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Risk Control

Recommendations for fire safety in the electronics manufacturing industry

RISCAuthority

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IMPORTANT NOTICE

CONTENTS

SCOPE

This document is intended to provide a practical guide to insurers and their clients regarding fire hazards and appropriate control measures associated with the manufacture of components and finished products in clean environments in the electronics industry. Other issues, such as biohazards and issues relating to the fabrication of products in a conventional environment, are outside the scope of these recommendations.

SYNOPSIS

These recommendations provide advice regarding the fire hazards associated with electronic manufacturing and fabrication processes, especially those carried out within clean rooms.

The recommendations address the care that needs to be taken in facilities where high voltage equipment, and flammable and pyrophoric gases may be in use. The impact of even a small fire on business continuity of an organisation is emphasised.

DEFINITIONS

Clean room

A clean room is an enclosed area that is maintained virtually free of contaminants, such as dust or bacteria, to levels in accordance with international standards. Environmental elements such as heat and humidity are also strictly controlled.

Flammable liquid

A liquid as defined for highly flammable liquid (see below) but with a flashpoint up to 55ºC.

Highly flammable liquid

The definition of a 'highly flammable liquid' in the Fire Certificates (Special Premises) Regulations 1976 has been amended in the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 (ref. 1) as follows:

'"Highly Flammable Liquid" means any liquid, liquid solution, emulsion or suspension, other than aqueous ammonia, liquefied flammable gas, and liquefied petroleum gas which:

'(a) when tested in accordance with Part A.9 of the Annex to the Directive has a flashpoint of less than 32ºC…;

'(b) when tested at 50ºC using the procedure referred to in Appendix B to the "Approved requirements and test methods for the classification and packaging of dangerous goods for carriage" (ref. 2) with a heating time of 60 seconds supports combustion…'

HEPA/ULPA

High efficiency particulate and ultra-high efficiency particulate, used to in relation to high quality air filters for use in clean room environments. HEPA filters are designed to remove at least 99.97% of airborne particles 0.3 micrometers in diameter whereas ULPA filters are designed to remove at least 99.999% of particles with a size of 120 nanometres or larger.

Pod

A fully fitted cabin or sled, normally designed to undertake a reaction or process, which is delivered ready for connection to services on site.

Pyrophoric

Pyrophoric substances are those which ignite spontaneously in air. Such materials may be handled safely in an inert atmosphere such as in argon or nitrogen gas.

INTRODUCTION

The development of electronics in recent years has been rapid, with an enormous impact on our daily lives. Large and cumbersome electronic valves, capacitors and resistors have given way to silicon chips as the building blocks of items as diverse as computers, calculators, toys, home appliances, mobile phones and even low power lights.

Before the silicon chip, discrete components were arranged on a non-conductive circuit board which contained copper layers providing electrical connections between the individual items. In recent years, a tiny silicon chip has become analogous to a printed circuit board by individual components being fabricated on the chip. The effect is to reduce the scale of devices from being measured in square centimetres to being measured in square millimetres. The manufacturing process, however, is highly reliant on the handling of pure materials to such an extent that even minute amounts of contamination could be disastrous to the quality of the end product, and hence the reputation of the company.

These processes are thus extremely delicate and call for careful control, not only of the process, but also of the environment in which it is undertaken. An example is the ion implantation process whereby ions are accelerated in an electrical field and impacted into the target material. This process changes the electrical properties of the target and is widely used in the production of semiconductors and similar devices.

It is not only the manufacture of materials that must be undertaken in a clean environment. Mechanical processes, such as disc drive assembly, which involves constructing devices with very low reader head 'flying heights' and precision rotating or mechanical seals, can also be susceptible to sub-micron particle inclusions and subsequent damage. Clean rooms are also used in the electronics industry for laboratory research work, the manufacture of components and for the production of precision mechanical equipment.

Important factors to ensure an effective facility are the design, the materials to be used, the quality of construction and the environmental management systems. One other practical way to reduce the number of particles in the atmosphere is to minimise the number of staff working in the clean room, although this is not always possible where intricate mechanical assembly processes are involved.

Although reference to a clean room suggests a single area, in practice the clean zone at the heart of the facility is protected by further areas, including staff changing areas to add more layers of protection. Good practice dictates, where possible, such a design employs additional layers around the clean zone, each with associated differences in pressure levels for effective operation.

In such a facility, not only must appropriate general fire precautions be taken, but good management is also needed to prevent a breakdown of the controlled atmosphere or equipment being used outside the parameters for which it was designed. Any factor that could lead to the loss of the clean room, even on a temporary basis, can lead to the necessity for extremely costly remedial measures to be taken before manufacture can resume and thus has the potential for serious impact on the continuity of the business.

These recommendations should be read in conjunction with the advice set out in RC5: **Fire protection of laboratories** (ref. 3).

RECOMMENDATIONS

1. Compliance with fire safety legislation

1.1 A suitable and sufficient fire risk assessment for all parts of the premises should be undertaken in compliance with the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) (refs 4-8). These measures should include:

- establishing and maintaining clear and unobstructed fire escape routes with appropriate fire exit signs and emergency escape lighting, the latter being in compliance with BS 5266: **Emergency lighting** (ref. 9);
- physical segregation of the manufacturing area from other operations being carried out on site, whether these are automated or manned;
- suitable fire detection and warning systems in case of fire;
- the provision of appropriate portable firefighting equipment;
- development of an emergency action plan to protect life and property and ensure the continuing functioning of the business in the case of fire; and
- staff training in the actions to take in the event of fire, including the safe shut down of the process and evacuation of the premises.

1.2 Where equipment that presents an abnormally high fire hazard is present (such as ion implanters, furnaces) it should be subject to a specific fire risk assessment to ensure that suitable measures are provided to protect against fire or explosion.

1.3 An assessment in compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (ref. 1) should be undertaken where hazardous materials, such as significant quantities of flammable liquids, oils, compressed gases or dusts, are involved in the process.

