.5 Category B (LEVEL 2)

Category B areas exist where the processing and handling of explosives gives rise to an explosives dust atmosphere and/or hazard created by accumulation or settling. Category B areas may not encompass a whole room or building if the extent of any atmosphere created is limited to a local area, for example within a fume cupboard.

Exposed explosives that do not give rise to a flammable or explosive atmosphere or hazard created by dust accumulating or settling during normal use may be processed within Category C explosives buildings.

Only explosives items and explosives processes assessed as capable of generating a flammable or explosive atmosphere or hazard created by dust accumulating or settling during normal service need to be processed in Category B facilities. All explosives, even rubbery propellant, may generate dust. Explosives such as nitro-glycerine may give rise to vapour that can condense to liquid or crystalline explosive. Sublimation may occur during manufacturing processes.

During the decision-making process on the categorisation of an explosive device, it is important to address the packaging/enclosure of the device and its capacity for preventing the egress of dust during the full spectrum of its service environment. Accidental spillage of dust in a Category B environment shall be immediately and safely removed.

Category B zones are summarised in Table 2:

Category B Zones	Definition	Dust Tightness to EN 60528
Category B Zone 20	An area in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods, or frequently.	IP6X
Category B Zone 21	An area in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.	IP6X
Category B Zone 22	An area in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, it will persist for a short time only.	IP5X

Table 2: Category B electrical zones

4.5.1. Buildings and installations near to Category B areas

Machinery rooms associated with Category B buildings, but with no direct access to the explosives area and with no risk of dust and vapour migration, should not be classified as explosives areas. Electrical equipment installed in such areas should be to explosives Category D standard as specified at Annex G. Weather proofing may be required for outdoor installations.

4.6 Category C (LEVEL 2)

Category C is the standard for all explosives buildings in which explosives do not give rise to flammable vapour or explosive dust at normal storage temperature. Electrical equipment and installations should comply with the specifications at Annex F.

4.6.1. Buildings and installations near to Category C areas

Machinery rooms associated with Category C buildings, but with no direct access to the explosives area and with no risk of dust and vapour migration, should not be classified as explosives areas. Electrical equipment installed in such areas should be to explosives Category D standard as specified at Annex G. Weather proofing may be required for outdoor installations.

4.7 Category D (LEVEL 2)

This standard applies to buildings, rooms, etc. where small quantities of explosives, except Hazard Division (HD) 1.1, are stored as agreed with the head of establishment and/or national technical authority. The explosives shall not be exposed and shall not give rise to flammable vapour or explosives dust. The Category D standard also applies to some plant rooms but it is not intended to allow storage of explosives in these rooms. Electrical equipment standards are at Annex G.

4.8 Combined Category A and B areas (LEVEL 3)

Should it be necessary to classify areas as having both flammable vapour/gas and dust atmospheres, the areas concerned shall meet the requirements for both Category A and Category B facilities. National technical authority standards (or if necessary international standards) can provide for gas and dust risks to be accommodated in a single equipment design and electrical equipment providing both gas and dust protection is widely available.

4.9 Surface temperature of equipment (LEVEL 3)

National technical authorities may develop their own temperature classifications, but Table 3 below shows commonly used standard maximum surface temperature levels.

Class	Maximum Surface Temperature Level (^{0}C)
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

Table 3: Surface temperature classification levels

The design surface temperature limitations for electrical equipment under normal conditions should not exceed the following:

a) for Category A facilities: the appropriate T Class, or 135°C whichever is the lower;

b) for Category B facilities: 135°C;

c) for Category C facilities: 135°C, with the exception of water or oil filled radiators which should be 85°C; and

d) for Category D facilities: there is no specified number but may follow the limits for Category C.

4.10 Electrical protection specific to Category A zones (LEVEL 3)

The national technical authority regulations concerning electrical protection in Category A should meet and apply the protective requirements as set out below at Table 4. The appropriate European (EN) standards are shown to enable comparison with national standards.

Type of Protection	Symbol	Description	Use in Category A Zones	EN Standard
Intrinsic Safety	Ex ia	Limits the energy of sparks and limits the temperature but includes specified fault conditions.	0,1 and 2	EN 60079-25:2004 EN 50020:2002
Intrinsic Safety	Ex ib	Limits both the energy of sparks and the temperature.	1 and 2	EN 60079-25:2004 EN 50020:2002

Type of Protection	Symbol	Description	Use in Category A Zones	EN Standard
Increased Safety	Ex e	No arcs, sparks or hot surfaces.	1 and 2	EN 60079-7:2003 EN 50019:2000
Oil Immersion	Ex o	Keeps flammable gas away from any hot surfaces and ignition-capable equipment.	1 and 2	EN 50015:1998
Encapsulation	Ex m	Keeps flammable gas away from any hot surfaces and ignition-capable equipment.	1 and 2	EN 60079-18:2004 EN 50028
Powder (Quartz / Sand Filled)	Ex q	Contains an explosion and quenches flames.	1 and 2	EN 50017:1998
Pressurised Apparatus	Ex p	Keeps flammable gas away from any hot surfaces and ignition-capable equipment.	1 and 2	EN 60079-2:2004 EN 50016:2002
Flameproof	Ex d	Contains an explosion and quenches flames.	1 and 2	EN 50018:2000 EN 6079-1:2004
'n' Type Protection Non Sparking Enclosed Break Energy Limitation Simplified Pressurisation Restricted Breathing	Ex n Ex nA Ex nW Ex nL Ex nP Ex nR	A type of protection applied to electrical apparatus such that, in normal operation, it is not capable of igniting a surrounding explosive atmosphere and a fault capable of causing ignition is not likely to occur.	2	EN 60079-15:2003 EN 50021:1999

Table 4: Category A electrical requirements

4.11 Electro-magnetic compatibility (EMC) (LEVEL 2)

Electromagnetic emissions from electrical equipment used in explosives buildings should be controlled to ensure the protection of: 1) any electrically initiated devices (EID), including electro-explosive devices (EED) in ammunition; 2) electronic equipment and radio receivers associated with weapons; and/or 3) control systems in the explosives buildings or in the near vicinity of these buildings.

Ammunition should have its electronic circuitry assessed against a national technical authority specified radio frequency (RF) environment. Such assessments are required, as part of the introduction into service process, for the ammunition in all modes of packaging, operation and testing. When packed in its approved container, stores are normally considered to be protected against the Electro-magnetic (EM) environment; but when unpacked, under test or during processing operations, their EM vulnerability susceptibility may be considerably increased.

To prevent radiation hazard (RADHAZ) problems, deliberate RF transmitters should in general be prohibited in explosive storage areas (ESA) and buildings. This includes low power transmitters such as those found in wireless LAN and Wi-Fi systems and personal radio transmitters. However, it is recognised that some of these may be required in ESA and buildings and they may therefore be allowed on a case by case basis.[4]

4.11.1. Compatibility levels in storage buildings (LEVEL 2)

EMC performance levels of electrical equipment in explosive storage buildings should meet national technical authority requirements. As a guideline, EU norms (EN) are shown below at the level necessary to ensure as low as reasonably practicable (ALARP) protection:

a) in storage buildings, installed and portable equipment should meet the specifications contained in EN61000-6-1 and EN61000-6-3; and

[4] See IATG 05.60 *Hazards of electromagnetic radiation*.

b) mechanical handling equipment (MHE) should meet the EMC requirements of EN12895.

4.11.2. EMC in process buildings – ammunition not connected to electrical equipment

EMC performance levels of electrical equipment in explosive processing buildings should meet national technical authority requirements. As above, the following EN standards are included to provide a guideline:

c) equipment permanently installed in process buildings but not electrically connected to ammunition items should meet the levels specified in EN 61000-6-1 and EN61000-6-3;

d) MHE should meet the EMC requirements of EN 12895; and

e) portable equipment should meet the EMC requirements of EN 61000-6-1 and EN 61000-6-3.

4.11.3. EMC in process buildings – ammunition connected to electrical equipment

Fixed or portable electrical equipment directly connected to a weapon[5] under test should be EMC tested by the manufacturer and the susceptibility to radiated and conducted emission levels provided with the weapon. The relevant tests and limits to be used shall be those applicable to the weapon being tested and relevant to the approved test layout.

For power supply lines that interface only with the facility domestic supplies, the tests and limits applied may be taken from EN61000-6-1 and EN61000-6-3 but with the addition of transient tests. It is suggested that the radiated susceptibility test for all equipment directly connected to weapon systems in explosive buildings shall, as a minimum, use a field strength of 20V/m from 1MHz to 1GHz.

5 Electrical equipment design, construction and use restrictions

The provision and maintenance of electrical installations and equipment to the standards outlined in this module is integral to the safety requirement for explosives buildings. Adherence to national technical authority standards is essential. Should these require amplification then international standards may be applied. The following points should be noted as being of particular importance:

a) suitable overload, short circuit and earth fault protection shall be provided to ensure the clearance of any fault condition;

b) the containment of overheating or sparking within equipment enclosures during normal use. This is in addition to any special provisions required by Category A, B, C or D electrical standards;

c) the use of certain materials such as light alloys in the construction of equipment intended for use in Category A and B buildings is prohibited. Specialist advice should be obtained before proceeding with the installation or alteration of electrical equipment in such buildings;

d) no electrical equipment should be installed, taken into or used in buildings containing explosives unless the national technical authority specifically permits it. If such equipment is not vital to the operation of the facility it should be sited elsewhere;

e) the protection level of any electrical equipment installed shall be that of the electrical category of the area in the building in which it will be used;

f) explosives should not be stored within 0.5m of any electrical equipment; and

g) areas from which explosives are specifically excluded shall be clearly demarcated.

[5] For example, a guided missile, which is both a weapon and item of ammunition.

5.1 Index of protection (IP) (LEVEL 3)

An index of protection (IP) requirement appropriate to the electrical hazard identified from Annex E should be identified. National technical authorities may have their own IP regulations or may apply the IP system shown at Table 5.

First Digit	Degree of protection	Second Digit	Degree of Protection
0	No protection of persons against contact with live or moving parts inside the enclosure. No protection of equipment against ingress of solid foreign bodies.	0	No protection.
1	Protection against accidental or inadvertent contact with live or moving parts inside the enclosure by a large surface of the human body e.g. hand, but no protection against deliberate access to such parts. Protection against solid objects greater than 50mm.	1	Protection against drops of condensed water. Drops of condensed water falling on the enclosure should have no harmful effect.
2	Protection against contact with live or moving parts inside the enclosure by fingers. Protection against solid objects greater than 12mm.	2	Protection against drops of liquid. Drops of falling liquid should have no harmful effect when the enclosure is tilted at any angle up to 15° from the vertical.
3	Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of a thickness greater than 2.5mm. Protection against ingress of small solid bodies.	3	Protection against rain. Water falling in rain at an angle up to 60° to the vertical should have no harmful effect.
4	Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of a thickness greater than 1mm. Protection against the ingress of small solid foreign bodies.	4	Protection against splashing. Liquid splashed from any direction should have no harmful effect.
5	Complete protection against contact with live or moving parts inside the enclosure. Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but dust cannot enter in an amount sufficient to interfere with satisfactory operation of the equipment enclosed.	5	Protection against water jets. Water projected by a nozzle from the direction under stated conditions should have no harmful effect.
6	Complete protection against contact with live or moving parts inside the enclosure. Protection against ingress of dust.	6	Protection against conditions on ships decks (decks watertight equipment). Water from heavy seas should not enter the enclosure under prescribed conditions.
		7	Protection against immersion in water. It must not be possible for water to enter the enclosure under stated conditions of pressure and time.
		8	Protection against indefinite immersion in water under specified pressure. It must not be possible for water to enter the enclosure.

Table 5: Electrical hazard Index of protection (IP) levels

When selecting equipment, care should be given to the requirement for environmental protection against the weather, the ingress of solid or liquid particles, and the protection of persons against contact with live or moving parts inside the enclosure.

Any electrical supply that will exceed the energy limits of electro-explosive device (EED) test equipment should be contained by a compliant enclosure with a minimum of IP44 or national equivalent protection.

5.2 Fixed and portable electrical equipment (LEVEL 2)

The precise definition of fixed and portable electrical equipment should be an integral part of the appropriate regulations of the national technical authority. However, useful, and widely accepted, definitions are provided below:

a) fixed electrical equipment is that equipment supplied by one or more permanently wired outlets. This means that electricity is supplied without the use of plugs and sockets; and

b) portable electrical equipment is that equipment supplied from one or more plug or socket outlets. Additionally, all battery-operated equipment is defined as portable.

5.3 Fixed electrical equipment

5.3.1. Air conditioning, heating, and humidity control equipment (LEVEL 2)

Heating and air conditioning equipment should be permanently installed; portable equipment is not permitted in explosives buildings. All heating equipment shall comply with the electrical category of the area it is installed in and meet the maximum temperature requirements specified at Clause 4.9.

The heater should be fitted with a guard or positioned so as to prevent physical contact with the heater. The positioning of the heater and/or the guard fitting should not allow explosives to be laid on the heater by having an angled top surface. The following should also apply to heating equipment:

a) a thermal cut-out, which is not self-resetting with temperature drop, should be fitted to the hottest part of each heater to ensure compliance with the maximum surface temperature limits;

b) water and oil filled-electrically-heated radiators should have a high temperature cut-out set to T6 i.e. 85°C; and

c) heating equipment used for heating explosives should be fitted with an additional thermostatic regulator that will override all other controls and limit the temperature to a safe level, normally not exceeding 100°C. The setting device should be tamperproof, and its operation should be frequently tested. This heating equipment should be fitted with an indicator light to show when the heater is energised.

Electrically heated air re-circulating systems shall not be fitted in Category A or B facilities or in any heating appliances containing exposed explosives e.g. conditioning chambers.

Electrically heated floors and ceilings are not permitted in any explosives building.

5.3.2. Light fittings (LEVEL 2)

Light fittings and individual lighting units (also known as luminaires) shall be of the same standards as the category of the facility in which they are fitted. Lamps of the correct power rating as shown on the installation drawings should be used. Lighting installations should be designed to provide the levels, and quality, of illumination as laid down by the national technical authority.

Any keys held for access to light fittings shall be held in the office of the person responsible for maintenance of the installation and issued only to authorised personnel. Before opening any fitting, the circuit serving it shall be isolated from the supply and shall remain so until all work has been completed.

Emergency lighting fitted with internal power sources should not normally be permitted in explosives buildings as battery condition cannot easily be determined by a visual examination of the fitting from ground level. Also, battery condition will decrease with time and chemical breakdown within the battery may result in corrosion, a short circuit, overheating or fire. However, in Category C areas only, emergency lighting with an internal power source may be installed provided that:

a) the total assembly shall be constructed and installed to Category C levels;

b) maintenance procedures should be implemented that ensure any deterioration of the emergency lighting unit is detected in its early stages and the risks controlled as far as is reasonably practicable;

c) it should be possible to safely isolate the emergency lighting from both the alternating current (AC) and direct current (DC) supplies before the exterior case is opened or it is worked on within an explosives building; and

d) the emergency lighting unit should be removed from the explosives building for repair, major maintenance, re-lamping, and cyclic testing of the battery pack. The enclosure standard of the equipment should not be compromised whilst it remains within the explosives building.

If an uninterruptible power supply (UPS) is specified to power emergency lighting units for Category A and B buildings, it shall be sited in an external plant room.

Emergency lighting units with internal power sources may be fitted in Category D areas.

5.3.3. CCTV, communications equipment and alarm systems (LEVEL 2)

All equipment shall comply with the enclosure standard required by the facility in which it is to be installed and is also to meet both the general and EMC requirements described in this module.

In addition, communications and alarm systems wiring should be separated from power wiring.

5.3.4. Heat sealing equipment (LEVEL 2)

It may be necessary to install heat sealing machines in process buildings to assist in the provision of environmental protection to ammunition items. The equipment should comply with the enclosure standard required by the facility in which it is installed, and also meet both the general and EMC requirements of this module. Inductive heat-sealing machines should not be used in any category of explosives facility.

Heat sealing equipment with external surface temperatures exceeding the maximum temperature limitations for the facility (Category B, 135°C and Category C, 135°C) may not be installed or used unless approved by the national technical authority.

Heat sealing machines should not be used in a Category A facility.

5.4 Portable electrical equipment

5.4.1. Items which emit radio frequency (RF) radiation (LEVEL 2)

Currently, electrical and electronic devices are being introduced that employ RF transmissions in the normal usage e.g. laptop computers, data loggers, communication and location devices for security staff and mobile phones. These need to be strictly controlled and should normally be prohibited inside explosives buildings. Use of such systems outside buildings but in the ESA should only be permitted if the guidelines in IATG 05.60 *Hazards of electromagnetic radiation* are complied with. In addition, the following restrictions should apply:

a) equipment shall conform to the electrical safety requirements of Category A, B or C area as relevant to the facility concerned;

b) access to batteries and charging connections shall require the use of special tools not available to the user;

c) any external aerials on portable equipment shall be insulated; and

d) equipment carried by personnel shall be securely attached to the user.

