

BS 5908-1:2012



BSI Standards Publication

Fire and explosion precautions at premises handling flammable gases, liquids and dusts —

Part 1: Code of practice for precautions against fire and explosion in chemical plants, chemical storage and similar premises

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Foreword

Publishing information

This part of BS 5908 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2012. It was prepared by Technical Committee EXL/23, *Explosion and fire precautions in industrial and chemical plant*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

BS 5908-1:2012 supersedes BS 5908:1990, *Code of practice for fire precautions in the chemical and allied industries*, which is withdrawn.

Relationship with other documents

This part of BS 5908 is intended to be used with BS 5908-2, which gives guidance on the legislation and standards applicable to onshore industrial premises that handle significant quantities of flammable gases, liquids or dusts.

Presentational conventions

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard gives recommendations and guidance for the control of fire and explosion risks on sites at which chemicals are stored or processed in significant quantities.

NOTE 1 These precautions may extend well beyond those required under the fire safety legislation applicable to places of work, because of the wider range of risks. Additional legal requirements arise largely from the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) [1, 2], and the Health and Safety at Work legislation [3, 4].

NOTE 2 Annex A gives guidance on the classification of chemicals, while Annex B discusses ignition sources and Annex C covers hazards from smoke. Annex D gives guidance on the approaches to hazardous area classification.

The precautions recommended by this British Standard also address risks on and off site, within and external to buildings, that arise from the release of toxic materials, ejection of chemical containers from a fire, flowing fires where liquid products are handled, and special firefighting techniques.

The recommendations of this code of practice cover location, plant layout and design, separation distances, particular types of plant and facility with special fire hazards and other issues. Particular precautions might be relevant to preserving life safety or the health of persons on or off site; to property protection; and to protection of the environment.

2 Normative references

The following referenced documents are indispensable for the application 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.

BS 799-5, *Oil burning equipment*

BS 5908-2, *Fire and explosion precautions at premises handling flammable gases, liquids and dusts – Part 2: Guide to applicable standards and regulations*

BS 9999:2008, *Code of practice for fire safety in the design, management and use of buildings*

BS EN 54-2, *Fire detection and fire alarm systems – Part 2: Control and indicating equipment*

BS EN 671, *Fixed fire fighting systems – Hose systems*

BE EN 976-1, *Underground tanks of glass-reinforced plastics (GRP) – Horizontal cylindrical tanks for the non-pressure storage of liquid petroleum based fuels – Part 1: Requirements and test methods for single wall tanks*

BS EN 1012-1, *Compressors and vacuum pumps – Safety requirements – Part 1: Air compressors*

BS EN 1127-1, *Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology*

BS EN 1539, *Dryers and ovens, in which flammable substances are released – Safety requirements*

BS EN 1598, *Health and safety in welding and allied processes – Transparent welding curtains, strips and screens for arc welding processes*

BS EN 1991-1-2, *UK National Annex to Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire*

- BS EN 12094, *Fixed firefighting systems – Components for gas extinguishing systems* (all parts)
- BS EN 12259, *Fixed firefighting systems – Components for sprinkler and water spray systems* (all parts)
- BS EN 12285-1, *Workshop fabricated steel tanks – Part 1: Horizontal cylindrical single skin and double skin tanks for the underground storage of flammable and non-flammable water polluting liquids*
- BS EN 12285-2, *Workshop fabricated steel tanks – Part 2: Horizontal cylindrical single skin and double skin tanks for the aboveground storage of flammable and non-flammable water polluting liquids*
- BS EN 12416, *Fixed firefighting systems – Powder systems*
- BS EN 12845, *Fixed firefighting systems – Automatic sprinkler systems* (all parts)
- BS EN 12573, *Welded static non-pressurized thermoplastic tanks*
- BS EN 12921-3, *Machines for surface cleaning and pre-treatment of industrial items using liquids or vapours – Part 3: Safety of machines using flammable cleaning liquids*
- BS EN 13463-1, *Non-electrical equipment for use in potentially explosive atmospheres – Part 1: Basic method and requirements*
- BS EN 13463-5, *Non-electrical equipment intended for use in potentially explosive atmospheres – Part 5: Protection by constructional safety 'c'*
- BS EN 13480, *Metallic industrial piping* (all parts)
- BS EN 13565-1, *Fixed firefighting systems – Foam systems – Part 1: Requirements and test methods for components*
- BS EN 13565-2, *Fixed firefighting systems – Foam systems – Part 2: Design, construction and maintenance*
- BS EN 13575, *Static thermoplastic tanks for the above ground storage of chemicals – Blow moulded or rotationally moulded polyethylene tanks – Requirements and test methods*
- BS EN 14015, *Environmental management – Environmental assessment of sites and organizations*
- BS EN 14122, *Safety of machinery – Permanent means of access to machinery*
- BS EN 14491, *Dust explosion venting protective systems*
- BS EN 14797, *Explosion venting devices*
- BS EN 14994, *Gas explosion venting protective systems*
- BS EN 15004, *Fixed firefighting systems – Gas extinguishing systems*
- BS EN 61511-1, *Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and software requirements*
- BS EN 61511-2, *Functional safety – Safety instrumented systems for the process industry sector – Part 2: Guidelines for the application of IEC 61511-1*
- DD CEN/TS 14816, *Fixed firefighting systems – Water spray systems – Design and installation*
- API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*
- API 650, *Welded Tanks for Oil Storage*
- API 2000, *Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated*

