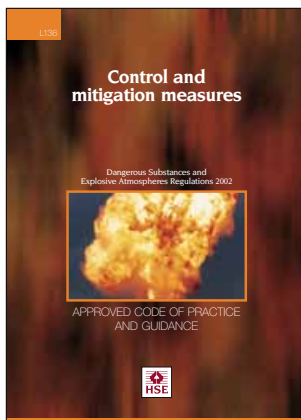


Control and mitigation measures

Dangerous Substances and Explosive Atmospheres
Regulations 2002

Approved Code of Practice and guidance



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Dangerous Substances and Explosive Atmospheres Regulations 2002 Approved Code of Practice and guidance

This publication is part of a series of Approved Codes of Practice and guidance intended to support The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).

The Code of Practice gives practical advice on what employers have to do to meet the requirements of regulations 5 and 6 of DSEAR (on assessment and control) with regard to control and mitigation measures for activities involving dangerous substances. In particular, it details the requirements of ventilation, ignition avoidance and adequate separation to prevent or mitigate the risks of fire and explosion.

DSEAR is concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. They set minimum requirements for the protection of workers from fire and explosion risks related to dangerous substances and potentially explosive atmospheres. The Regulations apply to employers and the self-employed at most workplaces in Great Britain where a dangerous substance is, or could be, present.

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This Code has been approved by the Health and Safety Executive, with the consent of the Secretary of State. It gives practical advice on how to comply with the law. If you follow the advice you will be doing enough to comply with the law in respect of those specific matters on which the Code gives advice. You may use alternative methods to those set out in the Code in order to comply with the law.

However, the Code has a special legal status. If you are prosecuted for breach of health and safety law, and it is proved that you did not follow the relevant provisions of the Code, you will need to show that you have complied with the law in some other way or a Court will find you at fault.

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Preface

This publication contains an extract from the Dangerous Substances and Explosive Atmospheres Regulations¹ (regulations 5 and 6 and Schedule 1), together with an Approved Code of Practice and supporting guidance.

For convenience, the text of the Regulations is set out in italic type, with the ACOP in **bold** type and the accompanying guidance in normal type.

Notice of Approval

By virtue of section 16(1) of the Health and Safety at Work etc Act 1974 and with the consent of the Secretary of State for Work and Pensions, the Health and Safety Commission has on 13 May 2003 approved the Code of Practice entitled *Control and mitigation measures*.

The Code of Practice gives practical guidance with respect to regulations 5 and 6 of the Dangerous Substances and Explosive Atmospheres Regulations 2002 with regard to safe maintenance, repair and cleaning procedures where dangerous substances are or may be present.

The Code of Practice comes into effect on 27 October 2003.

Signed

MARK DEMPSEY
Secretary to the Health and Safety Commission
3 October 2003

Introduction

1 The Dangerous Substances and Explosive Atmospheres Regulations 2002¹ (DSEAR) are concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. They set minimum requirements for the protection of workers from fire and explosion risks related to dangerous substances and potentially explosive atmospheres. The Regulations apply to employers and the self-employed and apply at most workplaces in Great Britain where a dangerous substance is, or could be, present.

2 DSEAR revokes, repeals or modifies a large amount of old legislation relating to flammable substances and dusts. Safety standards will be maintained through a combination of the requirements of DSEAR and ACOPs (Approved Codes of Practice) reflecting good practices in the old legislation.²⁻⁶

3 The key requirements in DSEAR are that risks from dangerous substances are assessed and eliminated or reduced. This ACOP provides practical advice on what employers need to do to meet the requirements of regulations 5 and 6 of DSEAR (on assessment and control of risks) at places where maintenance, repair and cleaning activities are carried out. It also provides advice on appropriate systems of work and details permit-to-work procedures for hot work and other activities that are identified as high risk.

4 This publication is part of a series of publications intended to support DSEAR. Other activity-related ACOPs and guidance material is available in the following publications:

- (a) *Dangerous substances and explosive atmospheres*² - This provides an overview of how employers can meet their duties under DSEAR.
- (b) *Design of plant, equipment and workplaces*³ - This gives practical advice on assessing the risk from, and the design and use of, plant, equipment and workplaces which handle or process dangerous substances. It includes measures for making redundant plant and equipment safe.
- (c) *Storage of dangerous substances*⁴ - This gives practical advice on the requirements of regulation 5 and 6 to assess the risks from, and the control and mitigation measures for, places where dangerous substances are stored. It includes the safe disposal of waste materials.
- (d) *Safe maintenance, repair and cleaning*⁵ - This gives practical advice on identifying hazards and implementing appropriate control measures and systems of work during maintenance and other similar non-routine activities. It includes advice on hot work and on permit-to-work systems for those activities identified as high risk.
- (e) *Unloading petrol from road tankers*⁶ - This gives practical advice and contains a code of practice in respect to regulation 6 with regard to the safe unloading of petrol tankers at petrol filling stations.

5 In addition, the free leaflet *Fire and explosion - How safe is your workplace?*⁷ provides a short guide to DSEAR and is aimed at small and medium sized businesses.