5.4.2. Mains operated portable equipment (LEVEL 2)

In general, the use of mains operated portable equipment should be avoided in Category A and B areas. If the use of such equipment is necessary, it should meet the requirements of this module and national technical authority standards for use of such equipment in hazardous areas. Authorising the use of portable equipment is the responsibility of the head of the establishment. He or she should carry out a risk assessment and provide the users of the equipment with the relevant safety precautions considered necessary.

Mains operated portable equipment used in Category C and D buildings should also meet the requirements of this module and national technical authority standards for use of such equipment in hazardous areas.

Any flexible cable or cord serving portable equipment should comply with national technical authority legislation for its use in a hazardous area. It should be sheathed with rubber, PVC[6] or PCP[7], tinned copper braided and then sheathed overall with PVC or PCP. A separate core should be provided for the protective earth conductor. The screening should be electrically bonded to the earth conductor unless the equipment is double insulated.

Specialist electrical engineering should be sought if the head of the establishment is considering the installation of this type of equipment, particularly if portable mains equipment is to be permanently switched on and/or left unattended.

5.4.3. Equipment containing batteries (LEVEL 2)

All equipment should comply with the standards laid out in this module and with national technical authority legislation. In addition, the following principles should be implemented:

a) only dry batteries shall be used and shall be of the type recommended by the equipment manufacturer;

b) batteries shall not be changed or charged in explosives facilities;

c) no battery powered equipment shall be left unattended or energised inside an explosives building unless written authorisation is given by the head of the establishment;

d) battery enclosures shall be sealed to the explosives category standards required; and

e) battery enclosures shall be held in place using tamperproof fasteners.

Specialist electrical engineering should be sought if the head of the establishment is considering the installation of this type of equipment, particularly if portable mains equipment is to be permanently switched on and/or left unattended.

5.4.4. Environmental monitoring equipment (LEVEL 3)

Electronic environmental monitoring equipment to be used should meet the requirements of this module and the national technical authority. It shall be compliant with the category of explosives area or building it is to be used in. Maintenance and data download should be carried out in an explosives process facility.

5.4.5. Equipment for testing electro-explosive devices (EED) (LEVEL 3)

This equipment should not be used unless it is approved in writing by the head of the establishment. The head of the establishment should seek specialist ammunition technical advice before authorising the use of such equipment.

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[6] Poly Vinyl Chloride.

[7] Polychloroprence.

5.4.6. Personal medical equipment

These do not need to comply with the electrical standards described within this module but their use in explosives buildings should be approved in writing by the head of the establishment. They shall be firmly attached to the wearer and should be properly maintained.

5.5 Computers, computerised equipment, and data logging equipment

These may be used within explosives areas provided they meet the requirements of the explosives building category. Category A and B area compliance requirements will require specialist products with appropriate certification, including EMC testing. Specialist containers may provide a compliant solution to "overwrap" equipment that fails to meet some aspects of compliance. In addition, they should meet the requirements as laid out in this module and of the national technical authority. They shall not be used in any explosives facility without the authority of the head of establishment.

5.5.1. Cathode ray tube (CRT) displays (LEVEL 2)

CRT displays shall not be permitted in explosives buildings because of the hazards associated with high voltages and static electricity.

5.5.2. Printers, display screen and other peripherals (LEVEL 2)

These may be used within explosives areas provided they meet the requirements of the explosives building category.

5.5.3. Asset tracking devices (LEVEL 3)

These shall not be taken into an explosives area unless specifically approved by the head of establishment who should seek specialist ammunition technical advice. Full compliance of the equipment for the building electrical category shall be required. Asset tracking system components will only be compliant with explosives area standards if those standards are specified prior to system design.

5.6 Vehicles and MHE (LEVEL 2)

Electrical systems on handling equipment permanently installed in explosives buildings shall comply with the specifications appropriate to the building in which they are installed. Safety requirements for electrical systems on vehicles and mobile mechanical handling equipment operated in explosives areas shall also meet these requirements.[8]

6 Commissioning, testing and inspection of electrical equipment

6.1 Safety precautions (LEVEL 1)

It shall be the responsibility of the head of the establishment to ensure that a safe system of work is in place and that any nominated representatives are qualified and possess written authority to carry out their tasks.[9] The protection and control of personnel working in explosives areas shall be in accordance with IATG 06.60 *Works services (construction and repair)* and be agreed in conjunction with the head of the establishment or a nominated representative. The number of operatives on site and the period of their exposure may be limited.

[8] See IATG 05.50 *Vehicles and mechanical handling equipment (MHE) in explosives facilities*.

[9] See IATG 02.10 *Introduction to risk management principles and processes*.

No testing or inspections shall be made on an installation in an explosives building without prior approval and written permission from the head of the establishment or his or her nominated representative. Additionally, a nominated person shall first check the facility to ensure that it is safe for testing to proceed.

Unless approved by the national technical authority, testing shall not be permitted unless the facility is certified free from explosives (CFFE). This will be dependent on the category of the facility being tested and the type of electrical test to be carried out. If, for any reason, it is necessary to test when explosive stores are present in the building, special permission shall be obtained from the head of the establishment.

It is of note that this may be an ideal time to carry out other inspections and testing when a building is free from explosives.

As a minimum, the following shall be necessary before any work commences. The list is indicative only and is not exhaustive:

a) ventilation of inspection spaces shall have taken place;

b) gas free certificates will be issued as appropriate;

c) personal protective equipment will be appropriate to the risk and be as per the risk assessment and shall be in date;

d) safety harnesses and fall arrest devices will be appropriate to the risk and be as per the risk assessment and shall be in date;

e) minimum occupation rules will be in force with normally a minimum of 2 people, (maximum occupation will be in accordance with the published person limits for each task);

f) the workplace will be obstruction free and will afford safe access and egress; and

g) all personnel will have been made aware of their escape routes and other health and fire safety requirements.[10]

Under no circumstances shall stacks of explosives or ammunition be used a work platform or to gain access.

6.1.1. Electrical safety (LEVEL 2)

The earth protective conductor shall be visually inspected before any electrical tests are carried out. All joints and conductive paths connected to the protective conductor shall be verified for their continuity in accordance with national technical authority standards. Confirmation of the protective earth conductor shall then be tested using heavy current earth loop tests in accordance with the requirements of the national technical authority.

All instruments used shall be certified to be intrinsically safe if they are to be used for testing installations in explosives buildings if explosives are present. Other test instruments may be used with the written permission of the head of the establishment.

The head of the establishment shall ensure that the following safety precautions are taken:

a) the distance between explosives and electrical conductors and equipment shall be kept to a maximum during the testing and never less than 0.5m, including where wiring is run overhead;

b) testing points for connecting instruments shall be well removed from explosives. No unsealed or exposed explosives shall be permitted in the area under test;

[10] See IATG 06.60 *Works services (construction and repair)*.

c) the installation shall be under continuous observation during testing and fire prevention measures approved by the head of the establishment or his or her representative shall be in force;

d) when all testing is complete, shorting resistors shall be connected to the network under test to dissipate any residual charge that may have built up. Shorting resistors shall be connected for a period of 30 seconds before disconnecting the test equipment; and

e) test equipment shall be removed from the explosives building upon completion of task or at the end of the working day.

6.2 Inspection and testing

6.2.1. Qualified personnel (LEVEL 2)

Inspection and testing in explosives facilities shall only be carried out by competent personnel. They shall have adequate knowledge of the relevant parts of the establishment's safety rules and procedures. In addition, they should have special competency in the inspection and testing of electrical equipment within explosives facilities and of any special requirements of the national technical authority.

6.2.2. Frequency and test requirements (LEVEL 2)

Table 6 below lists the frequency recommended for the various tests required and which are explained in this Clause.

6.2.3. Visual inspections

Visual inspections and physical checking shall take place as specified in Table 6. This shall also include the checking of safety signs and notices.

6.2.4. Continuity testing

Continuity testing of protective conductors and of main and supplementary bonding shall be carried out at the intervals specified in Table 6. The resistance between all parts of the earth conductor and the earth bar at the main intake switch for the building shall not exceed 0.5Ω.

Testing of the continuity of ring final circuit conductors shall also be carried out at the intervals specified in Table 6.

6.2.5. Insulation testing

Insulation tests including site applied insulation tests, if applicable, shall be carried out at the intervals specified in Table 6 and shall comprise:

a) testing the insulation resistance between live conductors. The result shall be not less than 2MΩ; and

b) testing the insulation resistance to earth. Each conductor shall be separately tested to earth and the result shall not be less than 2MΩ.

6.2.6. Lightning protection systems (LPS)

Two levels of lightning protection systems may be considered for ammunition storage and processing buildings. The first level of the lightning protection may be on the ammunition storage (of a faraday cage type), and the second level of the lighting protection should be near the ammunition storage. Examples are given at Annex C. A single type of lightning protection should be installed regardless of type.

Annex C lists the various requirements of an LPS and additionally the national technical authority shall specify testing regimes, in particular the required standards applicable to earth termination networks. The frequency of testing shall be as per Table 6. This will allow the build-up of a database of test results taking into account all seasonal variations.

6.2.7. Anti-static flooring

Anti-static flooring shall be tested at the intervals specified in Table 6 and in accordance with national technical authority requirements and the specifications laid out in Annex H. New anti-static floors shall be tested on installation and then at the three and nine month points. Thereafter tests should be made at intervals of eleven months. However, if there is evidence of wear and deterioration, the interval between tests should be reduced.

6.2.8. Conductive flooring

Conducting flooring shall be tested at the intervals specified in Table 6 and in accordance with national technical authority requirements and the specifications laid out in Annex H. New conductive floors shall be tested on installation and then at the three and nine month points. Thereafter tests should be made at intervals of eleven months. However, if there is evidence of wear and deterioration, the interval between tests should be reduced. When accepting new conductive floors, the head of the establishment shall ensure that the initial measurements of floor resistance made are well below the maximum of 50kΩ to allow for progressive degradation through life. A suggested limit at installation is below 30kΩ.

6.2.9. Residual current devices (RCD)

The use of external test equipment may induce large fault currents into the earthing system and caution shall be exercised when testing earth circuits using high test currents.

6.2.10. Communications, fire and intruder alarms and electrical installations

These shall be tested as per the requirements of Table 6.

6.2.11. Other electrical tests

The following additional electrical tests shall be carried out as per the intervals specified in Table 6:

a) separation of circuits if applicable;

b) barriers and enclosures if applicable;

c) protection by a non–conducting location;

d) correct polarity tests;

e) earth electrode testing excluding lightning protection;

f) earth fault loop impedance; and

g) measurement of the earth electrode and earth loop impedance and confirmation that the measurements obtained are within acceptable limits as defined by the national technical authority.

Test Requirement Clause	Cat A and Cat B	Cat C	Cat D	Non-explosives Buildings in an ESA
6.2.2.1	6 months	12 months	12 months	12 months
6.2.2.2 6.2.2.3 6.2.2.9	12 months	24 months	24 months	5 years
6.2.2.5 6.2.2.6	11 months	11 months	Not applicable	Not applicable
RCD 6.2.2.7	12 months	12 months	12 months	12 months

Test Requirement Clause	Cat A and Cat B	Cat C	Cat D	Non-explosives Buildings in an ESA
LPS 6.2.2.4	11 months	11 months	11 months	11 months

Table 6: Inspection frequency of electrical equipment

6.2.12. Flexible power cables

Flexible cables shall be inspected and tested as follows:

a) on portable, plug-in type electrical appliances they shall be inspected monthly or prior to use. A portable appliance test (PAT) shall be carried out every six months;

b) on fixed electrical appliances fitted with an electrical interface plug in an explosives building, they shall be inspected prior to use and inspected monthly with a PAT test every six months; and

c) on fixed electrical appliances in an explosives building they shall be inspected prior to use with a full electrical inspection and test every six months.

6.2.13. Cranes and lifting appliances

Cranes and other electrical lifting appliances shall be tested in accordance with national technical authority legislation.

6.2.14. Testing of conducting footwear

Conducting footwear should be tested when new and subsequently at intervals of not more than twelve months. As conductive footwear is checked before use with a hazardous area personal test meter (HAPTM), there is no need for an annual resistance test. Conducting footwear shall also be tested for impact protection to the standards laid down by the national technical authority. The test voltage shall not exceed 100 volts because this is the maximum voltage permissible on personnel that will avoid an ignition hazard to the most sensitive explosives substances and articles.

6.2.15. Testing of anti-static footwear

Conducting footwear should be tested when new and subsequently at intervals of not more than twelve months. It shall be tested against the standards, including impact protection, laid down by the national technical authority.

6.2.16. Testing of conveyor belts

Each surface of any conveyor belting used for the movement of static sensitive explosives substances or articles shall be tested in accordance with the standards laid down by the national technical authority. The electrodes shall be placed on the belting with one electrode on each surface. The maximum acceptable resistance should be 100kΩ.

6.2.17. Record keeping

All test results shall be recorded in accordance with the national technical authority requirements. However, it is strongly recommended that the minimum requirement should be that a log book be maintained. A record of tests, with the findings and any recommendations, shall be kept for comparison purposes with future results for a minimum period of eleven years to aid the detection of deterioration. Should any deterioration be detected a written report shall be made to the head of the establishment.

Equipment should be labelled to show when the next tests are due.

7 Power supply

7.1 External supply and overhead power lines (LEVEL 3)

Power supply overhead systems and any associated network and installations shall not be permitted in, or be allowed to pass over, an explosives area or building. They shall be sited at a safe distance from the perimeter of such areas. Although the breaking of an overhead conductor is a rare occurrence, the operation of circuit protection devices should not be accepted as a total safeguard. Safe distances shall be determined as below and the greater distance determined shall be observed.

7.1.1. Hazard to the power line from explosives

The distance between an explosives building and an overhead power line operating at 11kV or above should be the public traffic route distance,[11] subject to a minimum of 60m. The distance to particularly important lines, for example very high voltage lines, shall be at least the Inhabited Building Distance, subject to a minimum of 120m.

7.1.2. Hazard to the explosives from the power line

No overhead power line shall approach nearer to an explosives building than a distance equivalent to 1.5 times the height of the nearest conductor measured at the line supports, subject to a minimum distance of 15m.

7.1.3. Supply of electricity to explosives areas and cabling

Underground cables should be preferred means of supplying electrical power in explosives areas and should be provided wherever practicable. Cables should not be laid below buildings. Any overhead lines to buildings shall terminate at not less than 15m from the building and the remaining distance completed using underground cable.

Surge protective devices shall be fitted between live conductors and earth and between live and neutral conductors at the junctions of overhead lines and underground cables.

The head of the establishment shall hold and maintain plans showing the location and size of all underground cables, including the location of all joints in cables, cable pits, etc. within explosives areas.

No explosives facility should be within a minimum of 15m of underground cable runs whose working voltage exceeds 650V root mean square (RMS). Underground high voltage (HV) and communication cables, unless directly serving a potential explosion site (PES), are unlikely to be damaged outside the crater distance for the explosives building or stack. Therefore, for HD 1.1 the D5 distance[12] should provide adequate protection and should be used wherever possible. However, to prevent induced currents in either the structure or electrical equipment of a PES, underground cables should not be laid underneath a PES and should not be closer than 15 m to a PES containing any ammunition

7.1.4. Overhead lines and lightning columns

Supports for overhead lines shall not be fixed to buildings containing explosives. Poles or other forms of support for overhead lines, or lighting columns, shall be sited so as to ensure that in the event of failure no support or live conductor is able to fall onto an explosives building. A minimum distance of 1.5 times the height of the support shall be required.

[11] See IATG 02.20 *Quantity and separation distances*.

[12] Ibid.

7.1.5. Overhead lines crossing road and rail

Ideally, public supply and explosives area electrical distribution overhead power lines should not cross roads and railways. Where there are crossovers, precautions shall be taken to reduce to a minimum the length of time vehicles loaded with explosives are below the power lines. Power line crossings of roads and railways should be clearly marked as such by painting yellow box markings on roads.

Overhead power lines at road and rail crossings and the immediately adjacent spans should be inspected annually. Internal power lines spanning roads and rail crossing in explosive storage areas shall be visually inspected for signs of mechanical damage, corrosion, overheating, loose fastening and general deterioration. The inspection of the power line spanning the road/rail crossing is limited to the distance between the poles or pylons immediately adjacent to the crossing. Public supply authorities shall be requested to carry out a similar inspection of their overhead power lines.

7.2 Location of power generation and distribution equipment (LEVEL 2)

Electrical generating plant and distribution equipment with a working voltage of more than 650V RMS shall be sited not less than 45m from any explosives building. Generating plant and distribution equipment working at 650V RMS, or less, may be sited not less than 10m from any building containing explosives, provided that any plant is completely housed in a building or structure which provides complete containment in relation to the buildings containing explosives.