API RP 2021, *Management of Atmospheric Storage Tank Fires*
OFS T200, *OFTEC standard for steel storage tanks*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1.1 boiling liquid vapour cloud explosion (BLEVE)

event that follows the sudden failure of a vessel containing a liquefied gas under pressure after fire engulfment

NOTE A fireball and associated pressure wave occur.

3.1.2 dangerous goods

articles or materials capable of posing significant risk to people, health, property or environment when transported in quantity

NOTE This term is defined in the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) [5] and other international transport legislation, and goods are classified as dangerous depending on results from tests set out in the legislation.

3.1.3 dangerous substance

- a) substance or preparation which meets the criteria in the approved classification and labelling guide for classification as a substance or preparation which is explosive, oxidizing, extremely flammable, highly flammable or flammable, whether or not that substance or preparation is classified under the Chemicals (Hazard Information and Packaging for Supply) (CHIP) Regulations [6, 7]; or
- b) substance or preparation which because of its physico-chemical or chemical properties and the way it is used or is present at the workplace creates a hazard, not being a substance or preparation falling within a); or
- c) dust, whether in the form of solid particles or fibrous materials or otherwise, which can form an explosive mixture with air or an explosive atmosphere, not being a substance or preparation falling within a) or b)

(adapted from Dangerous Substances and Explosive Atmospheres Regulations 2002 [1, 2])

3.1.4 deluge system

system of fixed fire protection designed to release water from a large number of nozzles at the same time in response to manual or automatic activation in the event of fire

3.1.5 explosible

capable of being exploded or liable to explode

NOTE This term is used to describe a dust that is capable of creating an explosion if a dense cloud in air is ignited. It distinguishes dust which requires air for combustion from explosive materials, which can decompose rapidly and violently in the absence of air.

3.1.6 fire-resisting construction

ability of an element of construction to maintain its load-bearing capability, or provide a barrier to the passage of smoke, heat or flames for a stated period

NOTE This term comes from the Building Regulations [8, 9, 10]. In the context of premises which store and use chemical products with a range of special properties, the usual construction methods might not provide the anticipated fire-resistance time (see Clause 14).

3.1.7 hazardous area

site in which an explosive atmosphere might occur in such a quantity as to require special precautions to protect the health and safety of the workers

NOTE This definition is taken from DSEAR [1, 2], but hazardous areas may also be assigned where the occupancy is very low but the risk from fires or explosions is significant.

3.1.8 hazard and operability studies (HAZOP)

technique for analysis of hazards used in process plants

3.1.9 means of escape

safe route by which persons can travel from any point in the plant or building to a place of reasonable or ultimate safety in the event of fire

3.1.10 non-combustible

not capable of undergoing combustion under specified conditions

[BS EN ISO 13943]

3.2 Abbreviations

ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road [5]
API	American Petroleum Institute
ATEX	Atmosphères Explosive (ATEX Directive 94/9/EC [11])
BLEVE	boiling liquid vapour cloud explosion
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
FIBC	flexible intermediate bulks containers
HAZOP	hazard and operability studies
HSE	Health and Safety Executive
IBC	intermediate bulk containers
LEL	lower explosion limit
LPG	liquid petroleum gas
NFPA	National Fire Protection Association (USA-based)
PRV	pressure-relief valve
SHEVS	smoke and heat exhaust ventilation systems
VCE	vapour cloud explosion