2. Business continuity

2.1 A small fire can have a disproportionate effect on a business, even if it occurs in a relatively inexpensive piece of equipment. If it occurs in a critical piece of equipment or in a clean room it can result in severe disruption over a prolonged period, with associated loss of jobs, income and profits. Many items of modern equipment in a large-scale manufacturing process are increasingly expensive with the associated economics dictating that they be used to the maximum benefit, to include automatic running during the night or over weekends when no, or very few, staff are present. Careful consideration must be given to fire and safety implications before such a decision is made. Further advice in the case of unattended processes is set out in RC42: **Recommendations for processes involving the production of heat with the potential to be ignition sources for fire, in particular those left unattended for periods of time** (ref. 10).

2.2 All organisations should take steps to ensure the continued smooth running of their business by making a suitable emergency plan. Guidance for this is set out in **Business resilience: a guide to protecting your business and its people** (ref. 11). The emergency plan should address the implications of a fire, flood or other perceived disaster on all facets of the business model. It should indicate the lines of communication that should be followed and the contact details for specialist assistance, providers of alternative accommodation and suppliers of manufacturing plant.

2.3 The emergency plan should include details of specialists who can respond promptly in the event of a fire and advise with regard to any necessary action required to minimise the effects of contamination to components or equipment caused by corrosive smoke in the clean room.

2.4 When complete, the emergency plan should be tested by means of a table top exercise, with the results being assessed and amendments made to the plan as necessary.

2.5 Consideration may be given to applying commercially available computer programmes, such as the **ROBUST** software (**Resilient Business Software Toolkit**) that is available free of charge (ref. 12), or other appropriate product, to develop and check the adequacy of the plan.

3. Fire safety management

Effective fire safety management of conventional manufacturing and fabrication areas, as well as clean rooms, requires that potential ignition sources and combustible materials both be minimised. This philosophy may, however, be easier to enforce in a clean room because maintaining the clean environment dictates that items that cross the barriers between the different zones be minimised and controlled. These items include:

- routine personnel and supervisors;
- personal effects;
- raw materials and other products;
- packaging;
- plastic storage boxes containing masks and wafers;
- visits by management, inspectors and visitors;
- service engineers;
- test equipment;
- servicing materials;
- tools;
- cleaning equipment; and
- waste materials.

3.1 Equipment should be constructed from non-combustible materials where the processes allow. This includes ancillary items such as waste bins, which should be of metal unless being used in a corrosive atmosphere.

3.2 Wherever possible, documentation should be undertaken outside the clean area. Where this cannot be avoided, workstations in clean areas should also be of non-combustible construction.

3.3 Hot work, other than that involved in routine manufacturing or research processes should be subject to a hot work permit regime. Further information is set out in RC7: **Recommendations for hot work** (ref. 13).

3.4 At least one of the staff working in a clean room should be a trained fire warden to ensure that the evacuation procedures are observed and appropriate assistance is given to anyone in the area with a disability.

3.5 Careful attention should be given to maintaining a clean and tidy workplace. Extraneous packaging and combustible waste materials should be removed from the clean room to a safe location at least 10m from the building at the end of each work period. Further advice regarding this topic is provided in RC48: **Arson prevention, the protection of premises from deliberate fire raising** (ref. 14).

3.6 The cost and vulnerability of clean rooms is such that careful consideration needs to be given to the security of the premises, including the materials from which the envelope of the building is constructed, perimeter security and access controls. Further information is set out in RC48 (ref. 14).

3.7 While clear access to the premises must be maintained for emergency vehicles, car parking should be remote from the facility.

3.8 Wherever possible an area at least 6m wide around the facility should be maintained clear of grass and vegetation.

3.9 Cooking and the preparation of food or beverages should only be undertaken in purpose-built facilities away from clean rooms and separated from these areas by construction that would provide at least 60-minutes' fire resistance.

4. Design and construction

Clean rooms may be permanent structures but can also take the form of portable cabin arrangements. Clean rooms may also be classified as having 'soft' walls or conventional walls. Soft wall clean rooms (which may be permanent or temporary facilities) are normally constructed from coated mild steel or stainless steel, with PVC strip curtains or clear acrylic infill panels. Tent-like structures formed of a frame covered with PVC sheeting are also available.

Portable clean rooms can be supplied as a pod complete with all necessary services to sustain a clean environment. This may be to provide a permanent facility or to allow for increased capacity on a temporary basis or while refurbishment work is being undertaken.

4.1 During the design process, reference should be made to **Approved Document B... Incorporating insurers' requirements for property protection** (ref. 15).

4.2 The clean room should ideally be sited in a single-storey structure or located so that there is no other accommodation above this facility.

4.3 The layout of the facility should be designed to minimise the potential for an incident in one area to affect another through direct effects of heat, smoke, firefighting water or liquids and chemicals used in the processes.