6 Information on DSEAR can also be accessed via HSE's website: www.hse.gov.uk, which is regularly updated.

Assessment of the risks

Regulation 5

Regulation

(1) *Where a dangerous substance is or is liable to be present at the workplace, the employer shall make a suitable and sufficient assessment of the risks to his employees which arise from that substance.*

(2) *The risk assessment shall include consideration of -*

- (a) *the hazardous properties of the substance;*
- (b) *information on safety provided by the supplier, including information contained in any relevant safety data sheet;*
- (c) *the circumstances of the work including -*
 - (i) *the work processes and substances used and their possible interactions;*
 - (ii) *the amount of the substance involved;*
 - (iii) *where the work will involve more than one dangerous substance, the risk presented by such substances in combination; and*
 - (iv) *the arrangements for the safe handling, storage and transport of dangerous substances and of waste containing dangerous substances;*
- (d) *activities, such as maintenance, where there is the potential for a high level of risk;*
- (e) *the effect of measures which have been or will be taken pursuant to these Regulations;*
- (f) *the likelihood that an explosive atmosphere will occur and its persistence;*
- (g) *the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective;*
- (h) *the scale of the anticipated effects of a fire or an explosion;*
- (i) *any places which are or can be connected via openings to places in which explosive atmospheres may occur; and*
- (j) *such additional safety information as the employer may need in order to complete the risk assessment.*

5

ACOP

Release of dangerous substances

7 As part of the risk assessment required by regulation 5, employers must consider risks caused by the release of dangerous substances into the working environment.

8 When considering risks from releases of dangerous substances employers should include:

- (a) unavoidable releases, such as LPG cylinder/aerosol filling;**
- (b) intentional releases, such as spray coating; and**
- (c) foreseeable releases, for example leaks from process equipment or storage containers or spills during dispensing.**

ACOP

Ignition sources

9 Employers must:

- (a) identify all possible ignition sources in areas where dangerous substances are present;
- (b) assess where ignition sources have the potential to cause a fire, explosion or chemical decomposition which could adversely affect people's safety; and
- (c) introduce measures to prevent those ignition sources occurring where they could cause harm to people and ensure they do not come into contact with dangerous substances or explosive atmospheres.

10 As part of the assessment employers must assess and identify areas in which ignition sources need to be controlled. Regulation 6(3) recognises that certain ignition sources are necessary, ie where they are appropriate to the nature of the work activity because they are part of the work process. Employers must ensure that the risks from both intentional and unintentional ignition sources are assessed and controlled.

11 Employers should identify where explosive atmospheres may form using the technique of hazardous area classification.

Guidance

12 Hazardous areas, which are also referred to as hazardous places, are classified into zones depending on the frequency and duration of an explosive atmosphere.

13 Guidance on classifying areas into hazardous zones where flammable liquids and gases are present is detailed in *Electrical apparatus for explosive gas atmospheres Part 10: Classification of hazardous areas*.⁸ Guidance on classifying areas where flammable dusts are present is detailed in *Classification of areas where combustible dusts are or may be present*⁹ and *Electrical apparatus for use in the presence of combustible dusts Part 3: Classification of areas where combustible dusts are or may be present*.¹⁰

14 Typical hazardous area classifications for a number of different circumstances are given in HSE and industry publications on flammable substances. Further information on hazardous places and hazardous area classification is given under Schedule 2 of DSEAR.¹

ACOP

15 Employers should assess the direct effect of heat on dangerous substances.

Guidance

16 On heating, some dangerous substances could create a hazard as a result of auto-ignition, self-decomposition or an exothermic reaction. Employers should consider the effect of heat from sources such as steam pipes, heaters, flames, processing etc. Employers should also consider how the ignition of combustible materials, including packaging or rubbish, could occur and the possible escalation to involve any dangerous substances.

17 In considering whether controls on ignition sources are required or not, employers may take into account other control measures or the likely size of a fire. Where there is little or no risk of injury to people, controls on ignition sources may not be reasonably practicable. In these cases the basis of safety should be detailed in the risk assessment for the activity.

ACOP

Identifying ignition sources

18 Employers must consider all possible ignition sources that could arise in areas where the ignition of a dangerous substance will cause a risk. Examples of potential ignition sources include:

(a) heat energy, eg:

- heating installations,
- internal combustion engines,
- open fire and flame,
- hot surfaces,
- smoking,
- hot work, including welding spatter,
- laser or other intense radiation sources;

(b) electrical energy, eg:

- electrical lighting devices such as lamps,
- electromagnetic radiation,
- short circuit,
- electrical arc,
- earth fault,
- conductor fault,
- lightning strike,
- discharges of static electricity,
- loose contact,
- excessive temperature rise due to overload,
- induction heating,
- resistive heating,
- connection to inappropriate electrical supply;

(c) mechanical energy, eg:

- friction (eg overheating),
- ultrasonic,
- impact,
- grinding,
- compression (including adiabatic compression and shock waves);

(d) chemical energy, eg:

- self-heating,
- impact and heat sensitive materials such as pyrophoric substances and thermite reaction sparks,
- runaway exothermic reaction.

Guidance

19 When identifying potential ignition sources, employers will need to take into account the properties of the dangerous substance with respect to the manner and state that it is being kept and handled, or might be reasonably expected to arise during processes.

Further information

20 Relevant fire and explosion properties will normally be included on the safety data sheets supplied with the substance. Many dusts are not classified substances under the Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 (CHIP),¹¹ and for these materials there is no legal requirement to provide a safety data sheet. Suppliers should nevertheless be asked if they can supply any data relevant to assessing the fire and explosion risks. Where they are not known, for example with process intermediates and mixtures or where substances are used under non-standard conditions, additional testing may be required.