Section 1: Fire risk assessments

4 Fire risk assessment and fire precautions

Fire precautions should be implemented on sites handling chemical products to ensure the safety of people on site in the event of fire and to:

- a) limit any off-site risk to people in the surrounding area;
- b) facilitate firefighting by professional firefighters;
- c) limit the potential damage to the environment from release of chemicals;
- d) limit the potential loss of plant, equipment and inventory of products and raw materials;
- e) limit the consequential losses from loss of production;
- f) limit the risk of a fire starting;
- g) limit the rate of growth or fire spread; and
- h) prevent explosions.

NOTE 1 In England and Wales, a distinction is made between general fire precautions and process fire precautions by the fire safety legislation [12, 13, 14, 15]. In most circumstances, enforcement of requirements relating to general fire precautions is through the local fire authority, while process fire precautions are enforced by HSE, or its equivalent in Northern Ireland. This standard addresses precautions for all the purposes in a) to h), whether they are required under general fire precautions or process fire precautions, or for environmental protection.

The fire precautions to be implemented on site should be informed by a fire risk assessment, which should identify the various risks from processing or storing chemicals on site, including:

- 1) sources of ignition;

NOTE 2 A list of potential ignition sources is given in Annex B.

- 2) the hazards likely to arise from smoke, e.g. density and toxicity (see Annex C); and
- 3) the potential for an explosion to be initiated by fire or for a fire to result from the explosion, including the mechanisms that create explosions with different characteristics, for which different precautions and controls are needed.

The fire risk assessment should categorize the chemicals handled on site, including the fire hazards of solids which melt, products which are stored or processed well above ambient temperature, products which are both flammable and toxic, and dusts which can explode when dispersed as a cloud, but burn only slowly if exposed to a flame, and in many cases how the packaging influences the rate of fire growth (see Annex A).

An assessment of the fire hazard of flammable solids, for example, should consider the following.

- i) The surface area that would be exposed in the early stages of a fire.
- ii) The vertical extent of any surface across which fire could spread. Flame spread is always more rapid vertically than horizontally.
- iii) Whether a material would melt, soften or char when exposed to flames or intense heat.
- iv) The thickness of the material. A thin section of textile material burns in a different way from a tight roll.

- v) How quickly any packaging is likely to fail. Cardboard boxes and plastic sacks release their contents more rapidly than a metal bin.
- vi) The toxicity of any materials present, and whether this would change as a consequence of combustion (most organic products) or remain after a fire (e.g. products with a toxic metal content).

NOTE 3 To some degree these issues are common to all buildings, but chemical plants can have very large quantities of materials with specific properties that would determine fire development.

These inputs should be used to develop an understanding of possible fire scenarios in the early stages following ignition. From this the adequacy of the means of escape should be assessed, the need and form of any fixed fire protection established, and arrangements for firefighting agreed with the fire and rescue service.

NOTE 4 The conclusions may also influence the type of packaging used, the maximum height of any stockpile, separation of products with different fire hazards (see 30.8.4), and the maximum quantities in a given location.

Section 2: Site layout and design

5 Selection of site and layout

The location selected for a site for processing or storing chemicals should have:

- a) sufficient clear space from boundaries, plant buildings and other combustible storage that might create a fire exposure hazard;
- b) adequate clearance from public highways and railways;
- c) good access by all-weather roads;
- d) no risk of flooding;
- e) no gradient variations likely to cause hazards;
- f) subsoil capable of supporting anticipated loads;
- g) no underground piping or drainage that might create a hazard;
- h) no overhead power cables;
- i) adequate means to prevent unauthorized access;
- j) sufficient area to provide safe segregation of different types of chemicals;
- k) adequate water supplies for firefighting; and
- l) means to control the flow of potential spillages, to limit environmental damage on or off site.

Within a site that has both process units and storage, the layout should be designed to minimize the potential for escalation of a fire. This should involve, as necessary, minimum separation between blocks of process plant, adequate separation within a tank farm, and between a tank farm and process plant, suitable location of occupied buildings, and separation of areas with major chemical inventories from activities creating a permanent fire hazard (boiler houses, flare stacks and facilities for use of welding/hot work).