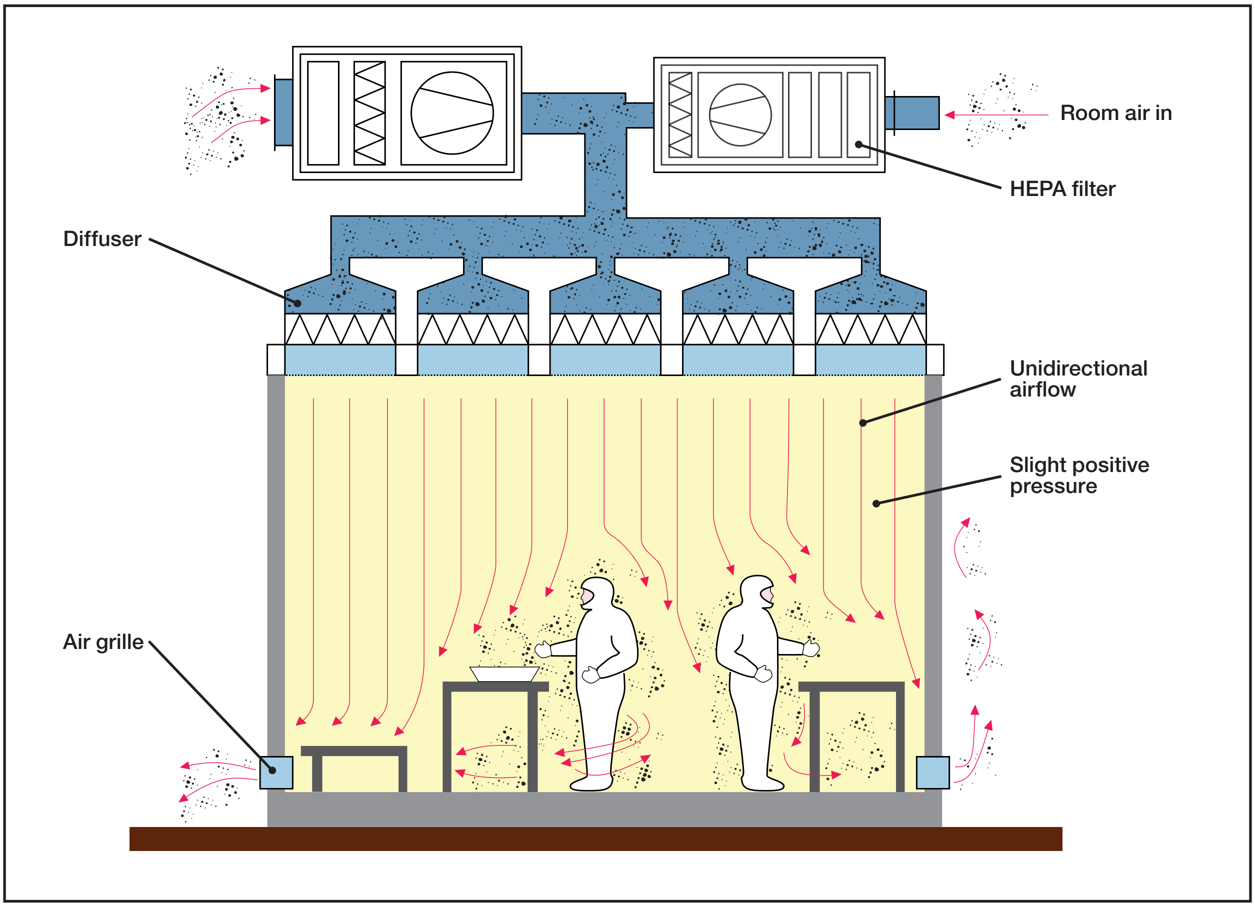
4.4 During the design process every effort should be made to eliminate or minimise the use of combustible materials in the new facility. Buildings, cabins and temporary structures should be non-combustible; plastic and plastic-coated building materials should be avoided.

4.5 Clean room partitions should be of non-combustible construction, using materials such as aluminium honeycomb, epoxy-coated steel panels, stainless steel and gypsum board. Any prefabricated panels incorporated into the structure must have non-combustible cores.

4.6 Filters used to filter air in clean rooms should be of the lowest flammability available and should be mounted in metal frames. Ductwork should be designed as set out in sections 5.5 to 5.7 below.

4.7 High efficiency particulate air filters (HEPA filters) should be renewed in accordance with the manufacturer's instructions.

Figure 1: A typical clean room



4.8 Flooring should be non-combustible. If floor coverings are necessary, they should be of limited flammability.

4.9 Vision panels should be of glass. The use of acrylic and polycarbonate plastics should be limited as far as is practical.

4.10 Where plastic materials are employed they should be inherently fire retardant or treated with fire-retarding material so as to comply with ANSI/FM 4910 (ref. 16) and not to propagate fire beyond the ignition zone. Such materials should produce only limited quantities of smoke. Products used should be selected so that any smoke produced has limited corrosive properties.

4.11 The use of equipment or materials that have been tested, certified, approved or listed by an appropriate laboratory or test house should be permitted only as long as they are used within their tested parameters.

4.12 Wherever possible, liquid services should be located below or outside clean rooms and not overhead.

5. Compartmentation

5.1 The size of the largest compartment should be limited following evaluation of life safety, property protection and business interruption considerations.

5.2 Clean rooms that form permanent structures should take the form of fire compartments separated from other processes or stored materials and designed to provide at least 60-minutes' fire resistance (integrity and insulation) or to a higher standard where determined by a fire risk assessment.

Where the fire risk assessment identifies especially hazardous processes, these should only be undertaken in separate, specially designed areas, preferably detached from the main building. Where detached accommodation is not available, compartment walls providing at least 120-minutes' fire resistance should be constructed between the high-risk areas and other parts of the premises and there should be no doorways providing direct access between these areas.

5.3 Clean rooms should be protected from the spread of smoke from outside the facility. This may be achieved by the clean room being at a higher relative pressure than the surrounding areas.

5.4 Within the clean room, partitions to limit smoke damage should be used where possible, so that in the event of a fire, damage is limited to defined areas. Different process groups such as photolithography, metallisation and wet etch areas or those that are more sensitive to contamination should be isolated from the rest of the clean room.

5.5 Ducts should vent to the outside by the most direct route. Wherever possible ducts should not pass through voids or other fire compartments.

5.6 Where ducts have to pass through compartment walls and floors they should be fitted with automatic fire dampers to maintain the fire separation. Dampers should operate automatically by means of a fusible link, or preferably by smoke detectors if circumstances are appropriate.

5.7 Fire dampers should not be installed inside fume exhaust systems extracting toxic or corrosive fumes from a clean room. Every effort should be made to vent these ducts directly to the outside.

6. Electricity

6.1 Business critical clean rooms should be provided with duplicate power supplies fed from different electrical substations (or different pylon supplies). Consideration may also need to be given to the installation of uninterruptable power supplies (UPS) for some key areas.

6.2 Old mineral oil-filled transformers should be replaced with cast resin types or motor generator sets. Until this can be undertaken, large transformers, such as those used to power ion implanters, should be protected with containment for oil leaks. Consideration should be given to protecting the compartment in which the equipment is installed with local automatic fire suppression systems, such as water sprays (see 8.16). Fire walls should also be constructed between transformers.