Guidance

21 More information on how potential ignition sources may occur or develop in explosive atmospheres is contained in *Explosive atmospheres - Explosion prevention and protection Part 1. Basic concepts*¹² and the *Storage of flammable liquids in containers*,¹³ which gives a method for determining the adequacy of natural ventilation.

22 Guidance on electrical equipment for use in explosive atmospheres is contained in *Electrical apparatus for explosive gas atmospheres - Electrical installations in hazardous areas*.¹⁴

23 Advice on electrostatic discharges is contained in a technical report entitled *Electrostatics. Code of Practice for the avoidance of hazards due to static electricity*.¹⁵

24 Guidance on preventing ignition from non-electrical equipment is contained in *Non-electrical equipment for potentially explosive atmospheres*.¹⁶

25 Additional guidance on hazardous area classification and controlling ignition sources is contained in the following publications:

- *Model code of safe practice - Part 15 Area classification*;¹⁷
- *Control of undesirable static electricity*;¹⁸
- *Safe use and handling of flammable liquids*;¹⁹
- *The storage of flammable liquids in tanks*;²⁰
- *Institution of Gas Engineers - Hazardous area classification*.²¹

ACOP

Separation

26 The risk assessment should identify the risks arising from the dangerous substance and in particular, determine adequate separation that, so far as is reasonably practicable, will ensure:

- (a) dangerous substances are not threatened by the thermal radiation effects from fires in the locality;**
- (b) there is sufficient distance from potential ignition sources so that any escaping gas or vapour from the dangerous substance will have dispersed sufficiently to be rendered non-flammable before reaching these;**
- (c) a fire involving the dangerous substance does not prevent, nor hinder the escape of individuals from the effects of the fire;**
- (d) safe access is provided to the emergency services for fire-fighting and rescue; and,**
- (e) that the minimum number of people possible are exposed to any potential explosion.**

Guidance

27 In determining what is adequate separation employers should take into account all relevant factors when assessing the installation, including:

- (a) the properties of the dangerous substance;
- (b) information provided by the supplier;
- (c) the quantities being stored or used;
- (d) the method of storage, eg in bulk tanks or in containers;
- (e) the type of activities and operations using dangerous substances;
- (f) the location of the facility storing or handling the dangerous substance in relation to other features including: the site boundaries, occupied buildings, heat sources, fixed sources of ignition, other dangerous substances and vehicle thoroughfares;
- (g) the design standards for the installation;

Guidance

- (h) activities on adjacent premises;
- (i) foreseeable incidents and emergencies;
- (j) structures or natural features that could hinder ventilation, or adversely prolong the time, or extend the distance, that any escape of a dangerous substance remains flammable;
- (k) security; and
- (l) the scale of the anticipated effects.

Elimination or reduction of risks from dangerous substances

Regulation 6

Regulation

(1) Every employer shall ensure that risk is either eliminated or reduced so far as is reasonably practicable.

(2) In complying with his duty under paragraph (1), substitution shall by preference be undertaken, whereby the employer shall avoid, so far as is reasonably practicable, the presence or use of a dangerous substance at the workplace by replacing it with a substance or process which either eliminates or reduces the risk.

(3) Where it is not reasonably practicable to eliminate risk pursuant to paragraphs (1) and (2), the employer shall, so far as is reasonably practicable, apply measures, consistent with the risk assessment and appropriate to the nature of the activity or operation -

- (a) to control risks, including the measures specified in paragraph (4); and
- (b) to mitigate the detrimental effects of a fire or explosion or the other harmful physical effects arising from dangerous substances, including the measures specified in paragraph (5).

(4) The following measures are, in order of priority, those specified for the purposes of paragraph (3)(a) -

- (a) the reduction of the quantity of dangerous substances to a minimum;
- (b) the avoidance or minimising of the release of a dangerous substance;
- (c) the control of the release of a dangerous substance at source;
- (d) the prevention of the formation of an explosive atmosphere, including the application of appropriate ventilation;
- (e) ensuring that any release of a dangerous substance which may give rise to risk is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe, as appropriate;
- (f) the avoidance of -
 - (i) ignition sources including electrostatic discharges; and
 - (ii) adverse conditions which could cause dangerous substances to give rise to harmful physical effects; and

(g) the segregation of incompatible dangerous substances.

6

Regulation

6

(5) *The following measures are those specified for the purposes of paragraph (3)(b) -*

- (a) the reduction to a minimum of the number of employees exposed;*
- (b) the avoidance of the propagation of fires or explosions;*
- (c) the provision of explosion pressure relief arrangements;*
- (d) the provision of explosion suppression equipment;*
- (e) the provision of plant which is constructed so as to withstand the pressure likely to be produced by an explosion; and*
- (f) the provision of suitable personal protective equipment.*

(6) *The employer shall arrange for the safe handling, storage and transport of dangerous substances and waste containing dangerous substances.*

(7) *The employer shall ensure that any conditions necessary pursuant to these Regulations for ensuring the elimination or reduction of risk are maintained.*

(8) *The employer shall, so far as is reasonably practicable, take the general safety measures specified in Schedule 1, subject to those measures being consistent with the risk assessment and appropriate to the nature of the activity or operation.*