NOTE Advice on the location and design of occupied buildings on chemical sites is given in the Chemical Industries Association Guide [16]. The particular issues of location of temporary or portable buildings on chemical sites are covered in code API 753 RP.

High-level design considerations for creating safer plant layouts was one of the objectives of the Mond Fire, Explosion and Toxicity index developed by ICI in the 1970s and 1980s. This used as primary inputs material properties, and inventories, and how the plant was or was intended to be subdivided. The subdivisions are intended to represent boundaries across which fire spread could be prevented by effective firefighting. Particular material properties included heat of combustion, flash point, potential for polymerization or dense phase explosion, ignition sensitivity, operating pressure, toxicity and aerial explosion hazards.

The calculated index does not give any indication of the frequency of possible events or take account of control measures of any sort. Instead, its value comes from setting a baseline for the inherent safety of an outline process design and site layout, and the ability to compare alternatives.

Details of the Mond Index were published mainly in the form of conference papers.

6 Access for firefighting

Roads or access over firm ground should be provided to allow fire appliances to approach within reasonable distance (generally 45 m) of all main fire hazards on site. Where practical, approach should be possible from two directions to major fire hazards. Access roads required for emergency use should be kept clear of parked vehicles, including disconnected trailers, and any other items that would create an obstruction, e.g. drums awaiting loading.

The advice given in BS 9999 on road widths, turning circles and load-carrying capacity for fire service vehicles should be followed.

NOTE 1 Because the weight of high-reach appliances, for example, is distributed over a number of axles, it is considered that their infrequent use of a carriageway or route designed to 12.5 tonnes is not likely to cause damage. It would therefore be reasonable to design the road base to 12.5 tonnes, although structures such as bridges ought to have the full 17 tonnes capacity.

For a large site, at least two points of access to the public road network should be provided.

Cul-de-sacs in internal road networks should be provided with sufficient space in which to turn a fire appliance.

NOTE 2 Requirements for access to buildings are set out in Approved Document B to the Building Regulations [17], Technical Handbook 2 to the Building (Scotland) Regulations 2004 [18] and Technical Booklet E to the Building (Northern Ireland) Regulations 2012 [19].

Where tall process plant or plant buildings are present on site, space should be provided for the operation of a turntable ladder or hydraulic platform.

Where open water sources might be needed for supplementary firefighting supplies, a hard standing should be provided beside each source.

7 Water supplies

NOTE Water is needed for the operation of any fixed sprinkler or drencher systems, for manual firefighting and for cooling plant, and equipment threatened by a nearby fire. The quantities needed might be very large, over an extended period.

Major chemical sites should consult their water supplier about the maximum flow rates that would be available immediately in an emergency, and how these could be augmented. Supplementary supplies, e.g. rivers, canals and lakes, might be available and should be considered as part of emergency planning.

Water as a jet should not be used for fighting fires involving the following.

- a) Chemicals that react with water.
- b) Flammable gases and liquefied flammable gases, for which water is generally ineffective and for which the risk continues if the flames are extinguished but the leak continues.
- c) Situations in which the application of water could spread toxic material into water courses or the environment.
- d) Flammable liquid, if the liquid is immiscible and lighter than water, and could be spread by the application of water jets.
- e) Dusts, if a water jet would raise burning material into a cloud and cause an explosion hazard.

Fine sprays, water fog nozzles or foam should be used in the situations described in items b) to e). In the case of an ignited gas release, the priority should be to switch off the gas supply.

Site operators should obtain information about the appropriate means of fighting fires involving the chemical products on site. Discussions should be held with the local fire authority.

Water supplies within a small site may be provided by hydrants at the site boundary, but on a larger site a ring main with hydrants at appropriate locations should be provided. Hard-standings should be provided beside each hydrant to allow a fire service vehicle or mobile pump to make a connection.

Any ring main should have an adequate number of isolation valves, and be maintained under pressure by a jockey pump. Any fixed fire pumps used to maintain the pressure in the ring main during operation, or to draw water from a supplementary source, should be located where they are not likely to be affected by any fire on site. To maintain availability at all times, a minimum of two pumps should be provided. Electric pumps should be fed by separate power supplies. Where the pressure in a fire main drops and cannot be restored by the jockey pump, the main fire pump should start automatically, with a signal indicating this condition sent to a permanently staffed location.