6.3 Electrical installations should be designed, installed and periodically tested by a competent electrician in accordance with the current edition of BS 7671 + A1: **Requirements for electrical installations** (ref. 17). Inspections should be carried out on a risk assessed basis as recommended in the Periodic Inspection Report.

6.4 Lightning protection systems to BS EN 62305: **Protection against lightning** (ref. 18) should be installed to protect the facility where deemed necessary by a risk assessment.

6.5 A suitable number of electrical socket outlets should be provided; the use of electrical extension leads and adaptors should be prohibited in clean rooms and wet process areas.

6.6 Portable electrical equipment should be inspected and tested at least in accordance with HS(G) 107: **Maintaining portable and transportable electrical equipment** (ref. 19) and/or the **IEE Code of practice for in-service testing of electrical equipment** (ref. 20). A risk assessment should determine the actual programme of inspection and testing.

6.7 Vacuum pumps should preferably be of a 'dry' design rather than involving hydrocarbon oils.

6.8 As static electricity in many cases represents a threat to the quality of the products as well as a fire hazard, appropriate measures, such as antistatic flooring and humidity control, should be incorporated into the design of the clean room. Staff should wear antistatic clothing, footwear and bonded wristbands as appropriate.

6.9 To further mimimise the hazard of static electricity, earthing and bonding of the equipment and any extraneous metal parts should be introduced and regular inspections of the arrangements be undertaken and recorded.

7. Hazardous materials and equipment

7.1 The operation of the facility should take into account the findings of the DSEAR assessment which should identify hazard zones where there may be potential for exposable quantities of flammable liquid vapours or dusts to accumulate.

7.2 Where gases are required for the processes, these should be piped into the clean room wherever practicable with the cylinders being stored in a safe area away from the facility. Further information is set out in RC5 (ref. 3).

7.3 Where possible, sub-atmospheric gas systems should be used as a source of ions for ion implanters. In these systems, the gas is adsorbed onto a substrate within the cylinder and is only released under vacuum or by diffusion.

7.4 The quantities of highly flammable and flammable liquids in the clean room should be subject to a risk assessment to minimise the volumes being used or stored in the area. (See also RC5 (ref. 3).)

7.5 Highly flammable and flammable liquids should be stored in purpose-built cabinets or bins providing at least 30-minutes' fire resistance and having integral spillage trays capable of holding 110% of the volume of the largest container being stored. Cabinets must be clearly marked with hazard warning signs. Ducting to vented cabinets should be of non-combustible construction with a plastic lining.

7.6 Corrosive materials such as acids should be stored in purpose-built cabinets or bins used solely for this purpose. Cabinets must be clearly marked with hazard warning signs and incorporate suitable trays to hold a spillage of up to 110% of the volume of the largest container present.

7.7 Ductwork for exhausting process fumes, air and heat from clean rooms should be suitable for these purposes and subject to a risk assessment. Where ducts are constructed of fibreglass or plastic materials they should incorporate sprinklers or other automatic fixed fire suppression system.

7.8 All equipment to be used in the clean room should be CE Marked to the Machinery Directive to indicate that it has been designed to avoid the risk of fire using BS EN 13478 + A1: **Safety of machinery. Fire prevention and protection** (ref. 21). Such equipment will have appropriate levels of fire detection and suppression systems incorporated into their design.

7.9 Equipment that does not carry a CE mark, together with high hazard processes such as ion implanting, liquid heating systems and the use of ovens and furnaces with potentially flammable or toxic gases, should be subject to a specific fire risk assessment and fire protection measures be taken according to the findings of this exercise.

7.10 Baths used in wet processes should be fitted with both high and low liquid level alarms as well as dual thermostats.

7.11 The following safeguards should be present on process liquid heating systems:

- electrical protection against over current and earth leakage;
- an electrical isolation device;
- a process temperature control system (usually software based);
- liquid over-temperature detection interlocked through a safety system;
- heater over-temperature detection interlocked through a safety system;
- low liquid level detection interlocked through a safety system (applicable for static systems such as baths); and
- liquid flow detection interlocked through a safety system (applicable in cases where in-line heating systems require a constant flow of liquid to cover a heating element).

7.12 All mechanical fittings, such as gas regulator valves, on gas lines carrying toxic, corrosive, flammable and pyrophoric gases should be enclosed in an exhausted enclosure fitted with gas detection.

7.13 Where appropriate, provisions should be available to enable a spillage of hazardous material to be promptly addressed. Staff should be trained in the use of the chemical spillage equipment.

7.14 In the event of a gas leak the area should be evacuated and the gas isolated from the stop valve outside the clean room (see 7.2). The area should be subject to thorough ventilation before reuse. Where there has been a leak of toxic or flammable gas a check should be made of the atmosphere using suitable detection equipment and appropriate action taken to safely remove the gas before personnel re-enter the area.

Pyrophoric gases

7.15 Some processes use pyrophoric gases such as silane, phosphine or diborane, because of their extremely hazardous properties; use of these materials should be subject to a specific hazard and operability (HAZOP) analysis during the planning stage.

7.16 In the event of a leak of pyrophoric gas, the supply of the gas should be isolated from the stop valve outside the clean room and the building be evacuated immediately.

7.17 Cylinders of pyrophoric gases stored or used on the premises should be of the smallest size practicable and incorporate the smallest orifice compatible with process requirements.

7.18 Cylinders of pyrophoric gases should preferably be stored outside the building. If inside, they must be stored singly in ventilated cabinets. Mechanical ventilation should be provided for the cylinder neck and purge panel area.

7.19 The mechanical ventilation for the ventilated cabinets should be provided with a back-up power supply. Emergency back-up power should also be provided for all electrical controls, alarms and safeguards associated with storage and process systems involving pyrophoric gases.

7.20 Remote manual shutdown devices for pyrophoric gas flow should be provided outside each gas cabinet or near each gas panel. Automatic shutdown devices for pyrophoric gas flow should be provided and linked so as to be activated by the automatic fire detection and alarm installation.