General safety measures

Schedule 1

Schedule

1. *The following measures are those specified for the purposes of regulation 6(8).*

Workplace and work processes

2. *Ensuring that the workplace is designed, constructed and maintained so as to reduce risk.*

3. *Designing, constructing, assembling, installing, providing and using suitable work processes so as to reduce risk.*

4. *Maintaining work processes in an efficient state, in efficient working order and in good repair.*

5. *Ensuring that equipment and protective systems meet the following requirements -*

- (a) where power failure can give rise to the spread of additional risk, equipment and protective systems must be able to be maintained in a safe state of operation independently of the rest of the plant in the event of power failure;*
- (b) means for manual override must be possible, operated by employees competent to do so, for shutting down equipment and protective systems incorporated within automatic processes which deviate from the intended operating conditions, provided that the provision or use of such means does not compromise safety;*

Schedule

- (c) on operation of emergency shutdown, accumulated energy must be dissipated as quickly and as safely as possible or isolated so that it no longer constitutes a hazard; and
- (d) necessary measures must be taken to prevent confusion between connecting devices.

Organisational measures

- 6. The application of appropriate systems of work including -
 - (a) the issuing of written instructions for the carrying out of the work; and
 - (b) a system of permits to work with such permits being issued by a person with responsibility for this function prior to the commencement of the work concerned,

where the work is carried out in hazardous places or involves hazardous activities.

ACOP

Ventilation

28 Wherever reasonably practicable, employers should control the source of release of dangerous substances by adequate containment.

Guidance

29 To control releases, the storage, transfer and use of dangerous substances should be carried out in closed systems wherever reasonably practicable. Work activities and locations where releases are unavoidable should be minimised.

ACOP

30 Where the release of dangerous substances is intentional or unavoidable, the process or operation should be carried out, where reasonably practicable within a ventilated cabinet or enclosure that prevents the escape of those substances into general work areas.

31 Employers should provide adequate ventilation to ensure that releases of dangerous substances do not accumulate to a concentration that affects the safety of employees, but are safely dispersed.

Guidance

32 Ventilation may also be required in certain circumstances for cooling to prevent the initiation of self-heating reactions.

ACOP

33 Adequate ventilation should maintain the average concentration of dangerous substances during normal operation to below that which could form an explosive atmosphere.

Guidance

34 In workrooms and work areas that are occupied, the average concentration of dangerous substances in the atmosphere should be maintained at or below the level of any relevant occupational exposure limit required by the Control of Substances Hazardous to Health Regulations 2002 (COSHH).²² These levels are significantly lower than the lower explosion limit (LEL) for most substances. For some specific activities higher concentrations in localised areas and for limited periods are acceptable in work areas, but these will require additional control measures and systems of work to ensure that:

- (a) sufficient safety margins and operational procedures exist to prevent the concentration of dangerous substances reaching the LEL;
- (b) the health of employees is protected; and,
- (c) no ignition sources are introduced into the area.

Guidance

35 During these activities the average concentration of dangerous substances should normally be maintained at or below 10% of the LEL, but occasional temporary increases up to 25% of the LEL may be permissible, eg during paint spraying or tank cleaning operations.

36 In cabinets and enclosures which are not occupied, the average concentration of dangerous substances should normally be maintained below 25% of the LEL. This may be increased to 50% of the LEL where additional safety measures are provided and the assessment shows that the fire and explosion risks are adequately controlled.

37 Adequate ventilation can be achieved using natural ventilation, mechanical ventilation or dilution ventilation. Mechanical ventilation includes systems often referred to as mechanical extract ventilation (MEV) and forced ventilation. Mechanical ventilation and dilution ventilation use fans (or other powered means) to draw air from, or blow air into, plant, process areas or work areas to dilute the released dangerous substances.

38 The discharge of a dangerous substance from a ventilation system into the general atmosphere may have an environmental impact, and processes may have to be employed to remove the dangerous substance from the extracted air. Advice on such matters should be sought from the local Environment Agency (EA) or local authority (LA) in England and Wales, or the Scottish Environmental Protection Agency (SEPA) in Scotland.

39 Natural and mechanical ventilation may not prevent explosive atmospheres forming under all circumstances and additional control measures may be necessary, including explosion protected equipment. Dilution ventilation is a system based on limiting any foreseeable accumulations of flammable mixtures so that if they are ignited by an unavoidable ignition source, they do not directly or indirectly create a hazard to people, eg from the collapse or failure of any enclosure.

Natural ventilation

40 Where reasonably practicable, process and storage areas should be located in the open air, with sufficient distances from nearby structures to allow the unimpeded flow of air. Such areas may be suitably weather protected, eg by the provision of a canopy, which is designed to prevent the accumulation of dangerous substances. Where there is limited space available, fire walls may be required. These should be located, ideally, on one side only, but never on adjacent sides of such areas.

41 Ideally buildings used for processing and storing dangerous substances should stand alone and be designed solely for that purpose. The buildings should be located and the ventilation designed to avoid the ingress of any dangerous substances that might be released from other process and storage areas.

ACOP

42 Buildings used for storing or processing dangerous substances should be provided with an adequate number of appropriately sized and located ventilation openings to prevent the accumulation of such substances to a concentration that effects the safety of employees.

43 Where reasonably practicable, ventilation openings should be positioned on all external walls and should be located at high and low levels to provide the required air changes.

