

# Paper mills

## Guidance on fire risk

Paper and Board Industry Advisory Committee



This is a revision of guidance originally published in 1995. It has been prepared, in consultation with HSE, by the Paper and Board Industry Advisory Committee, which was appointed by the Health and Safety Commission as part of its formal advisory structures. The guidance represents what is considered to be good practice by the members of the Committee. It was agreed by the Commission. Following this guidance is not compulsory and you are free to take other action. But if you do follow this guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

## **The Regulatory Reform (Fire Safety Order) 2005**

During the life of this document, the Regulatory Reform (Fire Safety) Order 2005 will come into force. This will repeal the Fire Precautions Act 1971 and other related legislation under which fire certificates are currently issued. It will also repeal the fire certificates themselves.

At this point, general fire precautions then become the responsibility of the duty holder, who has to provide a risk assessment. This determines the general fire precautions needed and fire brigades will continue to enforce general fire precautions under the new legislation.

This does not affect the advice given in the following pages except that the reader should bear in mind that the requirement for a paper mill to have a fire certificate prepared by the Fire Authority (mentioned in paragraphs 23, 55, 108, 112, 126 and 134) will be replaced by a specific requirement for the company to perform a risk assessment for fire safety.

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# Introduction

1 In the paper and board industry, management of risk arising from fire hazards is a critical part of any manager's job. This guidance is aimed at managers who have responsibility for fire safety. It will also be useful to engineering management, health and safety advisers, trainers, technical staff, supervisors, safety representatives and everyone working in the industry.

2 This guidance advises on good practice directed at minimising the outbreak and spread of fire and ensuring the safety of personnel in the event of fire. References are made to some standards of protection that are higher than the minimum required by law for the protection of people. Managers have to take into account asset protection, including the requirements of their insurance companies, and the resulting fire prevention and precautionary measures will reflect this combined approach.

3 Paper and board are combustible. While solid blocks of paper may not be easily ignited, once they have caught fire flames can spread rapidly and be difficult to extinguish. Loose paper, shrink-wrap material and flammable liquids or gases can ignite easily and spread the fire to other materials. High-temperature steam pipes can, if not properly insulated, be a cause of fire in insulation or other combustible material.

4 Every year, the fire service is called to a number of fires in the paper and board industry. In some incidents people have been injured, and there is always the potential for multiple fatalities. In many others, there has been extensive damage to buildings, equipment and materials; as well as the immediate material damage there are inevitably consequential losses, such as plant, customers, possibly jobs, and dispersal of skilled staff. For summaries of some fires in the industry see Appendix 1. Although malicious acts have had a lot of publicity and caused extensive damage, a past survey has shown that these only caused 7% of fires reported to local authority fire brigades. Machine faults and poor housekeeping were the cause of over 60% of fires.

5 In some firms, small fires occasionally occur without any significant damage or downtime. There is sometimes a tendency for these to be regarded as a normal part of the process but these small fires can spread. The incidence of such fires should be included in the assessment of fire hazard (see paragraph 23).

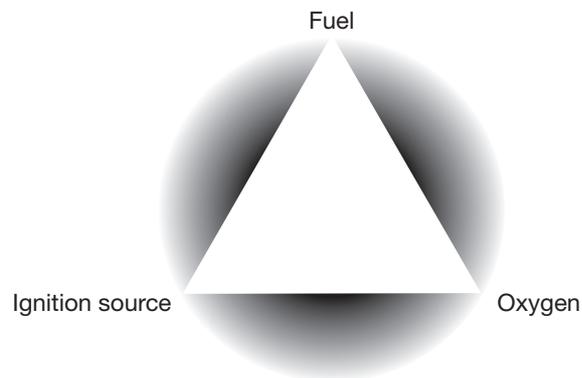
6 The risk of a fire breaking out in a particular place and spreading rapidly will depend largely upon the materials being used and stored, the general standards of housekeeping, the construction and layout of the factory and the training of employees. The risk to people after a fire has started will largely depend on the adequacy and maintenance of means of escape and of the alarm system and the training of the workforce in fire routine and evacuation procedures. Adequate controls should ensure that:

- the risk of fire occurring is reduced to the absolute minimum;
- the risk of fire spreading is minimised; and
- everyone is able, by their own unaided efforts, to reach a place of safety beyond the building (see paragraph 21 for the needs of people with disabilities).

7 Consult with your insurers about fire precautions, especially before any changes in the building or process activity, which could affect the spread of fire.