Mobile pumps should be provided, if necessary, to boost the water pressure delivered to fire hoses or the pressure in fire mains.

Plans showing the layout of the system, including hydrants and isolation valves, should be available for use by the fire and rescue service.

Fire pumps should be tested at a frequency not greater than six months.

8 Drainage and pollution control

NOTE 1 Environmental protection legislation imposes strict controls on:

- a) the deliberate release of liquid effluents that contain chemicals;*
- b) the accidental release from storage, transfer or processing activities;*
- c) chemicals released as a consequence of fire, including foam making compounds.*

Where large volumes of water used to fight fires involving chemical products stored or processed on site could result in quantities of potentially contaminated water flowing away from the site, the site operator should:

- 1) identify the environmental hazards that would arise from the release into drains or water courses of the products processed or stored on site;

NOTE 2 At sites where many chemical products are present, the chemical components in the water might be unknown.

- 2) ensure they understand the layout and capacity of normal drainage systems on site;
- 3) identify the likely direction of flow if the normal drainage systems cannot handle the water flows generated during firefighting activities;
- 4) identify the general direction that the drainage takes off site, including the location of any downstream sites that would be particularly sensitive to pollution;
- 5) determine the need for emergency containment systems;
- 6) discuss with the local fire authority the tactics to be used to tackle a major fire while minimizing the risk of pollution; and
- 7) if necessary, provide interceptors, permanent fixed tanks or emergency retention/containment systems to prevent the uncontrolled flow of potentially contaminated fire water off site.

NOTE 3 The quantities of water involved are likely to quickly overwhelm any drainage or interceptor system designed to capture or retain spills or leaks of product.

NOTE 4 Emergency containment systems may use temporary bunding and ground contours, together with areas impervious to water, such as roads or car parks, to create temporary lagoons.

The costs of retention facilities for fire water are likely to be high, and discussions should be held with the relevant authority [Environment Agency (EA) in England and Wales, Scottish Environment Protection Agency (SEPA) in Scotland, Northern Ireland Environment Agency in Northern Ireland] about the facilities required before committing to such expenditure.

NOTE 5 See also SEPA/EA guidance PPG18 [20].

9 Prevention of escalation

The plant design should limit the potential for fire growth by incorporating one or more of the following techniques for limiting escalation.

- a) Limiting the quantity of combustible material within a process.
- b) Separating process areas from storage areas.
- c) Subdividing storage areas where inventories are inevitably large.
- d) Design of open air plant to limit the potential for vapour cloud explosions (VCEs) in congested structures.
- e) Providing fixed fire protection to major storage units.
- f) Providing facilities for emergency isolation of large inventories and, where appropriate, depressurization.

Section 3: Buildings and structures

10 Fire resistance

Fire resistance should be built into the structure of buildings/structures to:

- a) minimize the risk to the occupants during evacuation;
- b) minimize the risk to firefighters engaged in search and rescue operations; and
- c) reduce the danger to people in the vicinity from collapsing structures.

NOTE Guidance on periods of fire resistance for elements of a structure is given in BS 9999 and the supporting guidance documents to the Building Regulations, e.g. Approved Document B [17], including minimum periods of fire resistance for industrial buildings. Chemical plant includes many structures that are not considered buildings. In these cases, fire-resistant structures might be required to prevent escalation by premature collapse of the main load-bearing structure.

The hydrocarbon heating curve specified in BS EN 1991-1-2 should be used for the design of fire-resistant structures, when consideration of the plant and its inventory indicates it is more applicable.

11 Compartmentation

Compartmentation should be provided to:

- a) prevent rapid fire spread if this could trap the occupants of a building;
- b) reduce the risk of very large fires, which are difficult and dangerous to extinguish; and
- c) where necessary:
 - 1) reduce the risk of release of toxic materials that are not initially involved in the fire;
 - 2) prevent the mixing of hazardous combinations of chemicals;
 - 3) make fixed fire protection systems effective;
 - 4) protect control rooms that cannot be immediately evacuated; and
 - 5) provide protection to electronic control equipment or power supplies that are important for the safety of the plant.

Internal doors in compartment walls generally permit the flow of spilt liquids to pass underneath. If the liquid is burning, fire is likely to spread in this way. Fire door sets are not tested against this risk. Where the spread of fire by flowing flammable liquids is possible, and needs to be prevented, a raised threshold or similar means to prevent or control the flow of liquid under a door should be provided.