Guidance

44 Roof ventilation openings may serve as high level ventilation, particularly for large buildings where there are large distances between outside walls. In such circumstances, low level ventilation may have to be ducted to central areas and be provided mechanically (forced ventilation). Where necessary, the adequacy of natural ventilation should be proven by flow measurements throughout the compartment.

45 Where process or storage areas are located in compartments of buildings, the compartment should have a minimum of two outside walls, ideally opposite each other, both with an adequate number of appropriately positioned ventilation openings. Where there is only one outside wall available for ventilation openings, mechanical extract ventilation should be provided. Alternatively, the whole wall could be replaced by an open mesh security fence with access door. This would also serve as an explosion relief for the compartment.

ACOP

Mechanical ventilation

46 MEV and forced ventilation systems should be provided at process and storage areas where natural ventilation cannot safely disperse dangerous substances. Local exhaust ventilation should be provided for processes where there is an intentional or unavoidable release of a dangerous substance to reduce the extent and/or classification of any hazardous areas. Fixed ducts, trunks and casings used for ventilation from workrooms, dryers, ovens and other enclosures which are required to be fire-resisting structures should also be fire-resisting.

47 The MEV and/or forced ventilation should be designed to have sufficient air flow to safely disperse dangerous substances. It should be located to provide the most efficient removal of such substances, having regard to their properties and the way they are used. There should be adequate provision of suitably sized and located air openings into the area to ensure the operation of the MEV.

Guidance

48 The location of the MEV duct openings will depend on the properties of the dangerous substances, but they will normally be required at a low level.

49 Where maintenance, repair, cleaning or demolition work is being carried out in enclosed or confined spaces temporary forced ventilation systems using extraction systems and flexible ducting may need to be provided to ensure that the concentration of any dangerous substances is maintained at a safe level. Temporary or flexible ducting does not need to be of fire-resisting construction.

ACOP

50 The air for forced ventilation or the replacement air for MEV should come from an uncontaminated source, free from other dangerous substances. The discharge from a mechanically ventilated area should be at a location where the dangerous substances cannot affect the safety of people.

51 Electric motors for fans should not be sited within the ducts used to extract air containing dangerous substances.

Guidance

52 Electric motors should not be positioned where deposits can build up on their surfaces and cause a fire as a result of the motor over-heating or the deposits attaining their auto-ignition temperature. This is particularly hazardous in ducts as any fire can spread from one area to another or ignite other dangerous substances that are being extracted. Electric motors should also be positioned where they can be readily inspected, cleaned and maintained.

Guidance

53 Fans may constitute an ignition source if they are not properly designed and installed. Where fans are located in ductwork or places that are considered to be hazardous areas they will need to be suitably protected.

ACOP

Monitoring

54 Whenever MEV or forced ventilation is required the systems should be monitored for continuous operation by means of a flow-measuring device. On flow failure an alarm and/or actions (eg standby systems) should be initiated, where applicable. Where the size or the configuration of a plant or storage area is such that it is possible that all locations within it may not be adequately ventilated, then the adequacy should be proven by flow measurements throughout the compartment.

Guidance

55 Where necessary, additional monitoring should be provided in the MEV exhaust to monitor for the presence of the dangerous substance. At a prescribed level, alarms and/or automatic actions should be initiated.

56 Where temporary ventilation systems are required for abnormal activities, for example during cleaning, repair or maintenance in tanks and other confined spaces, the atmosphere of the confined space should be monitored to ensure that it remains safe for those intended activities. See also the DSEAR ACOP on *Safe maintenance, repair and cleaning procedures*.⁵

Dilution ventilation

57 Where the consequences or probability of ignition are particularly high, risk assessment may indicate that it is necessary to ensure that accumulations of flammable mixtures are minimised as far as possible. In this case the higher standard of dilution ventilation should be used. This means that the ventilation should ensure that there are no stagnant or poorly ventilated spaces and that any foreseeable leak is quickly and effectively mixed with air and diluted to a safe concentration. Re-entrainment should be minimised, further reducing any accumulation of flammable mixture. This may require a large number of air inlet positions or baffles to achieve adequate overall distribution and, in extreme cases, supplementary fans or distributors.

58 The effectiveness of dilution ventilation should be verified. In some cases it may be studied with the use of smoke or tracer gas techniques. In many cases ventilation and leakage are best predicted by modelling with Computational Fluid Dynamics (CFD). Other techniques may fail to take full account of the influence of the momentum of the leak itself if the pressure is significant.

59 CFD results should be subject to sensitivity analysis and validation by velocity and temperature measurements. The technique has the advantage that ventilation modifications, if shown to be necessary, can be modelled without actual plant change, or even before the plant is built. It should be noted that how ventilation air is distributed may be more important than quantity, and that high ventilation rates may prevent small leaks being detected.

Guidance

Further information

60 Additional information on using ventilation to eliminate or control risks can be found in the following publications:

*Control of safety risks at gas turbines used for power generation;*²³
*An introduction to local exhaust ventilation;*²⁴
*Bulk LPG storage at fixed installations;*²⁵
*Storage of full and empty LPG cylinders and cartridges;*²⁶
*Safe filling of LPG cylinders at depots;*²⁷
*Institute of Petroleum model code of safe practice - Part 16 Tank cleaning code;*²⁸
*The spraying of flammable liquids;*²⁹
*The storage of flammable liquids in containers;*¹³
*The safe use and handling of flammable liquids;*¹⁹
*The storage of flammable liquids in tanks;*²⁰
*General ventilation in the workplace.*³⁰

ACOP

Control of ignition

61 Before establishing controls on ignition sources employers should ensure that processing and handling procedures have been designed to minimise the release of dangerous substances to reduce the extent of any hazardous area.