Electrical generating plant and distribution equipment whose working voltage is between 650V RMS and 11kV RMS and which does not contain any flammable insulation fluids may be sited not less than 20m from an explosives building provided the loss of the equipment can be tolerated by the whole establishment.

Notwithstanding the above distance limitations, it may be necessary to increase distances to comply with the explosives quantity distances from adjacent explosives buildings or to provide protection by traversing, in order to protect the electrical installation from the explosives risk.

Electrical installations that contain flammable insulation fluids in sufficient quantity to constitute a significant fire risk shall have drains to allow any fluids to flow into a shingle filled sump of adequate size to contain all leakage. An area clear of all combustible material for 5m shall be maintained around the sump.

7.3 Internal power supply in explosives buildings (LEVEL 2)

This section deals with the standards required for electrical safety inside explosives buildings. It is vital that expert advice is always obtained before work commences on the installation and/or repair of any electrical equipment or fittings. The recommended guidance below is based on various EU standards and are included to act as a reference against which national standards may be compared.

7.3.1. Earthing of explosives facilities (LEVEL 3)

The voltage to earth shall be defined by the national technical authority. As an example of the type of specification required, some systems state that it should not exceed 400V RMS, (+10% -6%) 50Hz, 230V RMS (+10% -6%) 50Hz. However, notwithstanding the specifications laid down, the source shall be directly connected to earth at one point of the system.

7.3.2. Switches

7.3.2.1. Master switches

The electrical supply to any explosives building shall be controlled by one or more master switches positioned outside the building. Master switches shall not be placed within a plant room if one is present. If there is more than one master switch, they should be situated close together and their purpose clearly marked.

Master switches shall be of a design capable of immediately isolating every live and neutral conductor entering the building and disabling the output of any uninterruptible power supplies (UPS).

7.3.2.2. Other switches

Switches and distribution boards controlling the electricity supply to an explosive building shall be located outside the building, or in a plant room that has a minimum half-hour fire resistance and does not open directly into the building or rooms containing explosives.[13] Pilot indicator lights, visible from a distance of at least 10m and preferably duplicated shall be fitted adjacent to the master switches to show when the supply is energised.

The provision of remotely controlled switchgear, with fail-safe configuration, may be considered. The remote control station should be sited outside the building concerned and in a clearly visible position. It should be suitably protected from the environment and provided with pilot light indication.

7.3.2.3. Uninhabited buildings

When an explosives building is vacated, all power shall be switched off. This however does not apply to supplies for services that are either completely located in the plant room or to heating appliances, emergency or security services and others permitted by the head of the establishment.

7.3.3. Final circuits

These shall be controlled by switches that ensure complete isolation of both live and neutral conductors from the supply. These switches may be located inside the building if they are the same category as the building. However, switches controlling heating systems shall always be located outside the explosives building or they shall be in the plant room. All circuits shall be provided with protection against over-current and earth faults. Re-wireable fuses shall not be used. Over-current protection shall be by fuses or circuit breakers complying with national technical authority regulations.

7.3.4. Residual current devices (RCD)

Where conducting or antistatic floors are used, RCDs shall be fitted. Portable devices and devices integral with socket outlets shall be tested daily before use. The test shall operate the integral test device fitted to the RCD. Fixed devices providing dedicated or multi-circuit RCD protection shall be tested at three monthly intervals. Fixed RCDs, including devices integral with socket outlets, should be tested using an approved test instrument in accordance with the times detailed at Table 6.

Portable devices failing a test shall be taken out of service until they are repaired or replaced. Fixed RCDs, including devices integral with socket outlets, that fail integral or instrument testing shall have their associated circuits isolated until defective devices are replaced or repaired.

Although RCDs provide a high degree of protection from electric shock, total protection cannot be guaranteed in a highly conductive environment. Electrical equipment used in conductive environments shall comply with the recommendations of this module and should be constructed to at least double insulated Class II standard.

7.3.5. Electrical sockets

If the installation of electrical socket outlets is necessary, then the classification and standard of sockets used shall meet the recommendations of this module and match the explosive category of the building in which they shall be used. Sockets of a distinctive pattern shall be used for non-standard electricity supplies.

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[13] See IATG 02.50 *Fire safety.*

Multi-plug adapters shall not be used unless there is a specific operational need such as for electronic equipment and in this case a risk assessment should be undertaken before the head of the establishment or his or her appointed representative approves the use of these items.

7.3.6. Surge and transient protection and protection levels

Dependent upon the work being undertaken, equipment in use, the ammunition being stored, the age of the building and its associated electrical cabling and circuitry, it may be necessary to carry out a risk assessment to establish if, and where indicated, transient overvoltage and over-current protection needs to be provided to all primary circuits feeding the final circuits in explosive category areas of explosives buildings. The risk assessment should also include the need for transient protection to all communications and instrumentation circuits that enter and exit the designated explosives area.

In explosives processing facilities two or more levels of protection may be necessary for the power systems and these levels shall be dictated by the national technical authority. The protection shall be required for:

a) incoming mains power (for example waveform 10/350µs with 100kA lightning current arrestors); and

b) internal electrical distribution (for example waveform 8/20µs with 3kA surge arrestors).

Other systems such as CCTV, telephone or control circuits require separate consideration and specialist advice should be obtained.

7.3.6.1. Protection in explosives buildings

In general, processing facilities should be fitted with transient protection. While storage facilities may not, all electrical cabling and wiring entering an explosive facility may conduct dangerous surges of voltage and current. The surge size is normally governed by the gauge or size of the cable, but all cables should be treated as potentially dangerous and therefore protected by surge protection devices.

Surge protection devices shall be provided to protect explosives assemblies when they are connected in any way to the electrical supply system. These protection devices should be installed on each cable or wiring entering the lightning protected area of an explosives processing buildings, between the respective conductor and the building earth and/or Faraday cage, at the conductor’s penetration point.

7.3.6.2. Protection during explosives operations, thunderstorms, and silent hours

Surge protection devices designed for specific equipment may not provide protection for explosives operations and additional surge protection and/or transient protection for sensitive test equipment located in the protected volume of the building may be required. Specialist ammunition technical advice should be sought.

Explosives assemblies shall be disconnected from any test equipment during silent hours and when under a thunderstorm threat. Correctly rated and installed transient over-voltage and over-current devices provide effective protection against sparking but cannot guarantee that sensitive electronics will not be damaged or that sensitive electro-explosive devices will not be ignited.

7.3.6.3. Earthing of surge protection devices

Earth conductors leading from the surge protection devices shall be kept separated from the protected conductors. All earth leads shall be as short as possible to minimise the inductance. As a guide the earth leads should be no longer than 300mm of 6mm diameter cable. If longer cables are unavoidable consideration should be given to adding extra down-stream surge protection.

All metallic utility lines and pipes shall be electrically bonded to the LPS or the structural steel of the facility at, or just before, they enter the facility.

When electrical test equipment is being used, it is essential that surge protection devices be installed to protect all up ammunition rounds (AUR) or explosives components from lightning effects which may occur during the period that the test equipment is connected.

7.3.7. Wiring and cable systems and their use in explosives areas

7.3.7.1. Chemical compatibility

Compatibility with chemicals and/or explosives in the area should be considered when selecting the type of cable to be used. The following wiring types should be used in explosives buildings and should be of fire retardant, low smoke and fume emission plastic materials.

7.3.7.2. Types of wiring and cable systems and their use in categorised areas

Cables for use within Category A and B facilities shall comply with national technical authority regulations concerning these areas. Specialist electrical engineering advice should be sought before the installation of any wiring or cabling in these areas. The following are the minimum recommended materials to be used:

a) synthetic rubber or PVC insulated cables in screwed steel conduit may be used in Category A, B, C and D facilities;

b) synthetic rubber or PVC insulated cables in trunking or non-metallic conduits should only be used in Category C and D facilities;

c) heavy-duty (750 volt) mineral insulated metal covered (MIMC) cables. The outer covering shall be made of low smoke and low acid gas emission material. Cables shall be fitted with terminations compliant with national technical authority regulations. Installation of MIMC cables in Category A and B facilities shall only be installed by appropriately qualified personnel. It is important that the cable, glands and termination are all supplied by the same manufacturer;

d) cross linked polyethylene (XLPE) or PVC insulated multi-core armoured cables shall be compatible with any explosives or chemicals used in the vicinity of the installation. Additional protection against mechanical damage may be necessary;

e) thermo-plastic insulated lead sheathed cables with a protective covering of thermo-plastic material;

f) thermosetting insulated cables in screwed steel conduit may be used in Category A, B, C and D buildings;

g) communications and instrumentation cables, including IT systems, contained in screwed steel conduits may be used in category A, B, C and D buildings; and

h) all cables with single core conductors are prohibited as are cables with a single layer of insulation, with the exception of MIMC.

7.3.7.3. Cable used in conduit and trunking systems

Power cables should be of synthetic rubber, PVC, low smoke and fume (LSF) or XLPE insulated to 450/750V grade or to a specification as laid down by the national technical authority. The cross-sectional area of a conductor shall be appropriate for the current loading and should be not less than 1.5mm^2. Cables for communication and alarm systems may be insulated flexible cords. The cross-sectional area of a conductor should be not less than 0.35mm^2.

7.3.8. Conduit standards

All metal conduits shall comply with national technical authority regulations. For Category A and B facilities specialist electrical engineering advice should be sought. However, in general the following standards should apply:

a) metal conduits shall be heavy gauge solid drawn or continuously seam welded and galvanised. Black enamel may only be used in Category C and D areas;

b) metal conduits shall be screwed tightly into all fittings and equipment with the minimum of exposed thread;

c) running couplers shall not be permitted in Category A or B areas; and

d) conduit boxes shall be of the correct type for the category of the area and zone concerned.

7.3.8.1. Category B area requirements

The following specific requirements should be applied to conduits in Category B areas:

a) joints in straight runs in conduits shall be made by means of a flameproof coupler with sealed or dust tight union;

b) conduits shall be fixed with a minimum of 12mm clearance from walls and be supported by solid backed-splayed saddles;

c) all conduit entries into equipment and fittings shall be made-off with glands certified to the appropriate zone as per Clause 4.5.1; and

d) the use of flexible conduit shall be kept to a minimum, but, if essential, then its use should be specifically authorised by the national technical authority.

7.3.8.2. Category C and D area requirements

Non-metallic conduits should only be used in Category C and D facilities but with the following restrictions:

a) any rigid PVC conduit system shall comply with national technical authority regulations for use in this area category;

b) protection against mechanical damage shall be provided;

c) if slip joints or sliding couplers are used, joints should be made using a suitable adhesive; and

d) separate and adequately rated earth continuity conductors shall be installed throughout the systems.

8 Lightning protection systems (LPS) (LEVEL 2)

It is essential that effective lightning protection measures are provided for facilities involved in the manufacture, processing, handling, or storing of ammunition. Although statistically the probability of a structure or building being struck by lightning is relatively low, it is of the utmost importance to provide lightning protection to facilities containing ammunition.

8.1 External protection

8.1.1. Probability of lightning strike

The probability of an explosives facility being struck by lightning is dependent upon the geographic location of the facility and the atmospheric and weather conditions prevalent at the time. Measured over a long period of time, it is the product of the lightning cloud-to-ground strike density and the effective collection area of the structure or building. Many sources of global lightning data exist that may provide the national technical authority with the relevant data.

8.1.2. Risk of explosion

Ammunition is at risk from lightning as a strike could cause an explosive event by direct or indirect means such as by:

a) causing a surface flashover or electrical arcing between conducting surfaces. This in turn could initiate the explosives or any associated explosive devices directly by heat, sparking and molten metal created by the arc;

b) arcing causing fires in electrical circuits and equipment;

c) lightning strikes starting fires; or

d) spalling generated by the heat of the current flowing through the structural components of the facility impacting on and initiating unprotected exposed explosives and explosive devices.

8.1.3. Facilities which may not require protection (LEVEL 2)

The national technical authority may choose to provide some exemptions to the types of facilities requiring protection. Yet there shall be no exemptions for facilities used for the manufacture, processing, or out-of-container handling of explosives. The following list is based on internationally accepted best practice:

a) underground storage or storage buried and subsequently constructed by excavation and with a minimum of 600mm of earth cover;

b) explosives stores that contain and are properly licensed to store a maximum of 25kg of HD 1.1 and where the explosives are packed in approved containers;

c) buildings containing only HD 1.4 small arms ammunition or other explosives assets that cannot be ignited by lightning or its indirect effects and are packed in their approved containers;

d) earth covered explosives stores with more than 600mm of earth cover and where structural steel or reinforcing bars are bonded to earth. Ventilation stacks and all metallic penetrations shall be bonded to earth. All electrical circuits shall be protected by transient over-voltage and over-current barrier devices.[14] The ammunition shall be in approved containers;

e) ISO containers containing explosives which are of an all welded construction, or where the frame and all panels are electrically bonded using heavy duty bonding straps, may be stored in the open without any specific lightning protection provided that the containers have at least two earthing points at opposite corners to connect to driven earth rods. The direct current (DC) resistance to earth at any point on the ISO container should be less than 10 ohms. ISO containers not designed to this standard shall require further lightning protection preferably via an overhead catenary system; and

f) storage structures and facilities where personnel are not expected to sustain injury and the economic loss of the facility, surrounding facilities and the ammunition would be negligible.

8.2 Types of external lightning protection

Various methods of external protection against lightning exist. However, international best practice may be achieved by enclosing the explosive in an interconnected network of electrical conductors. This in turn ensures that all exterior fields, currents, and voltages are shielded against and that ingression of these is prevented. An LPS is designed to intercept a lightning strike to the building and carry the current safely to earth without causing damage to the building or its contents.

A description of a complete system and its requirements are at Annex C. Appendix 1 to Annex C provides figurative descriptions of differing types of LPS systems

[14] It is difficult and expensive to establish the adequacy of earth bonding of reinforced concrete structures post-construction.

8.2.1. Faraday cage

A typical protection model may be one of reinforcing bars of a cast in-situ RC structure where the bars are fully bonded in a roof to walls to floor configuration and have deliberate earth connections. The use of widely spaced steel stanchions to provide the shield is effective at protecting the building structure but does not prevent magnetic fields penetrating the building. This method of protection imitates a Faraday cage and is called a Faraday cage LPS. It requires a minimum separation distance from the boundaries of the structure to the explosives assets. This should be determined by an electrical specialist.

8.2.2. Other models

Although other LPS such as early streamer emission (ESE) and charge dissipation systems exist they should not be used as preference.

8.3 Internal protection (LEVEL 2)

Buildings and any other structure used for storing or processing explosives should have an internal lightning protection installation. This should consist of equipotential bonding tape and bonds to metallic structures and components. This system is required in order to avoid dangerous flashover or sparking within the structure from any current flowing in the external LPS or structural steel components because this sparking is very dangerous. Sparking should be avoided by the use of equipotential bonding and/or insulation between the various components of the LPS system both internal and external.

8.3.1. Bonding and insulation

All internal equipment and structures such as weapon stands with dimensions exceeding 2m in any direction and within 2m of the walls or building structure should be bonded to earth. Earth bonding should be by the use of an equipotential bonding (EPB) strip running inside the building. The EPB strip should be as low as possible on the walls and should be bonded to the conductive/anti-static floor if one is in use and if it is practicable. Bonding strips or wires higher than 2m above floor level should not be used.

The EPB strip should be connected at one point only to the facility main earth bus bar. It should not be deliberately connected to the LPS down conductors at any other point and it should be in as straight a line as possible with the minimum of bends and corners.

When the strip approaches doors or other openings to buildings the strip should preferably be taken under the floor. However, if the door frame is metallic this may be used for continuity. If a strip has to be run over an opening, no bonding connections to it should be made above the opening.

8.3.1.1. Ammunition under test, assembly or repair

Ammunition shall not be directly connected to the EPB strip. They should be bonded to the stand or other equipment on which they are placed. This in turn should be bonded to the EPB by a single connection from the lowest part of the stand. If an item is not on a stand and its size or positioning requires an equipotential bond, a single connection to the EPB should be made with the connecting cable run as shown at Figure 1.