Compartmentation requirements should be discussed with the insurers of the premises.

NOTE 1 Guidance for the sizing of compartments is given in Approved Document B to the Building Regulations [17], Technical Handbook 2 to the Building (Scotland) Regulations 2004 [18] and Technical Booklet E to the Building (Northern Ireland) Regulations 2012 [19]. Compartmentation requirements under Building Regulations [8, 9, 10] are intended to prevent rapid fire spread which could trap occupants, and to reduce the risks of very large fires to fire and rescue service personnel and persons in the vicinity. They are not intended to reduce the financial risk to occupiers in the event of fire.

NOTE 2 The size and intensity of a fire is strongly influenced by the ease with which materials can be ignited (assessed by flash point and other factors) and the potential speed of fire growth (influenced by the disposition of chemicals, the type of processes used and other factors).

Where the fire hazard arising from the chemicals stored or handled is high, the following maximum compartment sizes taken from the Scottish Technical Handbook [18] are recommended by this standard. In England and Wales the maximum compartment size in Approved Document B [17] takes no specific account of the fire hazard of materials present.

a) Factory buildings 33 000m².

b) Storage buildings 1 000m².

These figures may be increased where a suitable fixed fire suppression system is provided.

A review of the benefits of compartmentation in chemical warehouses is provided in HSE Contract Research Report RR 152 [21].

12 Fire detection and fire alarm systems

Automatic fire detection and fire alarm systems designed to BS 5839-1 should be provided to a category M standard for all occupied buildings, unless the fire risk assessment indicates otherwise, e.g. in a small building it might not be necessary to provide such a system as occupants would be immediately aware of a fire and could shout to alert others.

Automatic fire detection (category L system) might also be necessary, particularly where an undetected fire could jeopardize the ability of people to escape, but the extent of such protection should be determined by a fire risk assessment.

NOTE 1 Chemical plants frequently include buildings with unusual characteristics, structures that are not fully enclosed, enclosed structures linked to open air process plant at multiple levels, tall or extended open air plant and tank farms, and less frequently cable tunnels or other structures below ground that might not be considered a building. Examples of unusual characteristics include process buildings with little or no internal fire compartmentation, buildings where there is a risk of explosion as well as fire, buildings where the fire hazard is very low because the fire load is minimal, and warehouses where all or most of the occupants are driving lift trucks for most of the working day.

Buildings on chemical sites are often also characterized by very low occupancy levels, areas where there might be a significant fire hazard, but which are normally unoccupied and only accessed under a permit to work system.

In large sites or open areas, there might be a general need to ensure all persons on site are aware of a fire or other developing problem, but the immediate risk to life from fire is low. Site wide alarms may be provided to warn staff of other dangers, such as the release of toxic gases.

Property protection considerations might dictate a higher level of automatic fire detection.

The fire risk assessment should cover all parts of the premises, specifically means of detection and escape, to determine:

- a) how fire would be detected (smoke, heat);
- b) what type of detection (e.g. point detection, beam detector or aspirating system) is best suited to each area and the most effective evacuation strategy for that area (simultaneous, phased or progressive horizontal);
- c) how quickly a fire would cause a hazard to persons in the area;
- d) how the alarm could be raised (bell sounder, beacons, voice);

- e) where the alarm needs to be heard (or seen); and
- f) the action to be taken by staff in response to a fire at any location across the site, e.g. if fire breaks out in an area where it creates no immediate hazard to life safety, the required response may not be evacuation; instead an emergency plan could be prepared, containing emergency procedures (see Clause 41) and the actions required.

As an alternative to fixed alarm call points, radios may be used both to raise the alarm and to alert staff with specific responsibilities in case of fire. Any such radio system used should be suitable for any hazardous areas in which they may be taken, and locations where a weak signal could cause them to be ineffective should be identified. Sufficient radios and spares should be available for all staff who need one. Mobile radio systems using the national networks are not recommended as a means of raising the alarm within a single site.

NOTE 2 Before major maintenance or other activities which significantly increase the numbers of persons present on site, the fire risk assessment ought to be reviewed. Temporary electric fire detection and fire alarm systems might be required and, where certain maintenance activities could trigger a detector, the temporary shutdown of part of the detection system might be necessary so as not to trigger a false alarm, e.g. welding activities could trigger an aspirated detection system.