7.21 Pyrophoric gases should be transported in welded, double walled, stainless steel pipework for containment purposes. The outer area of the pipework must contain an inert atmosphere (usually nitrogen) to prevent any leaking gas being exposed to air. Leak and pressure detection should be incorporated into the outer area and linked to automatically shut off the gas supply in the event of a leak. The coaxial pressure monitoring should extend to gas boxes protecting mechanical connections to equipment.

7.22 Gas lines should be fitted with trace heating or be insulated with a non-combustible material, such as mineral wool, to prevent the formation of condensation.

7.23 Pyrophoric gas flow, purge, and exhaust systems should have redundant controls that prevent pyrophoric gas from igniting or exploding.

7.24 All process equipment or components to be used with pyrophoric gases should be adequately purged with nitrogen before and after use using a dedicated inert gas cylinder.

7.25 Consideration should be given to use of a spark or 'bang' arrestor to introduce a localised inert atmosphere when the dust cap is opened during the change of cylinders. This operation should only be undertaken by suitably trained staff, who should take particular care that the cylinder valve is fully shut off before the changeover operation commences.

8. Fire protection

Because of the high capital value of the equipment in use and the importance of the facility to the continuity of the business, the fire risk assessment should assess the need for suitable automatic fire detection and suppression installations for the protection of the property and process equipment as well as for life safety purposes.

Automatic fire detection and alarm installations

8.1 The clean room, ducts and voids above the ceiling and below the floor should be protected by an automatic fire detection and alarm system designed and installed by an engineer with accreditation by an independent UKAS accredited third party certification body. The installation should be to a recognised category of installation in accordance with BS 5839-1 + A2: **Fire detection and fire alarm systems for buildings. Code of practice for system design, installation, commissioning and maintenance** (ref. 22) or to BS 6266: **Code of practice for electronic equipment installations** (ref. 23), as determined by a risk assessment and/or in consultation with the insurer. In some cases, air sampling smoke detection methods may be appropriate and effective.

8.2 The automatic fire detection and alarm system should be monitored either on-site or by an off-site alarm receiving centre with accreditation by an independent UKAS accredited third party certification body and operating in accordance with BS 5979: **Remote centres receiving signals from fire and security systems** (ref. 24).

8.3 The automatic fire detection and alarm system in the clean room should be linked so as to shut down process machinery, pressurisation and ventilation systems, and also to close any transfer hatches so as to prevent the spread of smoke and gases.

8.4 The installation should be periodically serviced and maintained by a competent engineer with accreditation by an independent UKAS accredited third party certification body in accordance with BS 5839-1 (ref. 22).

8.5 All automatic fire detectors and gas detectors should be monitored outside the clean room at a point that is manned at all times that the clean room is occupied.

Automatic fire suppression systems

8.6 Where sprinkler systems are to be installed they should be designed, installed, commissioned and maintained in accordance with the **LPC Sprinkler Rules incorporating BS EN 12845** (ref. 25) by engineers having accreditation by an independent UKAS accredited third party certification body.

8.7 Checks should be made to ensure that water supplies are adequate and reliable for the maximum sprinkler demand, especially in the event of a prolonged period of hot weather.

8.8 Clean room sprinklers should be designed and installed so that they are not obstructed by light fittings, laminar flow air curtains, or other equipment that will be installed in the completed facility.

8.9 Where determined by risk assessment, and in consultation with the insurer, local automatic fire suppression systems should be installed to protect wet benches, laminar flow hoods, alcohol vapour driers, flow soldering and similar process areas or equipment. Records should be kept of the original specification and service history of the installations.

8.10 Fixed fire suppression systems (other than sprinkler systems) should be designed, installed, commissioned and maintained by a company with accreditation by an independent UKAS accredited third party certification body as complying with the requirements of LPS 1204: **Requirements for firms engaged in the design, installation and commissioning of firefighting systems** (ref. 26) or other appropriate standard. Third party test reports should be provided to demonstrate the effectiveness of the system in the event of the worst case scenario on the end use application.

8.11 Where gas suppression systems are installed, these should be designed, installed, commissioned, maintained and tested in accordance with the relevant British Standard and/or supplier's specification by a competent engineer with accreditation by an independent UKAS accredited third party certification body. A copy of the specification should be retained, together with the service and maintenance records, as part of the log book for the premises.

8.12 Gas fire suppression systems should be set to operate automatically when the areas in which they are installed are unoccupied.

8.13 The mode of operation, and the associated warning systems, of any installed gas fire suppression system should be carefully explained to relevant staff at the time of their fire safety training.

8.14 Following the release of extinguishing gas, the system should be reinstated before operations within the clean room are restarted.

Other firefighting provisions

8.15 In addition to an automatic sprinkler installation or other fixed fire suppression system, a suitable number of appropriate portable fire extinguishers should be available and immediately accessible in the case of a fire. Such portable extinguishers should be approved and certified by an independent, third party certification body and be installed in accordance with BS 5306-8: **Fire extinguishing installations and equipment on premises. Selection and installation of portable fire extinguishers. Code of practice** (ref. 27) and inspected and maintained in compliance with BS 5306-3: **Fire extinguishing installations and equipment on premises. Commissioning and maintenance of portable fire extinguishers. Code of practice** (ref. 28).

8.16 Liaison should be established with the local authority fire and rescue service to ensure that adequate water supplies are available for firefighting purposes.

8.17 In the case of a large facility, inviting the fire and rescue service to visit the site, familiarise themselves with the automatic fire detection and suppression facilities and be involved in an emergency evacuation of the premises can be beneficial.

8.18 Information should be provided for the fire and rescue service at a prominent location to indicate:

- the layout of the site;
- the location of emergency shut down points for the process;
- the nature of the automatic fire suppression system(s) and the location of any controls;
- the nature and location of hazardous substances on the premises;
- contact details for specialist staff who may need to be consulted; and
- the location of hydrants, rising mains or other sources of water for firefighting purposes.