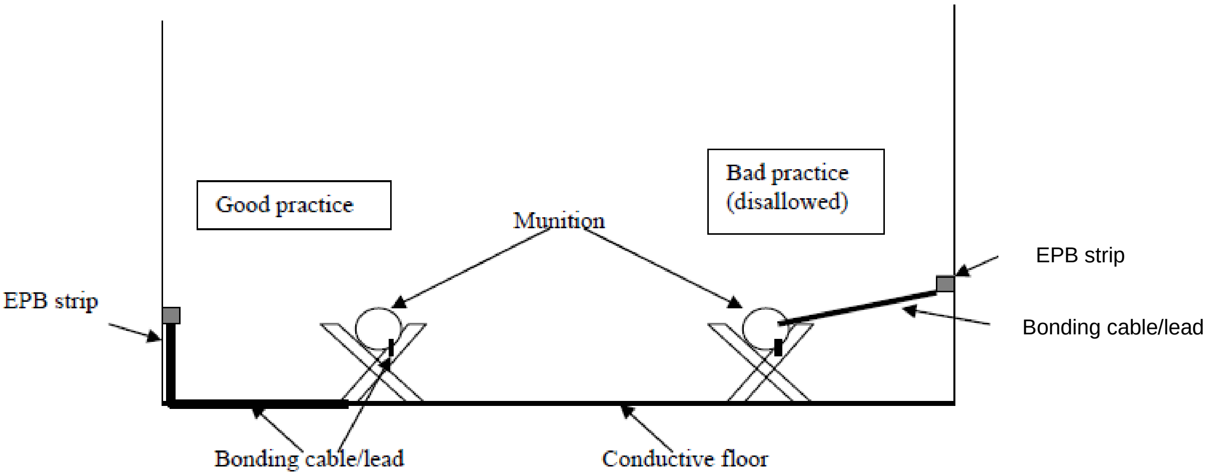


Figure 1: Bonding of ammunition with a connecting lead

All cables used to make bonds to the EPB strip should be run down the wall from the strip and along the floor to the munition stand. They should not be taken directly to the stand suspended or held above floor level.

The minimum stand-off distance of 500mm should continue to be maintained in processing areas and this distance should be increased to 2m if an EPB is not made and the item has a dimension greater than 2m. The stand-off distance is measured from metallic objects connected to the walls such as equipment, vent outlets/inlets and elephant trunk vents which do not have insulating sections.

8.3.2. Ammunition in storage

In storage areas EPB is not required for items that are in their approved containers or packaging.

8.3.3. Connections to anti-static and/or conducting floors

Connections to anti-static and/or conductive floors should continue to be made in the specified manner. Connection to an EPB strip is not necessary for electrostatic control purposes should such floor connections exist. The purpose of the EPB is to provide a low resistance earth bond for lightning protection purposes.

8.3.4. Facilities with no external LPS

Internal lightning protection may be needed even when the external LPS is not required as defined by the exclusions in Clause 8.1.3.

8.4 Lightning hazard to personnel (LEVEL 1)

An LPS cannot prevent a strike on an explosives structure or building and thus cannot ensure that an explosive event will not take place. It is essential to provide for the evacuation of personnel from an explosive site should a thunderstorm be approaching. Explosives sites shall have a clearly defined response to lightning hazards that shall include an evacuation plan that provides for making safe the munitions and securing and electrically isolating the evacuated facilities. The entire procedure shall be exercised at least annually.

8.4.1. Risk assessment

The head of the establishment shall carry out a risk assessment of the likelihood and consequence of thunderstorms affecting explosives areas. If the outcome of the assessment dictates that an effective warning system should be installed, then specialist guidance should be sought. Whichever system is eventually chosen should be capable of providing at least 30 minutes warning of an approaching thunderstorm.

8.4.2. Making safe the explosives facility in the event of a thunderstorm (LEVEL 1)

8.4.2.1. Storage facilities

In the event of a thunderstorm warning or a sudden thunderstorm:

a) stop work immediately;

b) do not deliberately earth explosives assemblies but ensure that they are least 500mm from the walls of the facility;

c) close all windows, doors, and vents;

d) switch off the electricity from outside; and

e) evacuate to a safe location.

8.4.2.2. Open storage facilities

In the event of a thunderstorm warning or a sudden thunderstorm:

a) stop work immediately;

b) cover and repack unpacked explosives should time permit; and

c) evacuate to a safe location.

8.4.2.3. Processing facilities

In the event of a thunderstorm warning or a sudden thunderstorm:

a) stop work immediately;

b) if time permits, disconnect electrical test equipment from explosives assemblies;

c) do not deliberately earth explosives assemblies but ensure that they are at least 500mm from the walls of the facility; and

d) evacuate to a safe location.

8.4.2.4. Stabling and marshalling areas

In the event of a thunderstorm warning or a sudden thunderstorm:

a) stop work immediately;

b) place all road and rail vehicles under cover if time permits; and

c) evacuate to a safe location.

9 Operation of conducting and anti-static regimes (LEVEL 2)

Many explosive substances and articles are sensitive to electrostatic discharge (ESD). If an item of ammunition cannot be hardened or protected against ESD then measures should be taken to prevent ESD endangering the explosives. This may be achieved by ensuring any electric charge is removed at least as fast as it is generated.

A sensitive component is any safety critical component of a weapon system or platform susceptible to the effects of ESD. Whilst initiation is the major hazard, other hazards should also be considered when any safety critical sensitive electronics, fuels, or degradation products such as gaseous hydrogen from aluminised explosives may be present.

9.1 Technical definition of anti-static and conducting regimes and safety

The technical definitions listed below are derived from the ignition energies of the explosives used in the most sensitive exposed components. Therefore, it is essential for safety that an ESD protected area (EPA) shall ensure that any electrostatic energy sources are below the ignition energy of the most sensitive exposed component.

The following definitions are vitally important for all aspects of explosives safety:

a) an anti-static regime is operated when explosive substances, EIDs or EEDs that in their current configuration have ignition energies of above 1MJ and below 156MJ. In the majority of cases the sensitive components of weapon systems are protected from harmful ESD by other components in the weapons system such as, for example, a rocket motor casing. Deliberate measures such as covers, packaging and circuit breaks provided by safety and arming units (SAU) are also provided. It is therefore reasonable to assess the weapon in its present state rather than its most vulnerable configuration; and

b) a conductive regime is required in the presence of explosive substances, EIDs or EEDs that in their current configuration have ignition energies of 1MJ and below. This regime should be enforced when processing any explosive or explosive assembly containing any components whose sensitivity is not known.

The selection of the correct electrostatic regime for explosives substances is based on the tests explained in IATG 01.50 *UN Explosive hazard classification system and codes*.

The above regimes shall be implemented in any situation in which explosives or explosive assemblies could be exposed to an electrostatic hazard. The manager of the building or process should ensure all exposed sensitive components are identified, their sensitivity is quantified and the appropriate regime implemented and maintained.

Training is a vital part of maintaining the above regimes. This training should include knowledge of the ammunition at the ammunition technical level for supervisors and training of all staff in operating in an ESD regime and the use of personal protective equipment such as clothing, footwear, earthing wrist bands, the use of the hazardous area personnel test meter (HAPTM) and hand tools. Whenever possible safe operation shall be achieved by design rather than procedure to ensure that the risk is reduced and/or mitigated to ALARP levels.

9.2 Sources of static electricity and control measures

9.2.1. Personnel (LEVEL 2)

In a properly constructed, maintained, and tested facility following the guidance in this IATG module, the single highest risk of the generation of hazardous levels of electrical charge are the personnel employed in the facility. Their mobility, high capacitance and conductivity mean that they constantly generate, store, and dissipate electrical charge. The charge build-up can be released by a single discharge. Therefore, all those involved in handling sensitive explosives or explosive processing should be effectively and continuously grounded. This can be achieved by providing a discharge path to ground via conductive and/or anti-static shoes and floors. Wrist straps connected to grounded conductors may suffice when dedicated facilities are not available.

9.2.2. Equipment (LEVEL 2)

Plant, conductors and other equipment should be earthed and bonded to ensure they are at a common ground potential. Trolleys, conveyors, and other mobile equipment also have the potential to generate static electricity, store it and subsequently discharge it. Therefore, they should be provided with an effective path to earth. Any tyres fitted to equipment should be of an antistatic or conducting material. Gaseous or fluidic systems such as low and high pressure compressed air systems should be fitted with grounded antistatic or conducting components. Drive or conveyor belts should be of anti-static or conductive material depending upon the regime in force within the room.

If operations performed within a building require the installation of an anti-static or conducting floor, it is preferable to install a conducting grade floor. This allows for future flexibility in the use of the building. However, in some environments this might be outweighed by the increased risk of electrocution in the event of an equipment fault.

9.2.3. Benches (LEVEL 2)

Explosives processing benches should be at least 500mm from any external facility wall and metallic structural members. Should the bench surface or structure be metallic and have a dimension >2m it should be connected to the facility equipotential bonding system at the lowest point. Metallic benches <2m and installations where a conductive mat is used for the work surface on an insulating bench may be connected to the conducting floor instead of the equipotential bonding system.

If it is impossible to achieve 500mm separation from the external walls or metallic structural members a risk assessment shall be undertaken which addresses the hazard from lightning side-flashes. However, should this be the case then:

a) no explosive items should be left on the bench when the room is unoccupied; and

b) an effective lightning warning system is in place that allows items to be safely stowed and an orderly evacuation to be undertaken.

9.2.4. Racks (LEVEL 2)

It may be necessary to provide racking in some PES. If this is the case, then the following restrictions should be in pace to protect the explosives against lightning:

a) the minimum distance between the walls and ceiling of the building and the racking should be 500mm; and

b) conductive explosives storage racking should be connected at its base to the facility earth system unless there is at least 2m separation between it and the building structure. An additional connection to a conductive or anti-static should not be an alternative. The racking should not be connected to earth above its base.

9.2.5. Specialist equipment (LEVEL 2)

Specialist equipment for explosives assemblies should have any special requirements for the dissipation of static charges identified at an early stage, be compliant with national technical authority regulations and the requirements of this IATG. It should have all necessary connections to the ground earthing plane using conductive wheels, tyres, feet etc. as appropriate.

9.2.6. Relative humidity (RH) (LEVEL 1)

It is important to maintain the correct RH within explosives processing rooms and storage facilities. This will ensure static charge will not easily be acquired and that it can be quickly dissipated. The RH limits are described in the specifications for the corresponding electrostatic regime. Some materials require hours of conditioning at the appropriate RH to achieve the desired electrical behaviour. To ensure safe dissipation of charge from the surface of exterior clothing and packaging made from natural fibres such as cotton, it is particularly important that they be conditioned at the appropriate RH.

All explosives process rooms should be fitted with sufficient displays to allow the user to readily confirm the RH meets the requirements of this module. Additional sensors and displays may be required within regions of large and/or segregated electrostatic areas.

9.2.7. Hazardous area personnel test metre (HAPTM) (LEVEL 2)

A HAPTM shall be used by any person as soon as they enter any area where a conductive regime is in force. Anyone who fails the test shall either make modifications to ensure a pass or shall leave the area. The HAPTM confirms the subject's total resistance to earth is below 1MΩ. This is the maximum acceptable resistance for operating in a conductive regime. Personnel wearing conductive footwear on a conducting floor will normally achieve a pass.

The term footwear means shoes or boots but does not include temporary systems of heel grounding or similar additions to ordinary footwear that are commonly issued to temporary visitors to explosives process rooms. Anyone approaching within 1m of any explosive or explosive assembly shall not use such temporary electrostatic dissipative material.

A HAPTM shall be placed at the entrance to the area and the earth electrode shall be connected to the earthed grid of the conducting floor. A metal earth plate should not be used as the foot electrode. Anyone undergoing testing shall stand on the conductive floor. The test shall only be undertaken in dry footwear as it is possible to obtain a pass with wet footwear which, when dry, would insulate the wearer from earth and cause a fail. Visitors equipped with temporary earthing devices such as heel grounders may be permitted into conductive and anti-static areas but shall not be allowed to touch any explosives assembly. HAPTM shall be calibrated as per the manufacturer's instructions.

9.2.8. Earthing

Earthing should be as per the requirements of the national technical authority and international good practice guidelines. Metal sheaths or armouring of all electrical cables, metallic pipes, rails or guides entering a building should be bonded to the nearest part of the LPS above the test links at the points of entry. They should also be earthed at positions 75m and 150m from the building. If the outer sheaths of cables are stripped to facilitate this connection the stripped length should be properly protected against corrosion.

In underground installations, extra earthing should be installed at intervals no greater than 75m along the access roadway or shaft. This measure is intended to protect the integrity of the earthing system by using protected multiple earths (PME) and also to provide a degree of transient suppression.

Metal service pipes should not be used as earth electrodes.

9.3 Anti-static regime and precautions (LEVEL 2)

9.3.1. Flooring

Anti-static flooring should be provided as required by national technical authority regulations and international good practice. This flooring is designed to dissipate a static charge by relatively slowly discharging the floor, and anything electrically connected to it, to earth. International best practice states that anti-static floors should have a resistance from the surface of the floor to earth of between 50kΩ – 100MΩ. However, in explosives processing buildings, especially in rooms with potentially explosive atmospheres, the upper limit should be 2MΩ. Flooring should be tested in accordance with Annex H.

In the absence of a suitable HAPTM for anti-static environments safety should be assured by annual floor and shoe testing. However, if there exists a requirement to upgrade to a conductive regime, then the building must include the addition of a HAPTM.

An RH of ≥40% should be maintained. RH monitoring equipment with an accuracy of at least +/- 5% RH is permitted.

9.3.2. Shoes and clothing

Personnel should wear anti-static footwear that complies with the resistance requirements of the national technical authority and international best practice including the inclusion of safety caps and other features to provide protection from accidental foot injury.

Personnel should wear outer clothing of materials whose outer exterior surfaces have a surface resistivity of $1 \times 10^{12}\Omega$ or less at an RH of 40%. The clothing should be stored in an environment of the same or higher RH than its working environment. The clothing must be of a homogenous textile and not of material that relies upon a conductive grid or coating and also provide protection against fire and flash burns. Clothing should fit properly and be correctly fastened. Gloves should not be worn unless, as a result of a risk assessment, they are identified as personal protective equipment (PPE) to protect operators from an additional hazard. In this situation, it will be necessary to balance the relative risks between the explosives and other identified hazard, although anti-static gloves are available. Personnel shall not don or remove clothing whilst in the presence of explosives substances or articles.

9.3.3. Other materials

Loose resistive, that is, material such as a plastic, rubber, glass etc with a surface resistivity of $10^{11}/m^2$ in the working area, should be restricted to a size <75cm². In this context the word "loose" is meant to permit the presence of >75cm² of resistive materials which will be safe because they are fixed and remote from the sensitive materials or devices. In many cases loose items may be treated to improve their electrostatic characteristics.

9.3.4. Relative humidity

An RH >40% should be maintained in the area at all times.

9.3.5. Wrist and leg straps

If wrist or leg straps are specified for use in an anti-static regime, then the following standards should be applied:

a) straps should be of the quick release type. End-to-end resistance including the strap, cabling and termination contact shall be ≥750kΩ and ≤35MΩ;

b) a dedicated connection point for straps should be established next to the working area and should be easily accessible. The connection point should be clearly identified; and

c) electrostatic dissipative footwear should be constructed such that the contact made with both feet meets the requirement for an electrical path from the wearer to contact points on each foot of the footwear in both toe and heel region.

9.3.6. Testing of anti-static equipment before use

Checks on wrist straps and ground cords should be made at the start of each working day. Each check shall be made with the wrist strap worn on the wearer's wrist and in contact with the wearer's skin. Checking shall include the measurement of end-to-end resistance.

Leg, toe and heel straps should be checked prior to use or on entry to the static controlled area. The wearer's leg strap shall be in contact with the wearer's skin. Toe and heel straps shall be tested with the appliance worn by the wearer.

Measurement of the above checks should be as per national technical authority requirements.

9.4 Conducting regime and precautions (LEVEL 2)

9.4.1. Flooring

Conducting flooring should be provided in accordance with the requirements of the national technical authority and international good practice. The resistance from the surface of the floor to earth should be less than 50 kΩ. If for some reason conductive floors cannot be used, an alternative system of control of electrostatic charge may be specified but will require the written agreement of the national technical authority. Flooring should be tested in accordance with Annex H.

9.4.2. Shoes and clothing

See Clause 9.3.2.

9.4.3. Other materials

No materials capable of retaining any significant electrostatic charge or of permitting the electrical isolation of significant conductors should be permitted within the working area. Should a high RH be maintained wood and other cellulose materials may be permitted.

9.4.4. Relative humidity

An RH of ≥ 65% should be maintained. RH monitoring equipment with an accuracy of at least +/- 5% RH is permitted. However, in exceptional circumstances approved by the head of the site RH limits may be reduced to an absolute minimum of 40%. However, should the head of the site wish to process at RH of 40 - 65% the following restrictions should apply:

a) there shall be no processing of bare primary explosives;

b) individual personnel shall continue to pass the HAPTM test;

c) all materials whose static dissipative properties are dependent upon a high RH shall be removed; and

d) it shall be demonstrable that no hazardous levels of electrostatic charge can exist at the reduced RH. This parameter will require the use of specialised equipment, testing techniques and personnel.

9.4.5. Equipment restrictions and effective grounding

Conveyor belts should be conducting types complying with tests approved by the national technical authority. The electrodes should be placed on with one electrode on each surface. The maximum acceptable resistance is 100 kΩ.

Bench tops, chairs and containers should be of conducting material and should be effectively bonded to the conductive floor or equipotential bonding system. Seat covering material should be of a static dissipative material.