13 Open air and unenclosed plant

NOTE 1 The structures found on chemical plants vary from conventional buildings with complete external walls and roof, together with solid internal floors, to plant that has no form of enclosure or weather protection. Sometimes a complete side of a building is open, or very large ventilation louvres are provided on more than one external wall. Some compressor houses have no wall at low level, but extensive enclosure at higher levels.

Frequently, internal floors are either of open-mesh construction or have large gaps where process vessels extend through more than one level. Sometimes structures are designed to prevent a liquid spill at one level from flowing down through the building; in other cases there is little to prevent this. Walkways and routes are commonly provided at one or more levels above ground between adjacent open air plant and enclosed buildings. Buildings or structures might need to be designed to provide some protection against explosion hazards. Fire loadings might be extremely high, but concentrated in distinct vessels or items of equipment.

Normal controls for fire growth and fire spread within buildings are therefore not applicable, e.g. compartmentation to limit the speed and extent of fire growth or the movement of smoke might be impractical.

When designing buildings or partial buildings, the following should be determined.

- a) The types and quantities of combustible process materials present.
- b) The characteristics of a fire involving these materials.
- c) In the event of a fire, how much smoke would be produced and how toxic or irritating it would be.
- d) How these materials would spread around the building if released.
- e) Whether the products would create the risk of an explosion, as well as a fire.

The following factors should be provided, where appropriate, as inputs to the initial risk assessment.

- 1) Whether open mesh floors and/or large opening vents in external walls (or incomplete walls) could prevent smoke logging, improving visibility, which might otherwise be poor.
- 2) Whether escape routes are to be provided to a place of comparative safety outside the building at levels above the ground, from which there is an open air route to ground level.
- 3) Whether ventilation capable of dispersing small leaks and minimizing the risk of an extensive explosive atmosphere forming is to be provided.

NOTE 2 Where large openings in external walls are provided fire is not likely to reach ventilation controlled burning rate, a state where smoke production typically increases sharply.

Buildings in which there is a risk of an internal explosion from the release of gas or dust should not have load-bearing masonry walls, as a small overpressure could cause disproportionate collapse.

Buildings with access levels higher than 20 m above the ground should either have a fire enclosed external stairway leading directly at ground level to a place of safety, or access routes to adjacent open-air structures.

Storage of flammable raw materials, intermediates or finished products within a process or reactor building should be minimized where practical.

In multilevel buildings, provision should be made to prevent the unintended release of flammable liquids at an upper level from flowing down through the building.

Where flammable bulk powders are discharged from flexible intermediate bulks containers (IBCs), the discharge point should be at ground level, or enclosed to prevent any spillage from forming a large dust cloud that descends through the building.

Control rooms should be at or close to ground level, with a short direct route to a place of safety, or ideally located in a separate building from the process if the risk of a fire/explosion is deemed sufficiently high.

Combustion plant, such as boiler houses, should be installed in separate structures from chemical process plant, with sufficient space separation to control the risk of fire spread between the two.

Separate rooms should be provided to house electrical distribution and control equipment, and these should be given a degree of fire compartmentation. The fire load within these rooms should be kept low.

The effect on the building of an external fire in adjacent process plant should be determined by calculating the radiant heat effect (kW/m^2) on the building.

Fire protection of steelwork supporting main process vessels containing hazardous materials should be provided as appropriate.

14 Materials of construction

Process and storage buildings should normally be constructed with steel or concrete frames. Where chemicals used in the process are liable to cause corrosion or degradation, special protective coatings should be applied.

Where there is any risk of explosion, masonry should not be used in the construction of load-bearing walls.

The selection of materials for external cladding should take into account any fire resistance and external fire spread needed to prevent fire spread to adjacent or higher level plant and equipment. Thin metal-profiled sheet provides little insulation, and masonry or blockwork should be preferred.

Combustible materials, such as insulating cladding with combustible cores (sandwich panels), should not be used for the construction of buildings for chemical plants.

Internal compartment walls that require a high level of fire resistance should be made from one of the proprietary systems of fire-protective boards.

Many process buildings require pipework and cabling to run through internal compartment walls, and this can negate any protection they provide. Proprietary systems for maintaining fire resistance should be used for cable penetrations where plastic pipe passes through walls.

NOTE As metal pipe conducts heat, it is not practical to prevent fire attack on one side of a wall generating high temperatures in metal pipes on the other side.