9. Checklist

		Yes	No	N/A	Action required	Due date	Sign on completion
9.1	**Compliance with fire safety legislation (section 1)**						
9.1.1	Has a suitable and sufficient fire risk assessment for all parts of the premises been undertaken in compliance with the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland)? (1.1)						
9.1.2	Where equipment that presents an abnormally high fire hazard is present, has it been subject to a specific fire risk assessment to ensure that suitable measures are provided to protect against fire or explosion? (1.2)						
9.1.3	Has an assessment been made in compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)? (1.3)						
9.2	**Business continuity (section 2)**						
9.2.1	Has careful consideration been given to fire and safety implications before expensive equipment is committed to automatic running during the night or over weekends? (2.1)						
9.2.2	Have steps been taken to ensure the continued smooth running of the business by making a suitable emergency plan? (2.2)						
9.2.3	Does the emergency plan include details of specialists that can respond promptly in the event of a fire and advise with regard to any necessary action required to minimise the effects of contamination to components or equipment caused by corrosive smoke in the clean room? (2.3)						
9.2.4	Has the completed emergency plan been tested by means of a table top exercise, with the results being assessed and amendments made to the plan as necessary? (2.4)						
9.2.5	Has consideration been given to applying commercially available computer programmes to develop and check the adequacy of the plan? (2.5)						
9.3	**Fire safety management (section 3)**						
9.3.1	Is equipment constructed from non-combustible materials where the processes allow? (3.1)						
9.3.2	Wherever possible, is documentation undertaken outside the clean area? (3.2)						
9.3.3	Is hot work, other than that involved in routine manufacturing or research processes, subject to a hot work permit regime? (3.3)						
9.3.4	Is at least one member of staff working in the clean room a trained fire warden? (3.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.3.5	Is careful attention given to maintaining a clean and tidy workplace? (3.5)						
9.3.6	Is careful consideration given to the security of the premises, including the materials from which the envelope of the building is constructed, perimeter security and access controls? (3.6)						
9.3.7	Is clear access to the premises maintained for emergency vehicles with car parking remote from the facility? (3.7)						
9.3.8	Wherever possible, is an area at least 6m wide around the facility maintained clear of grass and vegetation? (3.8)						
9.3.9	Is cooking and the preparation of food or beverages only undertaken in purpose-built facilities away from clean rooms and separated from these areas by construction that provides at least 60-minutes' fire resistance? (3.9)						
9.4	**Design and construction (section 4)**						
9.4.1	During the design process is reference made to **Approved Document B... incorporating insurers' requirements for property protection**? (4.1)						
9.4.2	Is the clean room sited in a single-storey structure or located so that there is no other accommodation above this facility? (4.2)						
9.4.3	Is the layout of the facility designed to minimise the potential for an incident in one area affecting another through direct effects of heat, smoke, firefighting water or liquids and chemicals used in the processes? (4.3)						
9.4.4	During the design process has every effort been made to eliminate or minimise the use of combustible materials in the new facility? (4.4)						
9.4.5	Are clean room partitions of non-combustible construction, using materials such as aluminium honeycomb, epoxy coated steel panels, stainless steel and gypsum board? (4.5)						
9.4.6	Are filters used to filter air in clean rooms of the lowest flammability available and are they mounted in metal frames? (4.6)						
9.4.7	Are high efficiency particulate air filters renewed in accordance with the manufacturer's instructions? (4.7)						
9.4.8	Is flooring non-combustible? Or, if floor coverings are necessary, are they of limited flammability? (4.8)						
9.4.9	Are vision panels made of glass? (4.9)						
9.4.10	Where plastic materials are employed, are they inherently fire retardant or treated with fire-retarding material so as to comply with ANSI/FM 4910? (4.10)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.4.11	Is the use of equipment or materials that have been tested, certified, approved or listed by an appropriate laboratory or test house permitted only as long as they are used within their tested parameters? (4.11)						
9.4.12	Wherever possible, are liquid services located below or outside clean rooms and not overhead? (4.12)						
9.5	**Compartmentation (section 5)**						
9.5.1	Has the size of the largest compartment been limited following evaluation of life safety, property protection and business interruption considerations? (5.1)						
9.5.2	Do clean rooms that form permanent structures take the form of fire compartments separated from other processes or stored materials and are they designed to provide at least 60-minutes' fire resistance (integrity and insulation) or to a higher standard where determined by a fire risk assessment? (5.2)						
9.5.3	Are clean rooms protected from the spread of smoke from outside the facility? (5.3)						
9.5.4	Within the clean room, are partitions used to limit smoke damage where possible, so that in the event of a fire, damage is limited to defined areas? (5.4)						
9.5.5	Do ducts vent to the outside by the most direct route without passing through voids or other fire compartments? (5.5)						
9.5.6	Where ducts have to pass through compartment walls and floors, are they fitted with automatic fire dampers to maintain the fire separation? (5.6)						
9.5.7	Are fire dampers absent inside fume exhaust systems extracting toxic or corrosive fumes from a clean room? (5.7)						
9.6	**Electricity (section 6)**						
9.6.1	Are business critical clean rooms provided with duplicate power supplies fed from different electrical substations? (6.1)						
9.6.2	Have old mineral oil-filled transformers been replaced with cast resin types or motor generator sets? (6.2)						
9.6.3	Have all electrical installations been designed, installed and periodically tested by a competent electrician in accordance with the current edition of BS 7671? (6.3)						
9.6.4	Are lightning protection systems to BS EN 62305 installed to protect the facility where deemed necessary by a risk assessment? (6.4)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.6.5	Has a suitable number of electrical socket outlets been provided and is the use of electrical extension leads and adaptors prohibited in clean rooms and wet process areas? (6.5)						
9.6.6	Is all portable electrical equipment inspected and tested at least in accordance with HS(G) 107 and/or the IEE **Code of practice for in-service testing of electrical equipment**? (6.6)						
9.6.7	Are vacuum pumps of a 'dry' design rather than involving hydrocarbon oils? (6.7)						
9.6.8	Are appropriate measures, such as antistatic flooring and humidity control, taken to reduce the hazard from static electricity? And do staff wear antistatic clothing, footwear and bonded wristbands as appropriate? (6.8)						
9.6.9	To further reduce the hazard of static electricity, are equipment and extraneous metal parts earthed and bonded as necessary? (6.9)						
9.7	**Hazardous materials and equipment (section 7)**						
9.7.1	Does the operation of the facility take into account the findings of the DSEAR assessment which identifies hazard zones where there exposable quantities of flammable liquid vapours or dusts may accumulate? (7.1)						
9.7.2	Where gases are required for the processes, are these piped into the clean room with the cylinders being stored in a safe area away from the facility? (7.2)						