All conductors are to be effectively grounded. For the purpose of this module, this means <1MΩ maximum resistance to earth.

9.5 Mixed or hybrid conducting areas

It is possible to mix the various conducting regimes i.e. uncontrolled, anti-static and conductive within the same building or room. However, specials precautions should be taken, and it should be noted that the administration and operation of such areas will be complex. This will require careful and deliberate control of personnel moving between the various regime areas. Areas to be considered are flooring, conveyor belts, bench tops, chairs, seat covering, footwear, clothing, PPE, explosives and other containers. This list is not comprehensive, and a careful study and comprehensive risk assessment of the process will be necessary.

9.5.1. Marking and mixing of different electrostatic regimes

The areas should be clearly defined in terms of the different electrostatic regimes in operation on a scaled drawing held by the national technical authority and the areas must be demarcated by permanent or semi-permanent barriers. Any change to the demarcated areas should be accompanied by a risk assessment and justification. This shall be sent to the national technical authority via the head of the establishment.

It is vital that the correct HAPTM should be available at the points of entry and/or exit to the controlled area. Within the controlled areas, the appropriate controls must be followed. If the fabric of a building or room provides a conductive regime but the building is required to process explosives natures that require an anti-static regime or an uncontrolled electrostatic environment, it is not necessary to fully maintain all features of the conductive regime. However, the rules for the testing and maintenance of conductive floors should still apply.

9.5.2. Mixed regimes and portable equipment use

Having mixed electrostatic regimes within the same room or building requires strict control on the use of portable electrical equipment. Any such equipment used within the zoned area should be double insulated to remove any risk to personnel of electrocution resulting from the use of defective equipment within a conductive regime.

9.6 Safety of personnel and safety checks (LEVEL 2)

9.6.1. Residual current devices (RCD)

If anti-static or conductive regimes are in operation, personnel should be protected from lethal electric shock by an RCD to levels as required by the national technical authority. Should it not prove possible to provide such electrical protection by the use of an RCD, the head of the establishment shall provide adequate protection to an operator such that the risk of a lethal electric shock is removed, in so far as is reasonably practicable.

9.6.2. Mains powered electrical equipment

All fixed electrical equipment installed within arm's reach of, or portable equipment used by, a person standing on the conducting floor should be double insulated to comply with national technical authority requirements. Alternatively, the equipment may be fed from a fixed separated extra low voltage (SELV) supply complying with national technical authority standards. This requirement should apply to all users of the facility including but not exclusive to cleaning staff, maintenance staff and process workers.

When conducting or anti-static flooring is installed a notice prohibiting the use of unauthorised electrical equipment should be displayed.

Weekly visual checks of the electrical bonding of benches, floors, chairs, trolleys, mats, workstations, separately grounded equipment or any other equipment that grounds an operator permanently or temporarily should be carried out. Equipment subject to change of configuration should be checked immediately after that change and thereafter at weekly intervals.

9.7 Electrical bonding of anti-static and conductive flooring (LEVEL 2)

9.7.1. Building floor and protective covering interface

The floor underneath the anti-static or conductive should be protected by an effective damp proof membrane. Bonding strips should be laid under each separate piece of floor covering to ensure effective electrical continuity throughout the floor. The bonding strips should be laid on the floor to form a grid of 600mm spacing under the protective floor covering. The spacing of the grid should ensure that the electrical resistance of the floor to building earth is compliant and consistent across the entire floor area.

9.7.2. Earthing and bonding

An absolute minimum of two paths to earth should be provided for each piece of floor covering. The grid should be connected to the electrical earth of the building in positions ideally at diagonally opposite points of the floor. Grids should not cross flexible expansion joints. If necessary, flexible bonding cables may be used to couple adjacent grids.

If the floor covering is made of tiles, then the bonding tape should be laid under each row of tiles and all of the tapes should be connected together by a tape laid at right angles.

9.7.3. Bonding materials and dimensions

Stainless steel bonding tapes should be used but the use of brass and copper is acceptable. However, aluminium shall not be used. The tapes should be at least 50mm wide if using sheet material as this will provide reliable connectivity across sheet joints; the tapes should be not less than 0.2mm thick. For some flooring systems such as those of homogenous polymeric material and with a trowelled finish, the width of the conductive tapes is not important.

However, the tapes should be of sufficient mechanical robustness to last the design life of the floor and provide a low enough resistance to not contribute to the 50kΩ limit for the electrical resistance of the flooring. Electrical continuity of under floor joints should be achieved by riveting, soldering or conducting adhesive and connections to the earthing system of the building should be made with screw clamps.

Any adhesives used should be electrically conducting but if a non-conducting adhesive is used care should be taken to prevent the adhesive affecting the conductivity between the bonding tapes and the under surface of the floor covering. Adhesives shall be chemically compatible with the explosives present in the building.

9.7.4. Protective surface maintenance

Waxes and polishes shall not be used on anti-static and conducting floors. The method and frequency of cleaning should be that recommended by the manufacturer of the flooring material. If any area of the floor exhibits evidence of contamination by dirt, grease etc. that could affect its electrical resistivity, then the area should be cleaned by the recommended method immediately.

Annex A
(normative)
References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this module. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this module re encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO maintain registers of currently valid ISO or EN:

a) IATG 01.40 *Glossary of terms, definitions and abbreviations*. UNODA;

b) IATG 01.50 *UN Explosive hazard classification system and codes*. UNODA;

c) IATG 02.10 *Introduction to risk management principles and processes.* UNODA;

d) IATG 02.20 *Quantity and separation distances*. UNODA;

e) IATG 02.30 *Licensing of explosives facilities*. UNODA;

f) IATG 02.50 *Fire safety*. UNODA;

g) IATG 05.50 *Vehicles and mechanical handling equipment (MHE) in explosives facilities*. UNODA;

h) IATG 05.60 *Hazards of electromagnetic radiation*. UNODA; and

i) IATG 06.60 *Works services (construction and repair)*. UNODA.

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UNODA) holds copies of all references[15] used in this guideline and these can be found at: www.un.org/disarmament/un-saferguard/references. A register of the latest version/edition of the International Ammunition Technical Guidelines is maintained by UNODA, and can be read on the IATG website www.un.org/disarmament/ammunition. National authorities, employers and other interested bodies and organisations should obtain copies before commencing conventional ammunition stockpile management programmes.

[15] Where copyright permits.

Annex B
(informative)
References

The following informative documents contain provisions, which should also be consulted to provide further background information to the contents of this guideline:

a) AASTP-1, Edition B Version 1. *NATO Guidelines for the Storage of Military Ammunition and Explosives.* NATO Standardization Organization (NSO). December 2015. http://nso.nato.int/nso/nsdd/listpromulg.html; and

b) DSA03.OME part 2 provides for the safe storage and processing of Ordnance, Munitions and Explosives (OME). UK MOD. November 2020.

The latest version/edition of these references should be used. The UN Office for Disarmament Affairs (UNODA) holds copies of all references[16] used in this guideline and these can be found at: www.un.org/disarmament/un-saferguard/references. A register of the latest version/edition of the International Ammunition Technical Guidelines is maintained by UNODA, and can be read on the IATG website: www.un.org/disarmament/ammunition. National authorities, employers and other interested bodies and organisations should obtain copies before commencing conventional ammunition stockpile management programmes.

[16] Where copyright permits.

Annex C
(informative)
Lightning protection systems (LPS)

Ideally, a LPS should be included as a requirement during the design and construction of explosives facilities. It should be effective, simple, rugged and permanent. It should also be accessible for testing and maintenance, particularly to earth termination networks that are hidden from view.

C.1 Construction and design of an LPS

Modern explosives facilities use metal extensively in their construction and it should be utilised in order to maximise the number of parallel conducting paths if use of a surface mounted air termination system is allowed. Properly bonded reinforcing bars in an RC building may be used as down conductors and steel roof cladding may be used as an air termination network provided a minimum gauge of metal is used.

The following types of construction provide the best options for the provision of inherent lightning protection:

a) a reinforced concrete (RC) construction with cast in-situ walls, roof and floor with all connections fully bonded and earthed; or

b) a steel portal frame with earth bonded profiled sheet cladding.

If the building is not of the above types, then a LPS system should be installed.

C.2 Construction materials

When selecting materials for a LPS system, their compatibility and corrosion characteristics will be critical. Different metals in contact with each other should be close to each other in the electro-chemical series to reduce the risk of electrolytic interaction. If the possibility of significant electrolytic action exists, thermic welded or dry sealed metallic joints should be used to provide adequate protection. Conductors for use as suspended air termination networks should be stranded hard-drawn copper, aluminium, or copper coated steel and be specified by the national technical authority.

C.3 LPS

Buildings may be designed with either an integral or separated LPS. In an integral system the LPS is either attached to the building or utilises parts of the building structure. A separated LPS is physically separated from the building LPS and is not fixed to or is part of the building structure.

C.3.1 The component parts of an LPS are:

a) an air termination network;

b) down conductors;

c) an earth termination network;

d) earth electrodes; and

e) test joints and bonds.

C.4 Air termination network (ATN)

An air termination network intercepts the lightning strike. It is generally fixed either to the roof of a building or utilises the roof structure in the case of an integral LPS or is a pole close to the building and standing taller than the building being protected and is struck in preference to the building.

C.4.1 Types of ATN

There are three types of integral ATN and they are illustrated at Appendix 1 to this Annex. The three types are:

a) surface mounted air termination;

b) an RC structure with fixed air termination (Figure C.1); or

c) a steel frame and roof (Figure C2).

There are two types of separated ATN and they are also illustrated in Appendix 1. The two types are:

a) suspended air termination (Figure C.4); or

b) vertical air termination (Figure C.5).

C.4.1.1 Surface mounted air termination

This design of LPS is by far the most common. The roof conductors should form a mesh of the size as required by the national technical authority but ideally 10m x 5m, or smaller if necessary, and it should be made of bare copper only.

Conductors may be laid directly on the roof as long as roofing materials do not cover them. The edges are the most vulnerable parts of a roof and therefore conductors running along an edge should be placed as close as practicable to the edge; 100mm or closer is the ideal.

If a single facility has roofs at different levels, each level should be protected. The fixed air termination network on a roof at one level may provide protection to a roof at a lower level. In this case a separate network on the whole or part of the lower roof may not be necessary. Specialist advice should be sought.

C.4.1.2 RC structures with fixed air termination

The wall and roof reinforcing bars of RC structures should be brought out in a minimum of two diagonally opposite locations on the structure. They should be bonded to the surface mounted air termination network and the down conductor. If separate down conductors are installed, these should also be bonded to the reinforcing bars at the tops of the walls.

Where a down conductor is attached to a reinforced concrete column or a concrete encased steel column, the steel work should be connected to the down conductor above the test joint. The reinforcement of the wall, floor and the reinforced column or steelwork should be contiguous with the reinforcement of the roof.

Pointed vertical conductors or finials are not normally provided on a surface mounted air termination but are entirely appropriate for RC structures and explosives buildings.

C.4.1.3 Steel Frame and Roof

If the building has a metal roof, then the roof will form the air termination network. It is vital that the metal roof is properly bonded to the LPS down conductors.

If the roof is part of a steel framed structure then the steel frame may be designed to form the down conductors for the LPS. In such cases all metalwork between the steel frame and roof should be electrically bonded and the joints tested to ensure they have a resistance of ideally 0.5Ω or less.

C.4.1.4 Suspended air termination network

A network of this type comprises two or more poles supporting and bonded to an aerial conductor or system of conductors. The support poles should be positioned at least 2m from the facility. When one pole consists of a non-conducting material, a conducting tape running the length of the pole is to be provided to bond the aerial conductor to the earth termination network. All stay wires are also to be bonded to the earth termination network.

In order to prevent flash over, the minimum clearance between the lowest part of an aerial conductor system and the protected facility should not be less than 2m in the maximum sag condition caused by snow and ice. However, should the facility have sharp or pointed metallic earth bonded components protruding from the protected building, such as a ventilation stack, a clearance of >5m should be required from the highest point on the structure.

C.4.1.5 Vertical air termination network

A vertical air termination network comprises a single metallic pole positioned at least 2m from the facility. Stay wires should be bonded at the upper end to the LPS and, at the lower end, should be bonded to the buried ring earth electrode.

C.5 Down conductors

Surface mounted air termination networks should be provided with two or more down conductors around the perimeter of the facility. They should be equally spaced as far as possible and not be more than 15m apart. Down conductor material should be copper, and each down conductor should have an associated earth rod as specified by the national technical authority.

Down conductors should not be taken inside buildings, but metal structural elements used as down conductors may have internally exposed parts. This should be taken into account with respect to the internal layout of the facility.

If the reinforcing bars or steel frames of a facility are being used as the down conductors, then the connection to the earth termination network should be approximately 100mm above ground level. The connection to the reinforcing bars or frame should be such that it can be inspected readily but it should also be protected from the elements.

C.6 Earth termination networks

These should be located as close as possible to the facility being protected but should be not less than 600mm from the wall footings. An earth termination should consist of rod electrodes, tapes or other means of providing a connection to the earth.

C.6.1 Metal rod electrodes

Rod electrodes should be driven to the depth necessary to give the desired earth resistance. The minimum depth should be that at which the rod penetrates into soil of permanent dampness. If more than one rod is necessary to obtain the desired resistance, the spacing between the rods should be at least equal to the driven depth. Rod electrodes have a life of some 30 years. Increasing resistivity is caused by failure of the copper plating and the subsequent rusting of the rod material. Failing rods should be replaced.

All earth electrodes of a system should be interconnected by a ring conductor buried at least 600mm below ground. The earth systems of adjacent structures should be interconnected where reasonably practicable and where the ground conditions make the achievement of the required earth resistance difficult. In difficult ground conditions where rod electrodes prove ineffective specialist civil engineering advice should be sought.

If a facility is sited on bare rock, a satisfactory earth electrode may be obtained by rock drilling and back filling the hole with sifted soil or a mixture of carbon powder and copper dust before driving the earth rods. The diameter of the hole should be 75mm or greater. Coke, breeze or fly ash should not to be used as back fill because they have a corrosive effect on copper. There are commercially available products that may be used to improve the ground conductivity around electrodes. In areas of high soil resistance or restricted space limiting the number of rods that can be driven chemical rods may be used in conjunction with conductive or moisture retaining backfill.

C.6.2 Chemical rod electrodes

Chemical earth rods provide a controlled release of a saline type solution into a backfilled area. They may be used if difficult ground conditions are encountered and may remove the need to drive extra rods if space is limited. These types of earth rod require regular re-filling with an appropriate chemical solution so a maintenance regime should be adopted when using these rod types in order to maintain their effectiveness. Chemical rods offer more consistent performance in desert conditions or climates with distinct wet and dry seasons.

C.6.3 Estate management and testing

Should increasing earth rod resistance necessitate the driving of additional rods, the facility engineering drawings should be amended to reflect the change and the future testing regime should test the rods as one electrode. Water pipes or other services should not be used as part of the earth termination system or as the earth electrode.

In order to allow for the electrical isolation of and access to the electrodes during testing, the upper ends of the electrodes should be terminated in a small covered service pit. Where conditions such as the need to bond to metal parts of the facility require a conductor to be exposed, the conductor should be attached to and encircle the facility at a height of 500mm above ground level. It should be permanently bonded to all down conductors. If the conductor is attached to the facility it is to be visible throughout its whole length. Should door openings, paths and roadways make it necessary for the conductor to go underground it should be drawn into a non-metallic pipe.

C.7 Test joints and bonds

C.7.1 Joints

A multi-way, clamp type test joint should be constructed in each service pit. Only earth termination networks should be permitted below a test joint.

Poles supporting an air termination network should be provided with test joints at 500mm above ground level and connected to the earth termination network and to any stay-wires at points as near as practicable to the pole.

Earth electrodes should be capable of being isolated and a reference earth electrode should be provided for testing purposes, particularly when the surrounding soil is concreted or tarmacked.

If the steel structures of a facility are used as the down conductors, sufficient test points should be provided to enable the low resistance continuity of the steel structure to be checked. This is especially important for those parts of the structure that are not visible or accessible.

C.7.2 Bonds

All major items of metal external to, and forming part of a facility, should be bonded to the LPS. Bonding material for both internal and external bonds for explosives buildings should be annealed copper. Steelwork that is less than 2m long i.e. metal window frames, small ventilators and other small metal fittings, provided they are more than 500mm from any LPS components, need not be bonded.

Resistance testing of bonds should be performed during acceptance of the LPS installation and requires periodic inspection through its life.

The metal sheath or armour of incoming electrical supply cables should be bonded to the LPS and to the enclosure of the main switch at the cable entry point only. The metal sheath or conduit of each circuit leaving the main switch should be bonded to the switch enclosure. All other metal service pipes or conduits should be bonded to the LPS at their point of entry to the facility only. All straight runs of metallic conduit, pipe work or metallic cable sheathing should be bonded to the LPS at each entry and exit point. It should be possible to isolate the LPS connection for test purposes.