15 Ventilation

The objective of any ventilation provided should be established, together with any risks this introduces.

The number and size of ventilation openings should be specified to permit dispersal of small releases and prevent the formation of an explosive atmosphere. Good natural high- and low-level ventilation should be provided where there are potential sources of release of flammable vapours or gases. Mechanical ventilation may be provided for the same purposes, or to limit the extent of a hazardous area or reduce the hazard expressed by the zone number.

NOTE 1 Mechanical extraction ventilation is often provided close to sources of release, resulting in duct work that runs for extended lengths. This may be provided mainly for occupational health reasons, or to capture dust releases to prevent them forming dust layers around the building. Deposits that collect within such duct work might provide a route for rapid fire spread, so fire dampers might be required to act as a barrier.

The following ventilation should be installed as necessary.

- a) Large ventilation openings to allow waste heat from the process to be dispersed or to provide an air supply for a combustion process.
- b) Pressurization ventilation to prevent smoke flow into a room housing electronic control equipment, or a process control room.

NOTE 2 Additional air movements not designed as ventilation can be generated by flows of process materials, particularly conveying systems for bulk powders or solids.

Mechanical ventilation systems are likely to affect the movement of smoke or heat within a building in case of fire. Ductwork should not run through fire compartment walls if this can be avoided. Alternatively, fire dampers may be provided. If ventilation systems or bulk conveying systems are likely to be a route for fire spread, they should shut down in the event of fire, and should be interlinked with the fire alarm or automatic fire detection systems.

16 Means of escape

Means of escape from process buildings and open-air structures should be provided in accordance with BS 9999:2008, Annex F, including the recommended maximum travel distances for different risk profiles, consideration of the different rates of fire growth to be expected in buildings with different inventories, and the occupancy levels at different times.

Where a site incorporates large machines with requirements for fixed access arrangements, these should conform to BS EN 14122.

Staff do not necessarily evacuate in response to an alarm. Where the response to an alarm is other than immediate evacuation, the following should be taken into consideration for process plant.

- a) The case where fire is external to any building, and the building is designed to provide a degree of protection from heat radiation.
- b) Preplanned shut-down actions by the operators are required to make the plant safe.
- c) An automatic fire detection system reports a fire or overheating from an unoccupied location and the preplanned response requires someone to go to the area to investigate the circumstances.

For these circumstances, emergency plans should be developed which do not require any individual to take more than a few actions in a short period in response to fire or conditions giving rise to an increased risk of fire.

17 Lighting

Permanent lighting should be provided in external areas where work during the hours of darkness is regularly required, particularly areas trafficked by lift trucks or road vehicles carrying chemical products, and external process plant. Where there are infrequently visited areas, the lighting may be turned on and off by an operator as needed, but all relevant staff should be made aware of the location of the switches.

Often, lighting at high level is located above any hazardous areas, but it should also be located away from process vents or pressure relief valves if these could release flammable gases.

Luminaires and associated light switches installed inside buildings should be suitable for any hazardous areas which have been designated.

The provision of emergency lighting for buildings should take account of the actions required of operators in the event of fire or loss of power on site. If operators are required under some circumstances to remain in the control room after normal lighting has been lost, the duration of operation of the emergency lighting supplied should be extended.

Hand-held battery-powered lighting might be needed for specific activities. Where there are hazardous areas on site, all such torches used should be suitable for any location in which they are to be used. Lighting should not be lowered into process vessels, storage tanks pits, drains or silos unless these have been made gas/dust-free.

Mains-powered portable lighting on flexible leads is a particular ignition hazard, as it is easily damaged. It should be visually inspected each time before use.

18 Space heating

In hazardous areas, or locations where any fire constitutes a high risk because of the presence of dangerous chemicals, space heating should be selected from a type that creates no fire hazard, such as steam or hot water radiators.

NOTE 1 This includes offices attached to warehouse areas or process plants.

Site-wide rules should emphasize that no temporary space heating is permitted without a review of the additional fire hazards it could generate and specific controls over its location.

NOTE 2 Gas-fired heaters may be installed at high level above storage racking and above any defined hazardous areas, though this creates access problems for maintenance and inspection.

NOTE 3 See Clause 45 concerning area classification and gas installation pipework.

Boilers for space heating should be located where no flammable materials are likely to be drawn into the burner air intake.