9.7.3	Are sub-atmospheric gas systems used as a source of ions for ion implanters? (7.3)						
9.7.4	Are the quantities of highly flammable and flammable liquids in the clean room subject to a risk assessment to minimise the volumes being used or stored in the area? (7.4)						
9.7.5	Are highly flammable and flammable liquids stored in purpose-built cabinets or bins providing at least 30-minutes' fire resistance and having integral spillage trays capable of holding 110% of the volume of the largest container being stored? Are these cabinets clearly marked with hazard warning signs? (7.5)						
9.7.6	Are corrosive materials stored in purpose-built cabinets or bins used solely for this purpose, the cabinets being clearly marked with hazard warning signs and incorporating suitable trays to hold a spillage of up to 110% of the volume of the largest container present? (7.6)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.7.7	Is ductwork for exhausting process fumes, air and heat from clean rooms suitable for these purposes and subject to a risk assessment? Where ducts are constructed of fibreglass or plastic materials, do they incorporate sprinklers or other automatic fixed fire suppression system? (7.7)						
9.7.8	Is all equipment used in the clean room CE Marked to the Machinery Directive to indicate that it has been designed to avoid the risk of fire using BS EN 13478? (7.8)						
9.7.9	Is equipment that does not carry a CE mark, together with high hazard processes such as ion implanting, subject to a specific fire risk assessment with fire protection measures being taken according to the findings of this exercise? (7.9)						
9.7.10	Are baths used in wet processes fitted with both high and low liquid level alarms as well as dual thermostats? (7.10)						
9.7.11	Are appropriate safeguards in place on process liquid heating systems? (7.11)						
9.7.12	Are all mechanical fittings, such as gas regulator valves, on gas lines carrying toxic, corrosive, flammable and pyrophoric gases enclosed in an exhausted enclosure fitted with gas detection? (7.12)						
9.7.13	Are provisions available to enable a spillage of hazardous material to be promptly addressed, with staff trained in the use of the chemical spillage equipment? (7.13)						
9.7.14	In the event of a gas leak, is the area evacuated and the gas isolated from the stop valve outside the clean room? (7.14)						
9.7.15	Because of the extremely hazardous properties of pyrophoric gases, is the use of these materials subject to a specific hazard and operability (HAZOP) analysis during the planning stage? (7.15)						
9.7.16	In the event of a leak of pyrophoric gas, can the supply of gas be isolated from a stop valve outside the clean room and the building be evacuated immediately? (7.16)						
9.7.17	Are cylinders of pyrophoric gases stored or used on the premises of the smallest size practicable and incorporate the smallest orifice compatible with process requirements? (7.17)						
9.7.18	Are cylinders of pyrophoric gases stored outside the building? Or, if inside, are they stored singly in ventilated cabinets with mechanical ventilation provided for the cylinder neck and purge panel area? (7.18)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.7.19	Is mechanical ventilation for the ventilated cabinets provided with a back-up power supply? Is emergency back-up power also provided for all electrical controls, alarms and safeguards associated with storage and process systems involving pyrophoric gases? (7.19)						
9.7.20	Are remote manual shutdown devices for pyrophoric gas flow provided outside each gas cabinet or near each gas panel? Are automatic shutdown devices for pyrophoric gas flow also provided and linked so as to be activated by the automatic fire detection and alarm installation? (7.20)						
9.7.21	Are pyrophoric gases transported in welded, double walled, stainless steel pipework for containment purposes and does the outer area of the pipework contain an inert atmosphere to prevent any leaking gas being exposed to air? (7.21)						
9.7.22	Are gas lines fitted with trace heating or insulated with a non-combustible material such as mineral wool to prevent the formation of condensation? (7.22)						
9.7.23	Do pyrophoric gas flow, purge, and exhaust systems have redundant controls that prevent pyrophoric gas from igniting or exploding? (7.23)						
9.7.24	Are all process equipment or components to be used with pyrophoric gases adequately purged with nitrogen before and after use using a dedicated inert gas cylinder? (7.24)						
9.7.25	Is consideration given to use of a spark or 'bang' arrestor to introduce a localised inert atmosphere when the dust cap is opened during the change of cylinders? And is the changing of cylinders only undertaken by suitably trained staff? (7.25)						
9.8	**Fire protection (section 8)**						
9.8.1	Are the clean room, the ducts and voids above the ceiling and below the floor protected by an automatic fire detection and alarm system designed and installed by an engineer with accreditation by an independent UKAS accredited third party certification body? (8.1)						
9.8.2	Is the automatic fire detection and alarm system monitored either on-site or by a suitable off-site alarm receiving centre? (8.2)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.8.3	Is the automatic fire detection and alarm system in the clean room linked so as to shut down process machinery, pressurisation and ventilation systems and also to close any transfer hatches so as to prevent the spread of smoke and gases in the event of a fire? (8.3)						
9.8.4	Is the installation periodically serviced and maintained by a competent engineer with accreditation by an independent UKAS accredited third party certification body? (8.4)						
9.8.5	Are all automatic fire detectors and gas detectors monitored outside the clean room at a point that is manned at all times that the clean room is occupied? (8.5)						
9.8.6	Where sprinkler systems are to be installed, are they designed, installed, commissioned and maintained in accordance with the **LPC Sprinkler Rules incorporating BS EN 12845** and by engineers having accreditation by an independent UKAS accredited third party certification body? (8.6)						
9.8.7	Are checks made to ensure that water supplies are adequate and reliable for the maximum sprinkler demand, especially in the event of a prolonged period of hot summer weather? (8.7)						
9.8.8	Are clean room sprinklers designed and installed so that they are not obstructed by light fittings, laminar flow air curtains, or other equipment that will be installed in the completed facility? (8.8)						
9.8.9	Where determined by risk assessment, and in consultation with the insurer, are local automatic fire suppression systems installed to protect wet benches, laminar flow hoods, alcohol vapour driers, flow soldering and similar process areas or equipment? (8.9)						
9.8.10	Are fixed fire suppression systems (other than sprinkler systems) designed, installed, commissioned and maintained by a company with accreditation by an independent UKAS accredited third party certification body as complying with the requirements of LPS 1204 or other appropriate standard? (8.10)						
9.8.11	Where gas suppression systems are installed, are these designed, installed, commissioned, maintained and tested in accordance with the relevant British Standard and/or supplier's specification by a competent engineer with accreditation by an independent UKAS accredited third party certification body? (8.11)						
9.8.12	Are gas fire suppression systems set to operate automatically when the areas in which they are installed are unoccupied? (8.12)						
9.8.13	Is the mode of operation, and the associated warning systems, of any installed gas fire suppression system carefully explained to relevant staff at the time of their fire safety training? (8.13)						