All railway and crane rails within a facility should be bonded at each end to the LPS. Any rails extending outside the facility should be bonded to the LPS at their point of entry/exit.

The LPS should be connected to the facility earth bus bar at one point only. The means of connection should be such that it can easily be disconnected to enable tests to be made.

C.8 Underground facilities

As stated previously, normally an underground facility does not require an LPS. However metal and structural parts of the site that have less than 600mm of earth coverage should be protected as for an above ground site.

C.8.1 Exposed headwalls

If an earth covered facility has an exposed headwall then the headwall should have an air termination network connected to the reinforcing bars of the roof concrete and all exposed metalwork should be bonded together and connected to the earthing system at the entrance to the structure.

C.8.2 Less than 600mm of earth cover

Should a facility have less than 600mm of earth cover it should be protected against lightning strikes. The following requirements should be met:

a) roof conductors may be fixed directly to the roof of the facility;

b) the earth termination network conductor should run underground at a distance of approximately 1m from the base of the earth cover. It should be taken across the head wall or other wall not covered with earth at 500mm above ground level;

c) down conductors should pass through the earth cover at a distance of 500mm from the structure. They should also be taken down the head wall or any other wall not covered with earth; and

d) the joints between down conductors and the earth termination network should be readily accessible for inspection. These joints should be within 150mm of the ground surface in a covered inspection pit.

C.9 RC facilities such as igloos and other cast in-situ buildings

C.9.1 RC facilities

If correctly designed and constructed RC facilities will have inherent lightning protection. The structural steel components of the structure create a shield only if the conducting elements are electrically contiguous. For RC structures this can only be assured by ensuring that the wall reinforcing bars are bonded to the reinforcements of the roof and floor during construction.

To provide the inherent protection all metallic penetrations should be bonded to the reinforcing bars where they penetrate the structure. Extensions of the reinforcing bars should be provided to connect strike termination devices to reduce the risk of structural damage from lightning. Steel portal frame with earth bonded profiled sheet cladding will provide a Faraday cage like structure but will afford less shielding effectiveness than reinforced concrete structures. Under-floor reinforcing mesh should also be bonded to the portal frames during construction.

It cannot be assumed that all existing RC and metal clad structures will provide inherent protection. Therefore, a low voltage shielding effectiveness test should be carried out by appropriately qualified personnel. If this is not possible then an approved external LPS should be installed.

The most important lightning protection feature of a RC explosives facility is the reinforcing bar mesh within the concrete shell. This will carry some 90% of the lightning current from a strike. Therefore, it is essential that the reinforcing bars completely encircle the volume of the facility i.e. the roof, walls and floor. The reinforcing bars in the roof, walls and floor should be bonded as follows:

a) reinforcement crossovers should be welded at a maximum of 2.5m centres in both faces; and

b) remaining reinforcement crossovers should be wire-tied at every intersection.

The nature of the metallic connection and the very large number of bars and crossing points of such a construction ensures a substantial sub-division of the total lightning current through a multiplicity of parallel discharge paths. To be fully effective as a shield against fields produced by lightning the RC mesh size should be no larger than 30cm.

No separate down conductors are necessary on a facility of RC construction. However, at roof level a surface mounted ATN should be fitted to reduce the structure's physical elements from damage due to external spalling should the facility receive a lightning strike. The fixed ATN should be directly bonded to the reinforcing bars in the number of positions required for down conductors in at least two diagonally opposite places.

If a pitched metal roof is fitted on a RC facility, then the roof may act as the ATN provided that the minimum material thickness requirements required by the national technical authority are met. If this type of roof is specified it is recommended that at least two finials are fitted, one at each end of the roof ridge.

Other metallic penetrations, such as conduits and pipes, should be bonded to the closest reinforcing bars at the point of entry. All doors and windows should be bonded to their frames and the frames should be bonded to the structure reinforcing bars.

C.9.2 Steel framed buildings

A steel-framed building with metal cladding may be regarded as a Faraday cage if:

a) the components of the facility are bonded together with a resistance of les than 0.5Ω; and

b) the resistance to earth of each vertical stanchion does not exceed 10Ω.

However, these values can only be tested during construction of the building and therefore all bonding and earth termination network resistance testing should be performed during the construction of the facility. Testing of the resistance to earth of each stanchion should be made before any electricity supply cables, rails or other metallic pipes are attached to the structure. Where these earth resistance requirements are not met with, a ring conductor bonded to each stanchion and with earth electrodes at each end of the structure should be provided

The minimum thickness of metal used for the cladding and the roof, which forms part of the air termination network, should be of a thickness as specified by the regulations of the national technical authority or to internationally accepted standards.

The foundations of the facility may have low earth resistance without the need for additional earth electrodes, particularly if the facility foundation includes reinforced piles. Measurement of the earth resistance of the newly completed foundations will identify if they are compliant or if more earth electrodes are needed.

The steel frames should be fitted with connections at the top and bottom as a means of bonding the roof and earth to the frames. If the foundation alone is used, provision should be made to bond each vertical stanchion of the steel structure to the earth matrix and in turn to the foundation concrete reinforcing bars and mesh.

Metallic penetrations, such as conduits and pipes, should be bonded to the facility at their point of entry. Details of bonding connections between the steel frame, cladding, roof, walls etc should be decided at the design stage.

Steel portal framed, metal clad structures may not need periodic testing of the permanently made bonds that make them self-protecting from the effects of lightning, and it should be the aim of the designers of the system to achieve this aim.

C.10 Open storage of explosives

Explosives being stored in the open for long periods require a LPS which provides a 30° cone of protection or suspended air termination. This requirement may be dispensed with if it can be shown after a thorough risk assessment that an explosives event due to a lightning strike is unlikely due to ammunition insensitivity, low strike probability etc.

Short term storage may be provided with LPS cover in the form of a temporary vertical, or suspended, air termination LPS.

C.10.1 ISO containers

ISO containers loaded with ammunition may be open stored with the following restrictions:

a) unpackaged explosives should not be stored in ISO containers. Ammunition packaging should provide a standoff distance from container walls;

b) the container meets the requirements of Clause 8.1.3; and

c) containers storing explosives should not be stacked.

C.11 Testing of LPS

Inspection, testing and recording of the results of LPS tests should follow national technical authority guidelines and meet the requirements of Table 6. When selecting a testing regime, the following requirements should be adhered to:

a) a 'fall of electrical potential' test utilising supplementary electrodes is the preferred test method;

b) in commissioning of new or refurbished facilities use of the fall of potential method is mandatory;

c) clamp-on style test equipment may be used for periodic testing of LPS, but every fifth test period should be conducted using the fall of potential method;

d) clamp-on testers cannot test earth electrodes accurately if a ring conductor is still in circuit and if the LPS is still cross bonded to the low voltage incomer sheath. It is mandatory that both should be disconnected for the earth electrode test; and

e) test records shall clearly show which test method has been used.

C.11.1 Testing conformance and parameters

When an LPS is tested it should meet the following parameters:

a) the resistance to earth of an individual earth electrode with all connections removed should not exceed 10Ω multiplied by the number of earth electrodes in the entire earth termination network;

b) a buried ring conductor should be treated as part of the earth termination network. With all earth electrodes connected to the ring conductor and all equipotential bonding conductors to incoming services, crane and railway rails etc removed the total resistance to earth should not exceed 10Ω;

c) with all earth electrodes connected to the system and all equipotential bonding removed the resistance to earth of a system at points approximately equidistant between earth electrodes should not exceed 10Ω; and

d) there should be a maximum resistance of no more than 0.5Ω across equipotential bonds.

Structures with a Faraday cage LPS (Figure C.6) and without an external LPS should be tested if specific control of the requirements was not in place during construction. Adequacy of bonding and electrical continuity of the structural elements in the walls, roof and floor should be validated by measuring the transfer impedance frequency response using appropriate test instruments. These are complex tests and specialist electrical and civil engineering advice should be sought.

C.12 Design parameters

No LPS can guarantee total immunity from damage by lightning discharge. The Faraday cage, together with suspended air termination, is considered to provide maximum protection when all other measures such as surge protection and equipotential bonding have been taken.

The main danger from structural metal or metal cladding not forming part of the LPS is damage from side flashing where its position relative to roof or down conductors may offer an alternative current path to earth. This can be avoided by isolation, by distance or by bonding.

Each earth electrode of the system should be inter-connected by a ring conductor, which should preferably be buried. Because of the need to bond other objects to it, it is permissible to leave it exposed on the walls of the facility. In these cases, the interconnection is no longer part of the earthing system. It should not form part of the testing of the earth terminations and the connections to the down conductors, with which it inter-connects, should be fixed and permanent.

The use of unnecessary clamp connectors, which are liable to be disconnected, should be avoided. Such connectors should only be used where it is necessary to disconnect for test purposes.

External LPS conductors should not be coated in insulating material or painted.

C.12.1 High risk explosives

A 15°/30°zone of protection or the so-called 20m rolling sphere (see below) should be used for facilities of highest risk. Explosive items in this category are those sensitive to electrical induction, thermal shock, mechanical shock, or where the consequences of an explosion may be very serious.

C.12.2 Zones of protection of a separated LPS

International good practice and the results of much experimentation have shown that the zone of protection provided by a vertical air termination is a solid angle of 30° which has its apex at the highest point of the mast. For masts not exceeding 10m in height, the described volume is protected from all but the highest severity direct lightning strike as long as no part of the structure extends outside of the protected zone.

The zone of protection provided by a suspended air termination is described by a triangle with an angle of 30° to the vertical support pylons. As above, for suspended air terminations not exceeding 10m in height, the described volume is protected from all but the highest severity direct lightning strike as long as no part of the structure extends outside of the protected zone.

C.12.3 Rolling sphere protection

High structures that require a separated LPS exceeding 10m in height are special cases because the protected volume cannot be adequately defined by the 30° angle. As the leader approach of the lightning is described by a sphere centred on the leader end, the protected volume can be determined by rolling an imaginary sphere of radius equal to the step length all around the protected building and where it touches the LPS the protected volume is defined. The striking distance is related to the severity of the lightning strokes – the greater the severity of the stroke the greater the striking distance. In general terms, the smaller the sphere, the greater the protection but the LPS installation becomes more costly.

A 20m sphere should be used for buildings containing explosives and will describe protection against all but the lowest 5th percentile severity direct lightning attachments. Figures C.7 and C.8 of Appendix 1 show a 20m rolling sphere as applied to a vertical air termination and suspended air termination respectively where the height is greater than 10m. An approximate angle that would describe the protected volume derived from the rolling sphere method would be 15°. The rolling sphere principle is described at Figure C.9.