## CAUSES OF FIRES

8 For fires to start and spread, there needs to be fuel, oxygen and a source of ignition (see Figure 1).



**Figure 1:** The fire triangle

9 In paper mills, there is always paper and paper dust. Both of these are readily ignitable fuels. There may also be other flammable solids (eg shrink-wrap plastic), flammable liquids (eg oil, solvents etc) and flammable gases (eg liquefied petroleum gas in cylinders or hydrogen sulphide generated by the process).

10 Oxygen is always available from the air.

11 Sources of ignition cannot be completely eliminated. They are likely to include:

- frictional heating (eg hot bearings);
- sparks (eg from hand tools);
- static discharges;
- naked flames (eg on welding equipment or gas-fired plant);
- electrical sources (eg overloaded conductors);
- hot surfaces (eg steam pipes or infra-red dryers);
- cigarettes and/or matches.

12 Both the fuel and ignition sources should be controlled to minimise the risk of fire. Typically, problems arise from the following situations:

- poorly maintained equipment;
- welding and/or cutting of plant;
- faulty or misused electrical equipment;
- poor storage of packaging materials;
- poor storage or handling of flammable liquids and/or gases;
- inadequate site security;
- smoking and smoking materials.

13 Once started, fires can spread rapidly. The following will contribute to rapid fire spread:

- poor housekeeping and accumulation of waste material;
- unsegregated storage of materials increasing fire hazard;
- excessive stocks of paper in production areas;
- unbanded, end-stacked reels of paper;
- lack of fire separation between floors or rooms;

- fire doors wedged or propped open;
- combustibility and fire spread characteristics of wall and ceiling linings;
- poorly maintained fire-fighting equipment;
- inadequate/inappropriate fire detection and extinguishing equipment;
- inadequate provision of fire venting.

14 The actions of workers are critical to the spread of fire. If the wrong extinguishers are used or staff fail to follow appropriate instructions then the situation will be considerably worse than it need be. Where there is a mill fire team, there should be a clear policy as to when the local authority fire brigade is called in.

## FIRE RISK MANAGEMENT

15 Employers need to organise for fire safety. The appointment of a senior manager to be responsible for fire risk management and staff training is the first step towards an effective action plan. As well as the formal steps set out in paragraphs 16-21, successful fire risk management entails:

- constant and careful thought;
- an awareness of all the potential risks associated with the premises, its processes, the workforce and contractors;
- effective liaison with the fire authority (usually the local authority fire brigade);
- effective liaison with insurers.

16 Carry out an initial assessment of fire risk and the adequacy of the measures provided or needed to combat the risk. Identify the fire hazards (ie materials that burn and ignition sources, unsatisfactory structural features etc) then evaluate the fire risk (ie the likelihood that a fire will occur and the consequences of such a fire on the people present). The risk assessment should help you decide what measures must be taken to provide suitable arrangements for protecting people in the workplace from fire, and should ensure that:

- the risk of fire occurring is reduced to the absolute minimum;
- the risk of fire spreading is minimised; and
- everyone at the workplace is able, without outside assistance, to reach a place of safety.

17 It makes sense for employers to carry out the risk assessment required by regulation 5 of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) at the same time as they undertake the risk assessment mentioned in paragraph 16. The Regulations require assessment, elimination and/or control of risks arising from the presence of dangerous substances including flammable liquids such as those used in laminating processes and explosive dusts such as paper dust. Regulation 7 requires the classification and, where necessary, marking of zones where explosive atmospheres involving flammable vapours or dusts are likely to be present. Identification and classification of these zones should form part of the risk assessment. Further guidance and a comprehensive list of publications on this topic are available on the HSE website at: [www.hse.gov.uk/fireandexplosion](http://www.hse.gov.uk/fireandexplosion).

18 A range of key staff will be involved. They should consult with safety representatives in accordance with normal procedures. Your risk assessment and the arrangements for controlling fire risk will form part of the overall company health and safety policy. These arrangements should also be seen as good management practice and need to clearly allocate the responsibilities of everyone involved in fire safety.

19 Carry out a full audit to identify all the hazards and risks together with existing control measures, including information provision and training. The audit should identify hazards arising from the materials and processes used, and indicate the risk of outbreak and spread of fire. A site plan may be helpful for recording findings. The audit may be done either on a process-by-process basis (eg materials delivery, materials storage, process A, intermediate storage, process B etc), or area-by-area. There should be definite conclusions about the level of hazard and risk, and decisions about the adequacy of protection and the need for improvement.