		Yes	No	N/A	Action required	Due date	Sign on completion
9.8.14	Following the release of extinguishing gas, is the system reinstated before operations within the clean room are restarted? (8.14)						
9.8.15	In addition to an automatic sprinkler installation or other fixed fire suppression system, is a suitable number of appropriate portable fire extinguishers available and immediately accessible in the case of a fire? (8.15)						
9.8.16	Has liaison been established with the local authority fire and rescue service to ensure that adequate water supplies are available for firefighting purposes? (8.16)						
9.8.17	Has the fire and rescue service been invited to visit the site to familiarise themselves with the automatic fire detection and suppression facilities and be involved in an emergency evacuation of the premises? (8.17)						
9.8.18	Has appropriate information been provided for the fire and rescue service at a prominent location? (8.18)						

REFERENCES

1. Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002, SI 2002 No 2776, The Stationery Office.

2. **Approved requirements and test methods for the classification and packaging of dangerous goods for carriage**, L88, Health and Safety Executive, 1996.

3. RC5: **Fire protection of laboratories**, 2009, Fire Protection Association.

4. Regulatory Reform (Fire Safety) Order 2005, SI 2005 No 1541, The Stationery Office.

5. The Fire (Scotland) Act 2005, asp 5, The Stationery Office.

6. Fire Safety (Scotland) Regulations 2006, Scottish SI 2006 No 456, The Stationery Office.

7. Fire and Rescue Services (Northern Ireland) Order 2006, SI 2006 No 1254 (NI9), The Stationery Office.

8. Fire Safety Regulations (Northern Ireland) 2010, Statutory Rules of Northern Ireland 325 2010, The Stationery Office

9. BS 5266: **Emergency lighting** (several parts), British Standards Institution.

10. RC42: **Recommendations for processes involving the production of heat with the potential to be ignition sources for fire, in particular those left unattended for periods of time**, 2010, Fire Protection Association.

11. **Business resilience: a guide to protecting your business and its people**, 2005, Fire protection Association.

12. **ROBUST** software (**Resilient Business Software Toolkit**) may be found at https://robust.riscauthority.co.uk

13. RC7: **Recommendations for hot work**, 2007, Fire Protection Association.

14. RC48: **Arson prevention, the protection of premises from deliberate fire raising**, 2010, Fire Protection Association.

15. **Approved Document B: Fire safety (Volume 2) – Buildings other than dwelling houses: Incorporating insurers' requirements for property protection**, 2008, Fire Protection Association.

16. American National Standard for Cleanroom Materials Flammability Test Protocol, ANSI/FM Approvals, 2004, FM Approvals LLC.

17. BS 7671: 2008 + A1: 2011: **Requirements for electrical installations. IEE Wiring Regulations. Seventeenth edition**, British Standards Institution.

18. BS EN 62035: **Protection against lightning**, (parts 1-4), British Standards Institution.

19. HS(G) 107: **Maintaining portable and transportable electrical equipment**, 2004, Health and Safety Executive.

20. **Code of practice for in-service inspection and testing of electrical equipment**, 2008, Institution of Electrical Engineers.

21. BS EN 13478: 2001 + A1: 2008: **Safety of machinery. Fire prevention and protection**, British Standards Institution.

22. BS 5839-1: 2002 + A2: 2008: **Fire detection and fire alarm systems for buildings. Code of practice for system design, installation, commissioning and maintenance**, British Standards Institution.

23. BS 6266: 2002: **Code of practice for electronic equipment installations**, British Standards Institution.

24. BS 5979: 2007: **Remote centres receiving signals from fire and security systems**. **Code of practice**, British Standards Institution.

25. **LPC Rules for automatic sprinkler installations incorporating BS EN 12845: 2004 + A2: 2009** (**Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance**), 2009, Fire Protection Association.

26. **Requirements for firms engaged in the design, installation and commissioning of firefighting systems**, Loss Prevention Standard (LPS) 1204: Issue 2, 1994, BRE Certification.

27. BS 5306-8: 2000: **Fire extinguishing installations and equipment on premises. Selection and installation of portable fire extinguishers. Code of practice**. British Standards Institution.

28. BS 5306-3: 2009: **Fire extinguishing installations and equipment on premises. Commissioning and maintenance of portable fire extinguishers. Code of practice**, British Standards Institution.

FURTHER READING

BS EN ISO 14644: **Clean rooms and associated controlled environments**, eight parts, British Standards Institution.

NFPA 318, Standard for the Protection of Semiconductor Fabrication Facilities, 2006 edition, National Fire Protection Association.

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