Guidance

62 Employers should normally ensure that hazardous areas do not extend beyond site boundaries. However where the hazardous area arises only on a temporary basis it may be acceptable for the hazardous area to extend beyond the site boundary providing a risk assessment has identified adequate measures to control ignition sources. For example, some smaller sites may not be provided with a dedicated unloading bay and will require temporary barriers or bollards to prevent ignition sources from being brought into the hazardous areas from off-site during tanker unloading.

ACOP

63 In areas where the ignition of dangerous substances could affect the safety of people, measures must be introduced to avoid ignition sources occurring or being brought into those areas. The measures will include:

- (a) selecting and installing appropriate electrical and non-electrical equipment that has been designed to be safe in hazardous areas. All equipment supplied after 30 June 2003 for places where an explosive atmosphere may occur should meet the essential safety requirements appropriate to the equipment category as detailed in the Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations 1996 (EPS), as amended;³¹
- (b) implementing inspection, testing, cleaning and maintenance regimes for equipment to minimise ignition sources occurring as a result of overheating or fault conditions;
- (c) ensuring that any portable or mobile equipment brought into hazardous areas (see regulation 7) is either suitably protected or is only brought into those areas under safe conditions ensured by implementation of a permit-to-work scheme (see regulation 6 and Schedule 1 of DSEAR and *Safe maintenance, repair and cleaning procedures*);
- (d) prohibiting smoking and other open flames;
- (e) implementing controls and procedures to prevent the occurrence of hazardous electrostatic discharges;

ACOP

- (f) ensuring heating equipment installed in areas where dangerous substances are stored or used cannot act as an ignition source. Employers should also ensure that heating equipment or storage conditions cannot cause dangerous substances to attain their auto-ignition temperature or, where relevant, their self-accelerating decomposition temperature (SADT) for packaged materials, or the onset temperature at which thermal decomposition occurs within bulked materials;
- (g) preventing the accumulation of waste materials or deposits that are liable to spontaneously combust or are readily ignited. Such materials should be placed in a closed metal bin or removed to a safe place. Deposits should be removed in such a way that their removal does not create a risk of ignition;
- (h) avoiding incompatible materials that could either react together to produce heat or flames or give rise to incendive sparks following frictional contact during impact, machining, grinding or polishing. In assessing where incompatible materials could occur the employer should consider the dangerous substances being processed and the materials of construction of plant, equipment, process areas and tools.

Separation

64 Employers should ensure that there is adequate separation between dangerous substances and other features that pose a threat, or could be threatened by an incident involving the dangerous substances.

Guidance

65 Adequate separation may be achieved solely by the actual distance between the dangerous substance and the feature that is to be protected, or protected against. Where the necessary distance required for this is not available, adequate separation may also be achieved by the provision of a physical barrier of fire-resisting construction. The design and performance requirements for this depend on its particular function. These are discussed below.

66 For the majority of dangerous substances, advice on adequate separation is detailed in HSE or industry Codes of Practice and guidance. These may be specific to the dangerous substance (eg LPG, nitrocellulose), or be of a generic nature (eg flammable liquids).

67 Where such advice is not available, or inappropriate due to the quantity of dangerous substance stored, or manner of its use, the necessary separation distances to achieve safety will need to be determined from first principles and by taking into account any additional fire mitigation measures such as water deluge systems or monitors.

Physical barriers of fire resisting construction - design and performance requirements

68 The overall objective for physical barriers of fire-resisting construction is that they should be capable of maintaining adequate fire protection to allow sufficient time for evacuation and for emergency procedures to be implemented.

69 The fire safety performance of these barriers is specified in terms of:

- (a) resistance to fire; and
- (b) reaction to fire.

Definitions and technical specifications for these terms are given in Appendix A and B.

Guidance

70 Structures required to serve as a physical barrier of fire-resisting construction where the dangerous substance is either extremely or highly flammable, or where a substance is stored or used at a temperature above or near to its flashpoint should meet the relevant fire safety performance requirements detailed in paragraphs 75 to 105 below.

71 These fire safety performance standards are also considered to be good practice where the dangerous substance is flammable.

72 Compliance with the fire resistance and reaction to fire test standards referred to above may be demonstrated by testing, or by building the structure using materials and construction methods that are recognised to be capable of providing the required fire safety performance.

73 The following paragraphs give guidance on the performance requirements for fire walls, storerooms, workrooms, cabinets, ovens, cupboards, bins, ducts, trunks and casings where dangerous substances are stored or used. Further discussion of where such items need to be fire-resisting structures is given in *Design of plant, equipment and workplaces*³ and *Storage of dangerous substances*.⁴

Fire walls

74 Fire walls are a physical barrier of fire-resisting construction erected either as part of a building or as a free-standing structure in the open air.

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75 Fire walls should be imperforate. They should provide a minimum of 30 minutes fire resistance in respect of integrity, insulation and, where applicable, load bearing capacity.