20 Occasionally a fire will occur even in the best-run organisation. Assume that it will, and plan accordingly. Include written emergency arrangements. Where the assessment and, in particular, past experience indicates the types of fires which can be anticipated, specific plans to tackle these should be made. The emergency arrangements should specify the particular fire safety responsibilities of the most senior person present having overall control of the workplace, and specify the responsibilities of other nominated people. In the event of a fire, everybody in the workplace should be sufficiently familiar with the fire routine and fire safety arrangements to take the correct actions and evacuate the workplace safely. Planning can deal with ensuring the safety of employees and the implications for production. The arrangements could include the following:

- take each part of the process or plant in turn, assume it is out of commission and assess the potential for damage to production should a fire occur;
- consider whether the process can be done elsewhere;
- find out if alternative machinery can be obtained.

21 Particular planning is needed for people with disabilities. It is preferable for them to be able to leave the building in an emergency without help. This may need physical alterations to the premises or the provision of a suitable system whereby help would be always available when needed.

## **Assessment**

22 The detailed steps in paragraphs 23-29 will form part of your assessment.

### ***General fire precautions***

23 The main precautions are as follows:

- find out whether a fire certificate already exists; if not, ask the fire authority whether a fire certificate is required and apply for one if necessary. If a fire certificate already exists, check that it is up to date and all conditions are met;
- have any material alterations taken place? If so, inform the fire authority immediately – you could be in breach of the law;
- identify the existing means of escape and ensure they can be used safely;
- check the arrangements for giving warning in case of fire (a fire alarm is a requirement in any building requiring a fire certificate);
- identify the numbers, position and state of readiness of the portable fire extinguishers and/or hose reels;
- are fire evacuation drills being carried out and has training been given as specified in the fire certificate?
- do you have the record of training, fire equipment checks etc required by the certificate?
- do small fires occur frequently, and are they taken for granted? If so, are they investigated, what is the cause, and can they be eliminated? (It would be unusual if they could not);
- is there a need to provide information/signs in languages other than English?

### ***Process hazards/risks and control measures***

24 The main recommended control measures are:

- examine the process layout and flow of materials;
- identify materials that will burn readily. Make use of experience of previous incidents and the information that should be available from manufacturers and suppliers on their health and safety data sheets;
- identify hazardous activities, eg those involving the generation of paper dust, welding and cutting, storage of paper reels;
- review the arrangements for handling flammable liquids and controlling flammable vapours;
- identify and control sources of ignition including any transient sources from cleaning, maintenance or repair work;
- consider the amount of material, both in storage and in use, and where it is stored and used;
- identify conditions of fire spread, eg from storage to process areas and vice versa, and separate where necessary;
- consider standards of housekeeping, waste removal and improve these as necessary;
- consider the emergencies that might arise (including spills and leaks) and draw up appropriate procedures;
- consider the activities of contractors and provide adequate controls, eg by preparing and enforcing rules for contractors doing hot work;
- assess the adequacy of fences, doors etc, in keeping out children and other intruders;
- review the need for preventive maintenance, eg lubrication, electrical checks etc, so that hazards are minimised.

### ***Incident investigation***

25 It is essential that all fires or incidents giving rise to a risk of fire (eg spillage of highly flammable liquids (HFLs), overheated bearings) are thoroughly investigated and lessons learnt which are incorporated into the plan for the control of fire risk.

### ***Consider additional control measures***

26 Other control measures are:

- decide whether risks can be reduced by installing safer plant or by modifying existing plant;
- install fixed fire-fighting equipment where appropriate;
- plan what first-aid fire fighting can be done by your own staff, paying particular attention to the types of fire you have experienced and can anticipate, eg fires inside machine drier hoods;
- control smoking;
- obtain expert fire advice prior to any material alteration to the premises or the processes carried on there;
- review the role of supervision in preventing fire and dealing with emergencies.

### ***Training***

27 Adequate supervision and training is a key element of fire risk management. Employees need to be informed about:

- the process risks;
- the standards to be maintained;
- working practices to be adopted;
- fire routine and evacuation procedures.

28 Develop fire risk awareness among all employees by providing regular training in fire prevention and fire safety. During training on fire routines, inform employees about why some things are done in relation to fire precautionary measures, eg why fire doors should be kept shut, why fire alarm testing is done, etc. The best fire prevention is a well-trained and informed workforce.

29 The assessment should draw conclusions about the hazard and risk and identify any additional control measures needed. It should also specify what monitoring needs to be carried out to maintain effective control of the risks.

### **Monitoring**

30 Maintain standards by monitoring and measuring good practice and any improvements. Ensure that any shortcomings are corrected. Even though all employees should report any hazard that they notice, a system of regular formal inspection by management is necessary to monitor conditions and to identify changes that may introduce additional risks. The company safety policy should make it clear who carries out these inspections, and when. The results of the inspections should be recorded to aid assessment, and reported to senior management at defined intervals.