Appendix 1 to Annex C
(informative)
LPS designs

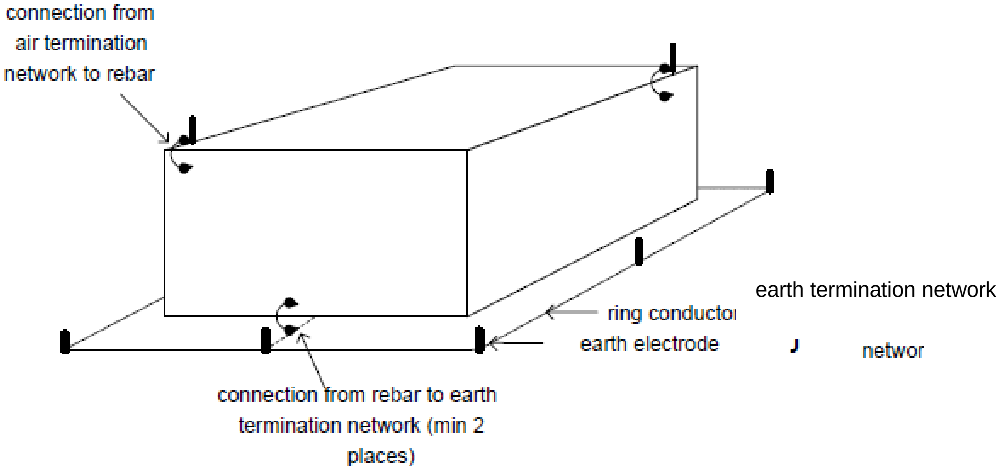


Figure C.1: Air termination network on a RC structure

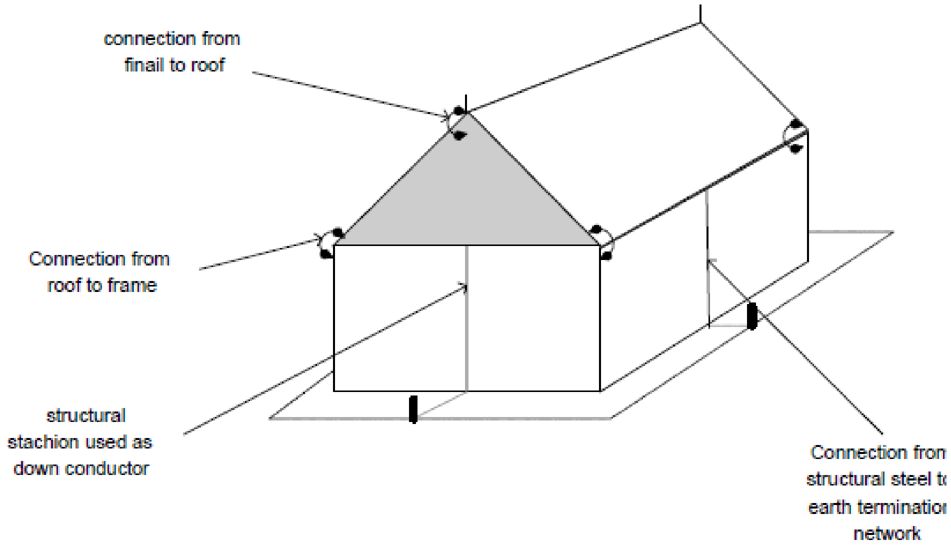


Figure C.2: Steel framed facility with metal cladding

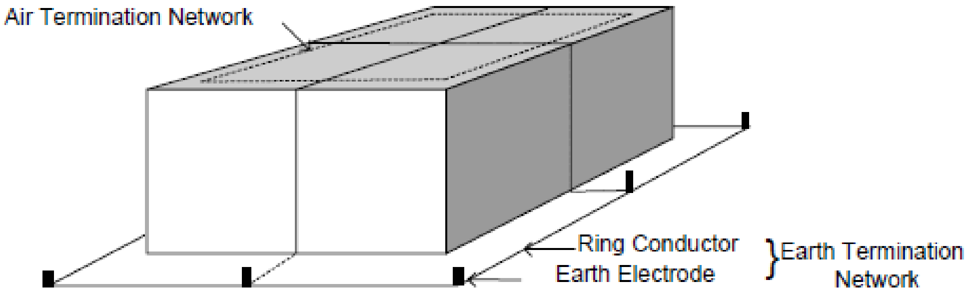


Figure C.3: Other methods of construction

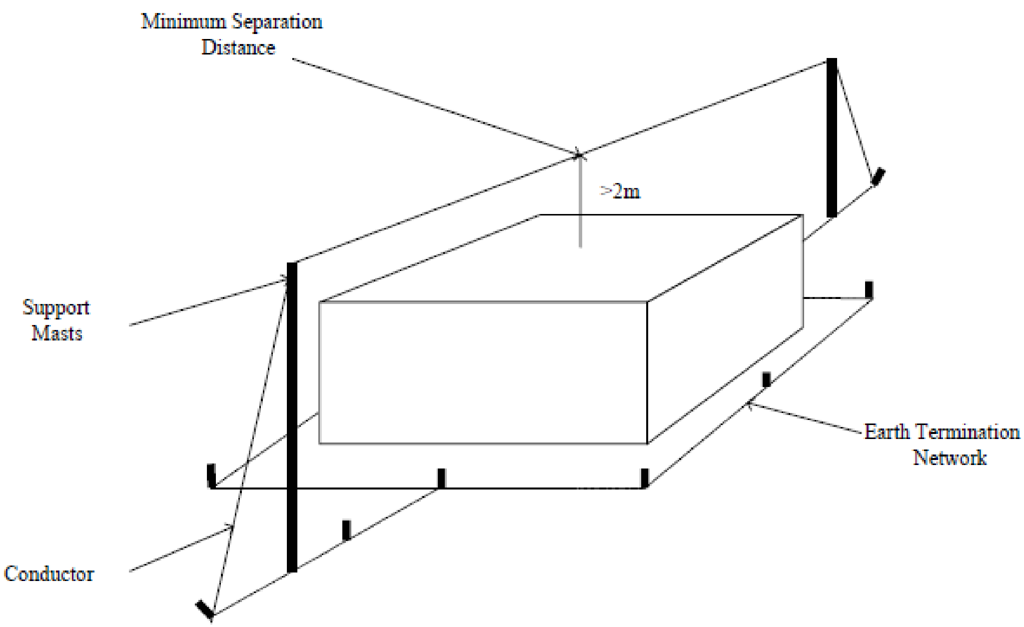


Figure C.4: Suspended air termination network

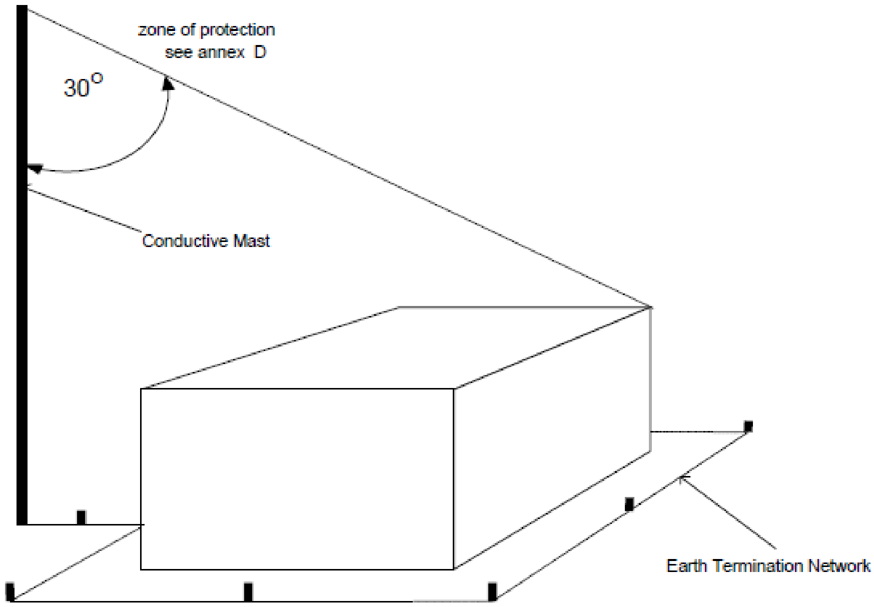


Figure C.5: Vertical termination network

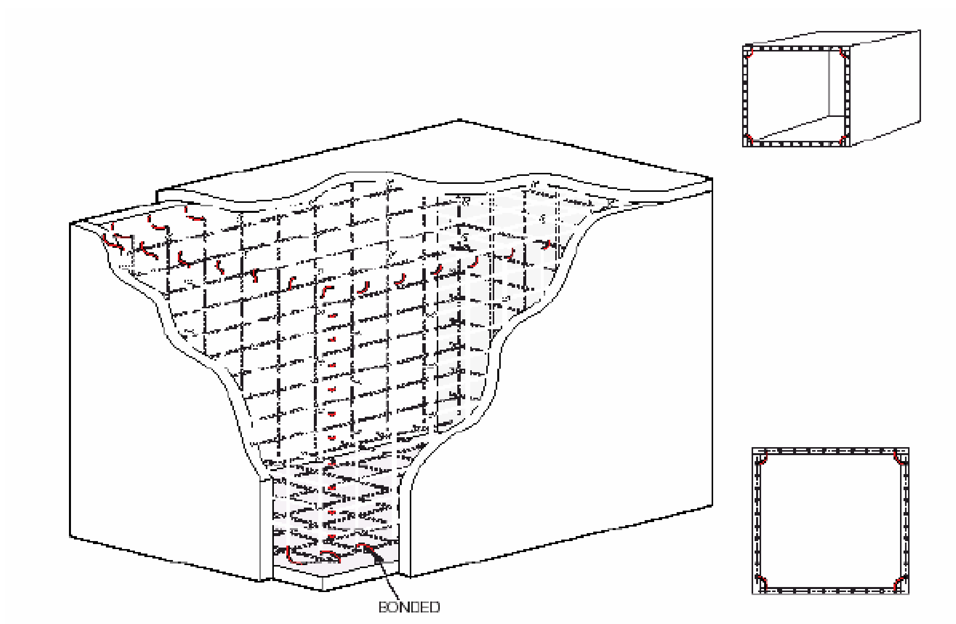


Figure C.6: Faraday cage construction

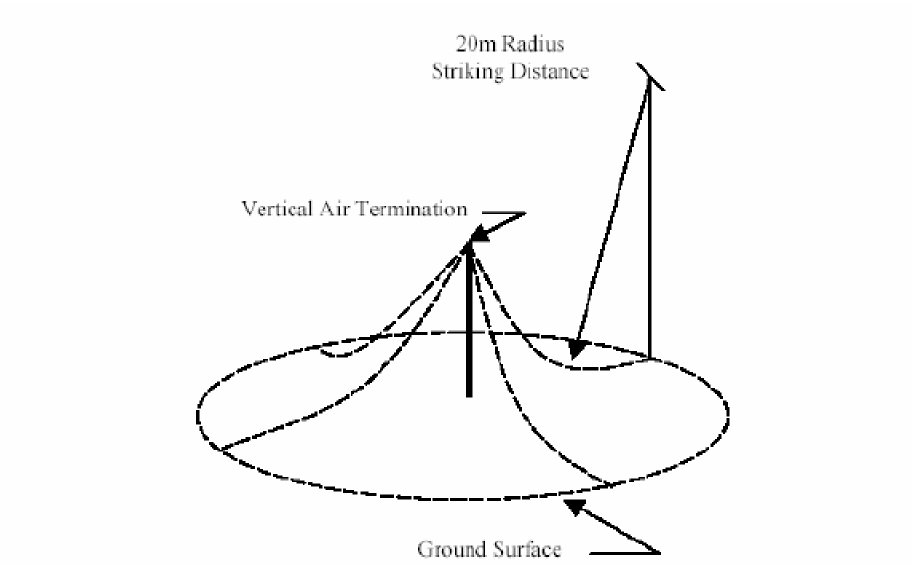


Figure C.7: Vertical air termination – 20m rolling sphere

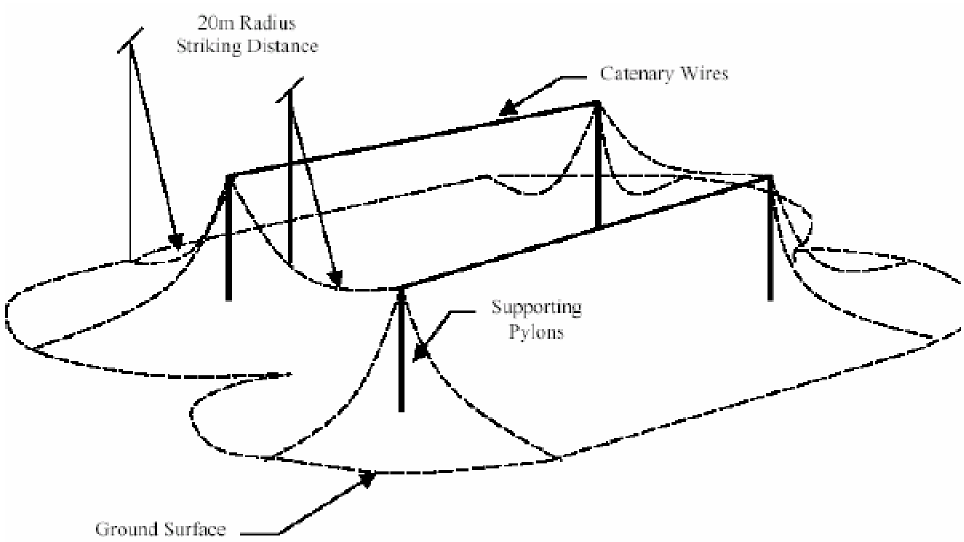


Figure C.8 Suspended air termination – 20m rolling sphere

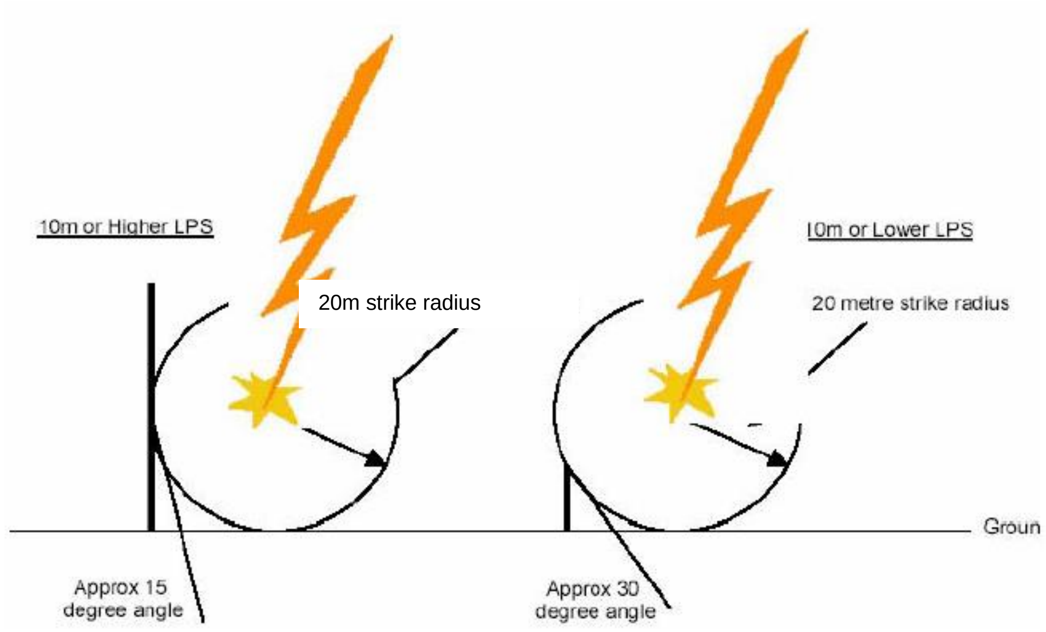


Figure C.9: The principle of the 20m rolling sphere

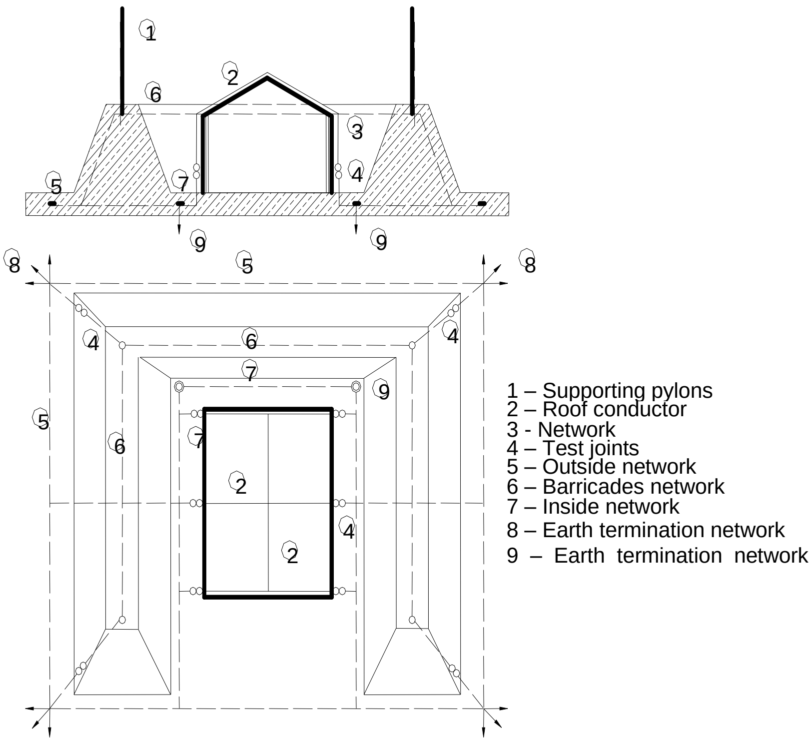


Figure C.10: The two levels of lightning protection systems

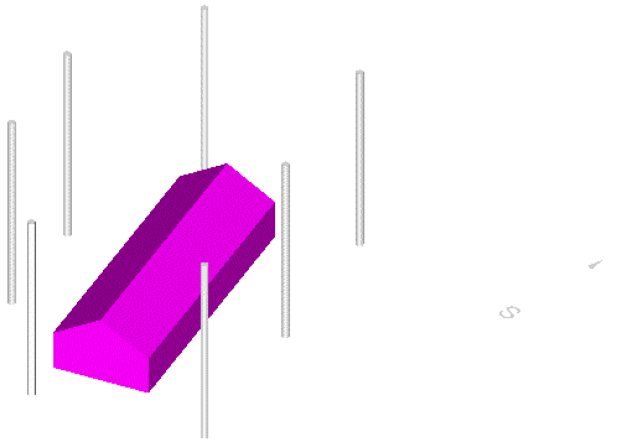
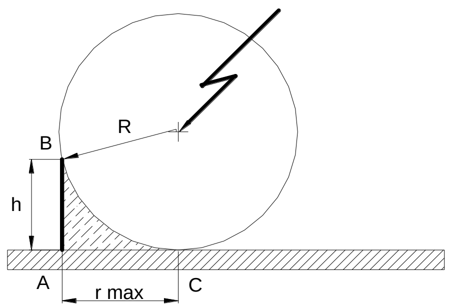
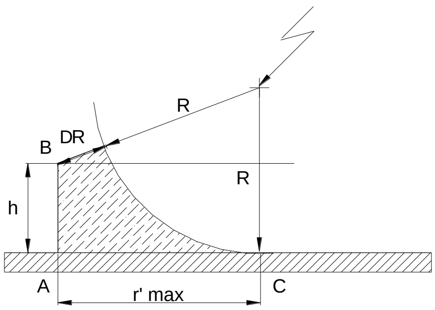


Figure C.11: Supporting pylons protection system around ammunition facility



$$AC = r_{\max} = \sqrt{h(2R - h)}$$

Figure C12: Protection zone of the supporting pylon protection system



$$R' = R + \Delta R \ (m), \quad \Delta R = v \ \Delta t \ (m),$$

$$r'_{max} = AC = \sqrt{h\left[2\left(R + \Delta R\right) - h\right]} \ (m).$$

Figure C13: Protection zone of the supporting pylon with LPS - early streamer emission

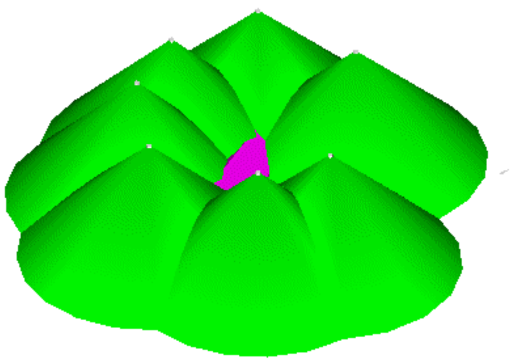


Figure C14: Improper Placement of the supporting pylons around the ammunition facility

Annex D
(informative)
Applicable EU regulations

Table D.1 contains European Union standards that could be used as reference by national technical authorities for electrical installations within explosive facilities.[17]