76 Where the wall separates vulnerable populations from the dangerous substance, the fire resistance provided should be a minimum of 60 minutes. Vulnerable populations include those in schools, hospitals, old people's homes and other residential accommodation.

77 The materials used in the construction of the wall should have a 'minimal risk' in respect of their reaction to fire (see Appendix B).

78 A free-standing fire wall should be at least the height of the stored dangerous substance but with a minimum height of 2 m.

Fire resisting storerooms

79 Every enclosing element, ie every wall (including any door), floor (other than a floor immediately above the ground), ceiling and its associated floor (other than the top or ceiling of a single storey building or of a top floor room) that acts as a physical barrier of fire resisting construction should provide a minimum of 30 minutes fire resistance in respect of integrity, insulation and where applicable, load bearing capacity.

80 Where the storeroom is within a building that also contains residential accommodation, the partition between the two should provide a minimum of 60 minutes fire resistance, with no connecting doors or direct access between the two premises.

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81 No glazed area should be installed in any physical barrier of fire-resisting construction. However, in the case of a door a glazed viewing panel may be installed provided it does not exceed an area of 20% of the door. Any glazing should still satisfy the integrity requirements. This can be achieved by using Georgian wired glass or a proprietary fire-resisting glazing panel.

82 Any door in a physical barrier of fire resisting construction should be self-closing from any position.

83 With the exception of storerooms for keeping cylinders containing LPG, the materials used in the construction of the storeroom (other than doors and windows together with their associated frames, and any provision made for explosion relief) should as a minimum, have a 'low risk' in respect of their reaction to fire (see Appendix B).

84 Where storerooms are used to keep cylinders containing LPG, the materials used in the construction of the storeroom (other than doors and windows together with their associated frames, and any provision made for explosion relief) should have a 'minimal risk' in respect of their reaction to fire (see Appendix B).

Fire resisting workrooms

85 Every internal enclosing element, ie every internal wall (including any door or window), floor (other than a floor immediately above the ground), ceiling and its associated floor (other than the top or ceiling of a single storey building or of a top floor room) that acts as a physical barrier of fire-resisting construction should provide a minimum of 30 minutes fire resistance in respect of integrity, insulation and, where applicable, load bearing capacity. Openings may be made in the internal partitions, provided they meet the requirements for ducts, trunks and casings below. In all other cases, a fire/smoke damper should be installed that, together with its frame, can provide a minimum of 30 minutes fire resistance in respect of integrity.

86 Where the workroom is within a building that also contains residential accommodation, the partition between the two should provide a minimum of 60 minutes fire resistance, with no connecting doors; direct access between the two premises; or any ducts, etc (whether common or not) that pass between the two premises.

87 In the case of a door, a glazed viewing panel may be installed provided that it does not exceed an area of 20% of the door. Any glazing should still satisfy the integrity requirements. This can be achieved by using Georgian wired glass or a proprietary fire-resisting glazing panel.

88 Any door in a physical barrier of fire resisting construction should be self-closing from any position.

89 The materials used in the construction of the workroom (other than doors and windows together with their associated frames, and any provision made for explosion relief) should as a minimum, have a 'low risk' in respect of their reaction to fire (see Appendix B).

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Fire resisting cabinets or other enclosures

90 Where cabinets or enclosures (other than an oven used solely for the evaporation of dangerous substances from materials contained therein) are provided, every side, top, floor and door should provide a minimum of 30 minutes fire resistance in respect of integrity. This requirement may be waived in respect of:

- (a) the glazed panel of any fume cabinet or glove box;
- (b) any booths where a screen is provided for environmental or quality control purposes; or
- (c) where provision is made for the explosion relief.

91 Where ovens are used for the evaporation of dangerous substances from materials contained within the oven, every side, top, floor and door should provide a minimum of 30 minutes fire resistance in respect of integrity, except where explosion relief provisions are made. Glazing still has to satisfy the integrity requirements. This can be achieved by using Georgian wired glass or a proprietary fire-resisting glazing panel.

92 The materials used in the construction of cabinets, other enclosures and ovens should, so far as is reasonably practicable, have a 'minimal risk' in respect of their reaction to fire (see Appendix B).

93 Cabinets and enclosures should be supported and fastened to prevent collapse of the structure in case of fire for at least 30 minutes. The supports and fastenings should be of high melting point material (in excess of 750°C).

Fire resisting cupboards and bins

94 Every side, top, floor, door and lid should provide a minimum of 30 minutes fire resistance in respect of integrity, except where provision is made for explosion relief and/or ventilation.

95 The construction materials used should, so far as is reasonably practicable, have a 'minimal risk' in respect of their reaction to fire (see Appendix B).

96 Cupboards and bins should be supported and fastened to prevent collapse of the structure in case of fire for at least 30 minutes. The supports and fastenings should be of high melting point material (in excess of 750°C).

Fire resisting ducts, trunks and casings

97 These should provide a minimum of 30 minutes fire resistance in respect of integrity and be constructed from materials that have, so far as is reasonably practicable, a 'minimal risk' in respect of their reaction to fire, except where provision is made for explosion relief (see Appendix B).

98 Ducts, trunks, and casings should be supported and fastened to prevent collapse of the structure in case of fire for at least 30 minutes. The supports and fastenings should be of high melting point material (in excess of 750°C).