### **Reassessment criteria**

31 Reassessment will be necessary if there are changes in operation, plant or buildings. It may also be necessary to reassess after particular fires, after other incidents which give rise to a fire risk, or where the monitoring reveals previously unforeseen inadequacies in the control measures or greater than anticipated hazard/risk.

## **HOUSEKEEPING**

32 It is essential that mills have a culture of good housekeeping to prevent hazards from waste materials lying around. The following actions are recommended:

- wherever possible, trim and/or waste should be automatically removed;
- set up a programme of regular cleaning and waste removal. Cleaning needs to be frequent enough to prevent any build-up of broke, dust or other waste;
- papermaking machines should be cleaned regularly by the machine crew or a special hygiene crew;
- clearing away broke etc from the paper machine should be a normal part of planned shutdowns. Whenever there are unplanned shutdowns, remove broke etc that cannot be removed with the machine running;
- cleaning must be thorough and include office and storage areas;
- particular attention should be paid to those areas where broke paper, dust or trim is produced, as this is easily ignited. Dust will accumulate on ledges and beams, and this should be regularly removed with vacuum equipment.

33 Contractors may produce significant amounts of combustible waste. There should be a system to ensure that this is removed promptly.

34 A sufficient number of non-combustible waste containers should be provided at appropriate points. There should be an organised system for the prompt removal of the large volumes of waste liable to be generated at both papermaking and reeling and slitting machines.

35 Chemicals should only be in the workplace while actually in use. Used containers must be disposed of safely or returned to a suitable storage area.

36 Pay attention to housekeeping in other areas, eg engineers' stores, where packaging material needs to be promptly and safely removed.

## SMOKING

37 Each mill should have a policy for controlling smoking. Workers need to be consulted when this policy is drawn up. Once non-smoking areas have been established, the policy should be strictly enforced. In general, smoking should only be allowed in designated safe areas.

## VANDALISM AND INTRUDERS

38 Fires started by vandals or intruders have been a serious problem at paper mills, especially at large sites with extensive external stocks of paper bales or reels. Adequate security should be provided to reduce the chance of intruders entering the mill. Consider the following measures:

- the site perimeter may need a wall or fence at least 2 m high that is regularly inspected and maintained in good condition;
- stocks of paper etc should not be kept up against or near site boundaries;
- there should be sufficient lighting in storage areas so that security staff can easily check for intruders;
- site access points should be limited and should be manned to check visitors coming onto the site;
- limiting the means of access should not be at the expense of restricting the ability of people to escape from fires or the ease with which fire fighting can be carried out;
- high-risk areas, eg boundaries, storage areas or parts of the site that are rarely visited by mill workers, should be continuously monitored by means of a closed circuit television system.

39 Detailed advice about security can be obtained from your local police force or from your insurance company.

## SAFETY OF MILL FIRE TEAMS

40 Many mills, especially those that are large or remote from local authority fire stations, have their own 'mill fire teams'. These teams can perform a valuable service in preventing small fires from spreading and giving detailed advice about the premises to local authority fire fighters. However, they must not be put into a situation (or put themselves into a situation) which is outside their competence. Some mills may have occupational fire brigades. Running these is a specialised matter and the local authority fire brigade should be consulted. 'Mill fire team' means a group of employees trained to implement fire safety plans to save lives and take initial action to protect property by using first-aid fire-fighting equipment. An 'occupational fire brigade' is an organised body wholly funded by a body other than a statutory fire authority. It is maintained for the purposes of saving life and protecting property in the event of fire or other emergency in locations owned, managed or occupied by the sponsor.

41 The role of a mill fire team should be clearly defined. Management, fire teams and safety representatives should be in no doubt as to the level of physical fitness, training, equipment and competence expected of the team.

42 The local authority fire brigade should be consulted about the procedures to be followed in case of fire. Management must issue clear instructions including specifying personnel to make decisions at as early a stage as possible. The limits of the mill fire team's responsibilities before calling outside assistance should be made clear. Where there is the slightest doubt of the ability of the mill fire team to cope with the situation, the local authority fire brigade should be called. In many mills it would be appropriate for the local fire authority brigade to be called irrespective of the size of the incident, and for the mill fire team to confine itself to first-aid fire fighting that it can then carry out safely.

43 Appropriate training should be given to the mill fire teams. It will not be enough for only initial basic training to be given. It is more likely that training will be a continuous process. Mills are advised to contact the local authority brigade, as they may well be able to provide training facilities. Particular points that should be covered include:

- causes of fires in paper mills and associated premises, ie offices, stores etc;
- basic fire-fighting techniques;
- past experience of fires in the paper industry;
- behaviour of fires;
- use, location and limitations of all relevant equipment;
- procedures in case of fire;
- familiarisation with all parts of the mill site including location of both static and mains water supplies;
- limitations on what team members are expected to do;
- communication with each other in a fire situation;
- liaison, training and exercising with the local authority brigade;
- basic first aid;
- behaviour of people in fire situations; and
- observing fire drills.