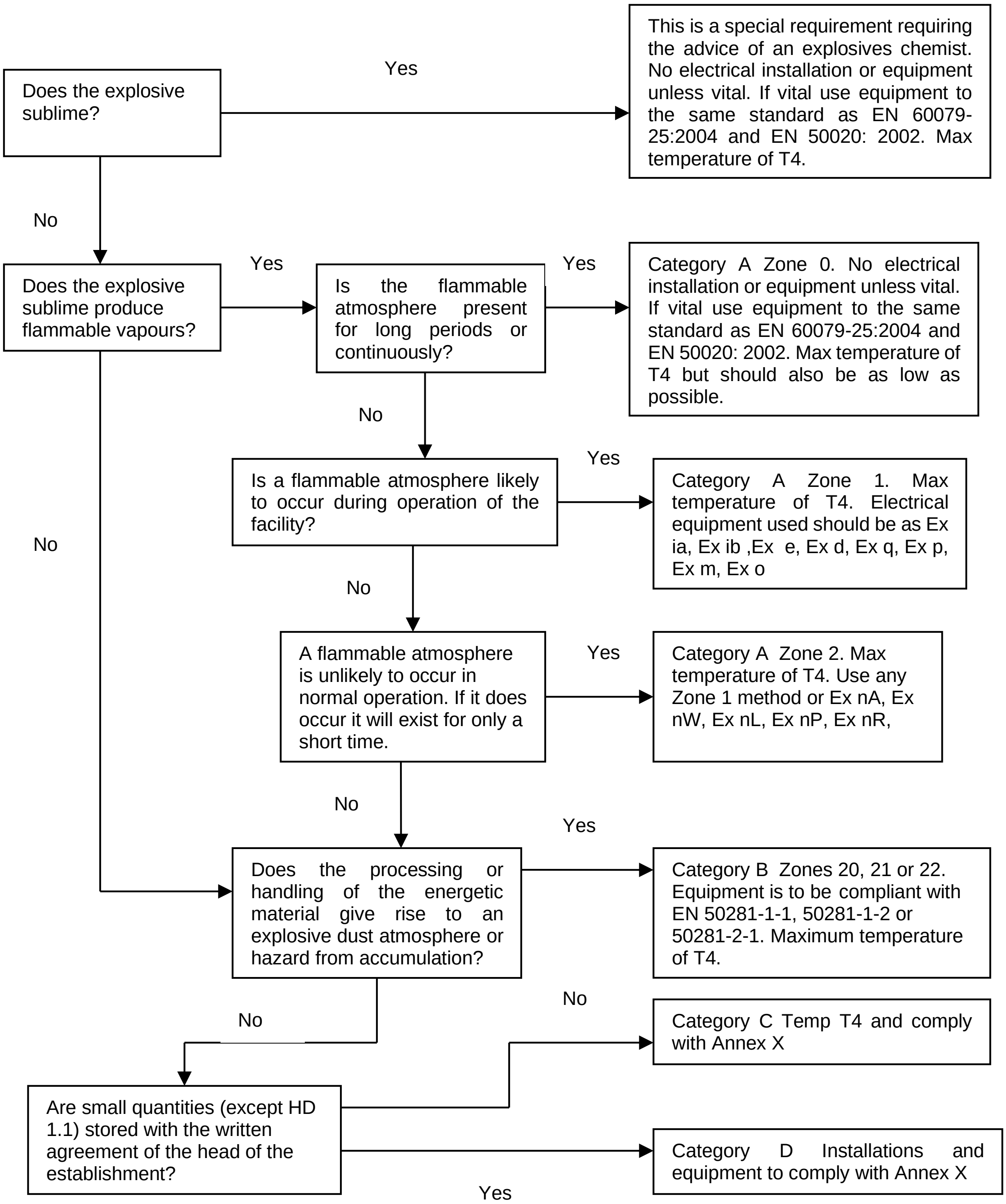
EN Standard #	Title
EN 1127-1:1998	Explosive atmospheres – Explosion prevention and protection – basic concepts and methodology.
EN 1175:1998	Safety of industrial trucks – electrical requirements.
EN 1755:2000	Safety of industrial trucks – operation in potentially explosive atmospheres – use in flammable gas, vapour, mist and dust.
EN 1834-1:2000	Reciprocating internal combustion engines – Safety requirements for design and construction of engines for use in potentially explosive atmospheres - Part 1: Group II engines for use in flammable gas and vapour atmospheres.
EN 1834-2: 2000	Reciprocating internal combustion engines – Safety requirements for design and construction of engines for use in potentially explosive atmospheres - Part 2.
EN 10015:1992	Basic specification. Protection of electrostatic sensitive devices. Part 1. General requirements.
EN 20284:1993	Conveyor Belts. Electrical conductivity. Specifications and method for test.
EN 20344:2004	Personal Protective Equipment – Test Methods for Footwear.
EN 20345:2004	Personal Protective Equipment – Specification for Safety Footwear.
EN 50014:1997	Electrical apparatus for potentially explosive atmospheres. Part 1 General Requirements.
EN 50015:2002	Electrical Apparatus for Potentially Explosive Atmospheres: Oil immersion 'o'.
EN 50016:1998	Electrical Apparatus for Potentially Explosive Atmospheres: Pressurised "p".
EN 50017:1998	Electrical Apparatus for Potentially Explosive Atmospheres: Powder Filling "q".
EN 50018:2000	Electrical apparatus for potentially explosive atmospheres. Part 5 Flameproof Enclosures 'd'. Superseded by 60079-1:2003 but remains current.
EN 50019:2000	Electrical apparatus for potentially explosive atmospheres. Part 6 Increased Safety 'e'. Superseded by 60079-7:2003 but remains current.
EN 50020:2002	Electrical Apparatus for Potentially Explosive Atmospheres: Intrinsic Safety "i".
EN 50021:1999	Electrical Apparatus for Potentially Explosive Atmospheres: Type of Protection "n". Superseded by 60079-15:2003 but remains current.
EN 50028	Electrical Apparatus for Potentially Explosive Atmospheres: Encapsulation "m". Superseded by 60079-18:2003 but remains current.
EN 50281:1999 (Parts1 and 2)	Electrical Apparatus for use in the presence of Combustible Dust.
EN 60529:1992	Degrees of protection provided by enclosures (IP code).
EN 60309-2:1992	Plugs, sockets-outlets and couplers for industrial purposes.
EN 60702-1:2002	Mineral insulated cables and their terminations with a rated voltage not exceeding 750V.
EN 60079-0:2004	Electrical apparatus for explosive gas atmospheres. General requirements.
EN 60079-1:2004	Electrical apparatus for explosive gas atmospheres. Flameproof enclosures 'd'.
EN 60079-7:2003	Electrical apparatus for explosive gas atmospheres. Increased safety 'e'.
EN 60079-10:2003	Electrical apparatus for explosive gas atmospheres. Classification of hazardous areas.
EN 60079-14:2003	Electrical apparatus for explosive gas atmospheres. Electrical installations in hazardous areas (other than mines).
EN 60079-15:2003	Electrical apparatus for explosive gas atmospheres. Type of protection 'n'.
EN 60079-17:2003	Electrical apparatus for explosive gas atmospheres. Inspection and maintenance of electrical installations in hazardous areas (other than mines).

[17] These have been deliberately excluded from the biography at Annex C to IATG 01.10 *Guide to the IATG*.

EN Standard #	Title
EN 60079-18:2004	Electrical apparatus for explosive gas atmospheres. Construction, test and marking of type of protection encapsulation 'm' electrical apparatus.
EN 60079-25:2004	Electrical apparatus for explosive gas atmospheres. Intrinsically safe systems.
EN 60898:2003	Specification for circuit breakers for over-current protection for household and similar installations.
EN 60947-2:1996	Specification for low voltage switchgear and control gear. Part 2. Circuit breakers.
EN 60947-5-1:2004	Electromechanical control circuit devices.

Table D.1: Technical design, test, and construction standards

Annex E
(informative)
Selection of correct electrical category



Appendix 1 to Annex E

Example of Electrical Category Signage for Explosive Buildings

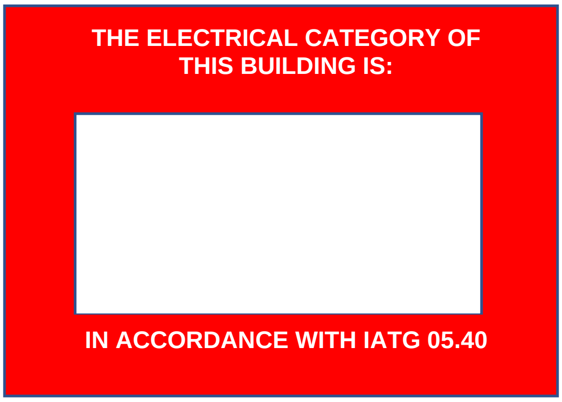


Fig E1 Example of Electronic Category Signage

Note: this signage can also be used for marking where electrical categories change within a building by replacing the word 'BUILDING' with room, area etc.

Annex F
(informative)
Requirements of Category C electrical fittings and equipment

F.1 General requirements

The following recommendations may be used as the selection criteria for equipment used in Category C explosives buildings. National technical authority requirements shall take precedence, but these recommendations are considered international good practice.

F1.1 Assumptions and protection levels

The recommendations are based on the assumption that enclosures without ventilation openings are not necessarily airtight, but comply with the construction requirements and type tests in the following paragraphs. The protection against ingress of solids and liquids provided by the enclosures is assumed to comply with IP 44 (See Table 5).

The design surface temperature of enclosures under normal conditions should not exceed T4 levels and water or oil filled radiators should not exceed T6 levels.

Any equipment that is compliant with a more demanding standard is acceptable for Category C environments, provided it meets the surface temperature limits above.

Acceptable standards are:

a) IP 45 – IP 68 (Table 5); and

b) hazardous area equipment for Zones 0, 1, 2, 20, 21 or 22.

F.2 Construction

The following construction parameters should be met:

a) enclosures may be made of metal or plastic;

b) all materials used in the construction including inspection windows and light transmitters should resist the propagation of flame;

c) transparent covers including inspection window and light transmitters may be glass or plastic. They should be positively secured to the main enclosure; and

d) enclosures should be provided with appropriate conduit and/or cable entries.

F.3 Testing

The tests are to be type tests and are to be made on a representative enclosure that is a new condition. It should pass all specified tests and should satisfy those requirements that can be checked only by inspection. The tests are to be carried out at an ambient temperature of 25°C +/- 5 °C.

Manufacturers should have the appropriate ISO 9000 accreditation and shall certify that production equipment complies with the specification against which the type tests were conducted.

F.3.1 Test schedule for electrical installation and equipment

Test number 1 is to measure protection against the ingress of foreign bodies at level IP40. This is a search test made with a steel wire of 1mm diameter. The test should be deemed satisfactory if the wire cannot enter the enclosure.

Test number 2 is test protection against the ingress of liquid at level IP04. The test ensures that the equipment is protected against liquid splashed from any direction.

Impact testing of enclosures, including light transmitting parts, should ensure that they withstand the impact energies listed in Table F.1. Each impact is to be made by a mass of 1kg falling from the appropriate height to provide the required impact. The striker should be a hardened steel sphere of 25mm diameter.

The enclosure is to be tested when it is fully assembled and mounted on a rigid base. When the plane of the impact is to be altered the base should be moved to achieve the desired new position.

Component	Impact Energy (J)	Drop Height (m)	EN50102 Code
Guards, protective covers, fan hoods and cable entries.	3.5	0.35	IK08
Plastic enclosures.	3.5	0.35	IK08
Light metal or cast metal enclosures.	3.5	0.35	IK08
Enclosures of materials other than above with wall thickness of less than 1mm.	3.5	0.35	IK08
Light transmitting parts without guards.	2	0.2	IK07
Light transmitting parts with guards.	1	0.1	IK06

Table F.1: Impact energies for testing

F.4 Drop test for portable equipment

One sample of the portable equipment electrical apparatus is to be dropped. The equipment should be dropped four times from a height of 1m. The attitude of the equipment when dropped should be such to ensure maximum damage would be caused by the drop e.g. on a corner, a glass face etc. The drop is to be on to a concrete surface. The integrity of the apparatus enclosure should be impaired after this test, but the equipment need not necessarily be functional after the test.

Annex G
(informative)
Requirements of Category D electrical fittings and equipment

G.1 General

Category D comprises buildings and rooms where authorised quantities of explosives, except HD 1.1, are stored with the written agreement of the head of the establishment. The explosives shall not be exposed and should not give rise to flammable vapours or explosives dust.

G.1.1 Protection

The protection against the ingress of solids and liquids provided by the enclosures should be IP 44. Enclosures including light transmitters should be capable of withstanding the impact energy as required by EN 50102, IK08.

G.2 Construction

Equipment construction requirements are as follows:

a) all plastics used in the construction including inspection windows and light transmitters should resist the propagation of flame;

b) transparent covers including inspection windows and light transmitters may be glass or plastic, but the plastic material must comply the flame propagation requirements above. They should be positively secured to the main enclosure; and

c) enclosures should be provided with appropriate conduit and/or cable entries.

Annex H
(informative)
Measuring the resistance of conductive and anti-static flooring

H.1 Background

In order to avoid a hazardous accumulation of electrical charge, the dissipation path should permit a current that at least balances the worst case charging current of 10^{-4}A. In several standards 100V is used as the threshold value and these electrostatic control measures are based on the assumption that a person below this potential will not present a credible hazard to explosives.

This limit is reflected in the design of the conductive regime hazardous area personnel test meter (HAPTM) that applies 100V across the test subject-footwear-flooring combination. However, it is important not to test at voltages significantly in excess of 100V because it is probable that some of the elements in the path from the contact surface of the floor to the earth point will not obey Ohm's Law. As a consequence, the effective impedance of any such element is likely to decrease with increased potential. This means that if the test is conducted at a potential **above** 100V it may give a false impression of the effectiveness of the earth system.

H.2 Pre-test cleaning

The head of the establishment should ensure and certify in writing that all explosives have been removed from the facility before anyone with electrical equipment is allowed to enter the building. Floor cleanliness is essential in providing integrity and extending the life of the flooring material. Contaminants such as oils and grease can be removed using proprietary spill absorbent and then cleaned as described below. The floor is to be cleaned prior to testing using materials approved by the manufacturer and the following method should be used:

a) prepare the floor cleaner in accordance with the manufacturer's instructions;

b) clean the floor, either manually or with a floor scrubber that has transverse horizontally mounted brushes only. Machines with contra-rotating brushes should not be used as they concentrate the dirt at the junction of the brushes and may ingrain it into the floor;

c) remove all traces of the cleaning agent by rinsing with clean water; and

d) allow the floor to dry.

H.3 Floor inspection

After cleaning the entire floor area it should be inspected before proceeding with the test. The inspection shall:

a) identify worn areas which should be repaired or replaced as necessary;

b) identify any floor damage which should be repaired or replaced as necessary;

c) identify any areas of contamination not removed by the pre-test clean. These should be re-cleaned; and

d) map on the matrix shown below at Figure H.1 the outline of the facility, the chosen test points, and all areas of wear, damage, and contamination. Include the position of the connections from the facility earth to the floor. The floor is not to be marked. A test should be conducted at least once in each area of flooring measuring 1.5m x 1.5m.

H.4 Conductive floor testing

The floor should be measured using the following testing regime:

a) carry out a visual check to confirm the electrical integrity of the connection of the floor to the facility earth system;

b) confirm that the electrical continuity of the earth electrode connection to the conductive floor connection, at more than one point, is less than 0.5Ω. It may be necessary to remove any outer protective covering from the connections before electrical testing;

c) wet the test point using the wetting agent;

d) connect one end of the test instrument to the floor earth reference point and connect the other to the movable test probe;

e) measure the floor resistance at each test point and record the result on the matrix;

f) any results of greater than 50kΩ mean the floor has failed test. However, re-cleaning and testing may cure marginal test results. If this not successful repair or replacement should be necessary; and

g) insert the completed matrix into the building log book.

H.5 Anti-static floor testing

The floor should be measured using the following testing regime:

a) carry out a visual check to confirm the electrical integrity of the connection of the floor to the facility earth system;

b) confirm that the electrical continuity of the earth electrode connection to the conductive floor connection, at more than one point, is less than 0.5Ω. It may be necessary to remove any outer protective covering from the connections before electrical testing;

c) connect one end of the test instrument to the floor earth reference point and connect the other to the movable test probe;

d) measure the floor resistance (dry) at each test point and record the result on the attached matrix. If any result indicates less than 100kΩ wet the test point using the wetting agent and retest to ensure that no result is less than 50kΩ;

e) if any result indicates more than 2MΩ, wet the test point using the wetting agent and retest to ensure that no result is greater than 2MΩ;

f) all results should be between 50kΩ and 2 MΩ, or the floor will have failed the test. However, re-cleaning and testing may cure marginal test results. If this not successful repair or replacement should be necessary; and

g) insert the completed matrix into the building log book.

H.6 Wetting agent specification

A general purpose wetting agent can be made of four (4) parts by mass of polyethylene glycol and one (1) part by mass of distilled water.

H.7 Test equipment

The test probe should be a clean metal electrode of brass or copper, having a diameter of 25mm ± 1mm and a mass of 225g ± 15g.

H.7.1 Conductive flooring

To measure conductive flooring resistance the measuring instrument should have an open-circuit voltage of approximately 100V direct current (DC) and be capable of measuring resistance between the values of 0 and 100kΩ with a resolution of 1kΩ or better and an accuracy of ±5%. The test should also require low resistance test leads of sufficient length to span the entire facility floor.

H.7.2 Conductive flooring

To measure anti-static floor resistance the measuring instrument should have an open circuit voltage of 100V DC and be capable of measuring resistance between 50kΩ and 100MΩ with a resolution of 5kΩ and an accuracy of ±5%. The test should also require low resistance test leads of sufficient length to span the entire facility floor.

Conductive Floor Test Sheet Results (each square has sides of 1.5m)							
						Test Results	
						Measuring Point	Value (kΩ)
						1	
						2	
						3	
						4	

Figure H.1: Example conductive floor test sheet

Amendment record

Management of IATG amendments

The IATG are subject to formal review on a five-yearly basis. This does not preclude amendments being made within these five-year periods for reasons of operational safety, efficacy and efficiency or for editorial purposes.

As amendments are made to this IATG module they will be given a number, and the date and general details of the amendment will be shown in the table below. The amendment will also be shown on the cover page of the IATG by the inclusion of the amendment number and date under the edition number and date.

As the formal reviews of each IATG module is completed, new editions will be issued. Amendments will be incorporated into the new edition and the amendment record table cleared. Recording of amendments will then start again until a further review is carried out.

The most recently amended, and thus extant, IATG module is posted onwww.un.org/disarmament/ammunition

Number	Date	Amendment Details
0	01 Feb 15	Release of Edition 2 of IATG.
1	31 March 21	Release of Edition 3 of IATG.