ACOP

Additional requirements for physical barriers of fire-resisting construction

99 Fire walls, storerooms, workrooms, cabinets, ovens, cupboards, bins, ducts, trunks and casings need to be sufficiently robust so that their integrity will not be impaired by any reasonably foreseeable damaging event.

Guidance

100 Foreseeable damaging events will include wear and tear from normal operational activities such as collision damage from vehicles or fork lift trucks. It may also include blast overpressure when the risk assessment identifies an explosion as a likely event following a significant release of dangerous substances.

ACOP

101 Where fire walls and fire-resisting structures provide containment for leaks of the dangerous substance and/or prevent any escaping vapours from reaching an ignition source while still flammable, such barriers should be imperforate and without openings. They should also be constructed to withstand contact with the dangerous substance in the form and quantity that might foreseeably occur in the event of an incident.

102 When any surface of the structure, except for fire walls, is liable to be coated with residues, the structure should be sufficiently durable so that its capacity to resist spread of flame and its fire resistance will not be impaired by the removal of such residues.

103 For storerooms and workrooms, the junction between each part of the physical barrier should be sufficiently bonded or fire-stopped to ensure that the fire resistance of the structure is not compromised.

104 Cabinets, ovens, cupboards, bins, ducts, trunks and casing should be bonded or fire-stopped to prevent or retard the passage of flame and hot gases for a period of at least 30 minutes.

105 The reaction to fire of the external surface of a storeroom, workroom or fire wall should be to the standard required under the relevant building legislation or that appropriate to the activity being carried out on that side of the barrier, whichever is the higher standard.

Appendix A

Fire resistance

1 The fire resistance of a physical barrier of fire resisting construction is a measure of its ability to withstand the effects of fire in one or more of the following ways:

- *Integrity*: resistance to fire penetration, ie the prevention of the passage of flame and smoke;
- *Insulation*: resistance to the transfer of excessive heat; and
- *Load-bearing capacity*: resistance to collapse, ie to maintain support of the design load of other parts of the building, plant or structure, where the barrier also provides this.

2 The level of fire resistance is specified as the duration that the barrier is able to withstand the effects of fire in respect of one or more of these properties. This is determined through standard test procedures, where the periods of fire resistance are conventionally reported as: short (or 30 minutes); medium (or 60 minutes); or, long (or 120 minutes).

3 The standard test procedures are those described in the following standards:

BS 476: Part 20³² in conjunction with:

- for load bearing elements of construction, BS 476: Part 21;³³
- for non-load bearing elements of construction, BS 476: Part 22;³⁴
- for components, BS 476: Part 23;³⁵ and
- for ventilation ducts, BS 476: Part 24.³⁶

BS 476: Part 8 where this was current at the time of construction of the 'barrier';³⁷

BS EN 1363³⁸ in conjunction with:

- for non-load bearing elements of construction, the relevant parts of BS EN 1364;³⁹
- for load bearing elements of construction, the relevant parts of BS EN 1365;⁴⁰
- for service installations, the relevant parts of BS EN 1366;⁴¹ and
- for door and shutter assemblies, the relevant parts of BS EN 1634.⁴²

Appendix B Fire reaction

1 The reaction to fire of a physical barrier of fire-resisting construction is a measure of the contribution the materials used in its construction have on the development and spread of the fire. This contribution is categorised as minimal, low, medium, high, and very high risk. The categories are determined in accordance with standard test procedures, though some materials are deemed to be of minimal risk and do not require to be tested. These are:

- concrete;
- fired clay (ie bricks);
- ceramics;
- steel;
- plaster and masonry containing not more than 1 per cent by weight or volume of organic material; and
- concrete bricks or blocks.

2 The categories of materials that may be used in the construction of a physical barrier of fire-resisting construction is limited to: minimal, low, or medium. The minimum category that may be used depends on the type of barrier, this is discussed in paragraphs 68 to 105 of this document.

3 The test procedures and performance required by either the British Standards or the comparable European Harmonised Standards for the three categories are as follows:

	British Standards	European Harmonised Standards
Minimal	The material is certified non-combustible according to the test specified in BS 476: Part 4 ⁴³ throughout, or the material does not flame or cause any rise in temperature on either the centre (specimen) or furnace thermocouples according to the test specified in BS 476: Part 11. ⁴⁴	The material has achieved a classification of A1 when tested in accordance with BS EN ISO 1182 ⁴⁵ and BS EN ISO 1716; ⁴⁶ or the material has achieved a classification of A2 when tested in accordance with BS EN 13823 ⁴⁷ and BS EN ISO 1182 ⁴⁵ or BS EN ISO 1716. ⁴⁶
Low	The surface of the material (or where it is bonded throughout to a substrate, the surface material combined with the substrate) has a surface spread of flame of Class 1 when tested in accordance with BS 476: Part 7; ⁴⁸ and, when tested in accordance with BS 476: Part 6 ⁴⁹ has an index of performance (I) not exceeding 12 and a sub-index (i,) not exceeding 6.	The material has achieved a classification of B or better when tested in accordance with BS EN 13823 ⁴⁷ and BS EN ISO 11925-1. ⁵⁰
Medium	The material has a surface spread of flame of Class 1 when tested in accordance with BS 476: Part 7. ⁴⁸	The material has achieved a classification of C or better when tested in accordance with BS EN 13823 ⁴⁷ and BS EN ISO 11925-1. ⁵⁰

References and further reading

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