44 Suitable equipment should be provided, which is appropriate for the level at which the mill fire team is expected to operate. Equipment needs to be properly maintained by competent staff.

45 Breathing apparatus which is provided for other purposes should not be used for fire-fighting unless it is by an occupational fire brigade who are appropriately trained and use proper local authority fire brigade breathing apparatus control procedures.

46 You should have a clear and effective chain of command for the mill fire team. In a fire, the safety of the fire fighters depends on there being no confusion about who is in charge.

47 On arrival, the senior officer of the local authority fire brigade has the sole charge and control of all operations for the extinction of the fire.

48 The procedures for liaison with the local authority brigade need to be worked out in consultation with them. On arrival of the local authority fire brigade and following consultation between the appropriate manager and fire officer in charge, the mill fire team may be requested to withdraw partly or wholly from the fire incident. However, they may be asked to provide advice and assistance to the local authority fire brigade in relation to the premises and processes.

49 Senior management should report on incidents, including the way in which these were tackled, and monitor the mill fire team.

50 There should be adequate and suitable insurance cover for the mill fire teams.

## HAZARDS AND PRECAUTIONS IN VARIOUS OPERATIONS

### Storage

51 The main principles of safe storage are to segregate the storage areas from the process work areas, and to segregate combustible materials from each other so that in the event of a fire in one area, other areas are not affected. Only authorised people should be allowed access to fire-separated storage areas.

52 One method of reducing the risk of fire spread and controlling the fire size is to ensure that the fire is vented in its early stages. This should preferably be achieved by automatic smoke venting, or by the provision of roof panels that will fail early in any fire. Such provisions have the added advantage of allowing fire fighters to enter the building and locate the seat of the fire.

53 Storage in a separate building, a single-storey extension to the main building, or in a safe place in the open air is preferable, but may not always be possible. In such cases, storage areas should be separated from workrooms by partitioning with a fire resistance of not less than half an hour for personal protection. Higher standards of fire resistance will be required for protection of the building and contents. If frequent access is needed into a store, automatically closing fire doors will provide a satisfactory standard of protection. The risk of fire spreading is reduced by compartmentalisation of storage areas.

54 In certain limited cases where storage areas cannot be separated, safety will need to be achieved by other means (but see paragraph 127). You should assess the characteristics and quantity of material stored, conditions of use and storage, the nature of the building and the adequacy of emergency procedures and fire precautions. For example, it may be possible to achieve safety by a combination of other measures such as spatial separation, or fire or smoke detectors linked to an alarm system, sprinklers and smoke control systems. Although such arrangements may be reasonable to protect employees, it must be remembered that lack of physical separation can lead to more extensive fire damage.

55 Separation may be specified in a fire certificate or by the conditions of a petroleum licence. Adequate separation will also be required where the highly flammable liquids are used or stored.

56 The following points are particularly worth noting:

- Gangways in stacking areas should be sufficiently wide to ensure free movement to fire exits; a currently accepted minimum width is 1.1 m. Where mechanically powered or hand trucks are used in the gangway, it should be wide enough for people to pass freely. Gangways should also be clearly marked, eg by lines marked on the floor, and kept clear. An exit should be provided from each end of any main gangway and dead ends should be avoided. (Check that the closing of fire stop doors does not compromise the escape routes.)

- Stored combustible material should be kept well away from potential sources of ignition, such as light fittings and direct-fired or convector-type heaters.
- Raw materials and products should be stored so that they do not obstruct means of escape, fire-alarm call points, fire-detection equipment, fire-fighting equipment or fire doors and shutters. In particular, the storage should not put sprinkler systems at risk from damage during material handling or be so close as to affect the performance of the spray nozzles.
- Smoking should be prohibited in the store.
- Boilers, emergency generators and other similar plant should be segregated by fire-resisting walls, floors and doors.
- Battery charging should not be done in storage areas.
- Used pallets and empty containers stored outside should be well away from openings into buildings and preferably at least 1 m clear of any boundary fence.
- Vigilance against vandalism and intruders is needed, especially where there are very large quantities of stock and few employees.
- Packaged dangerous substances should be stored safely in accordance with current standards and guidance.
- As well as paper there may be other flammable solids, eg foam plastic. These should be stored safely.
- Stocks of paper should not be kept up against or near site boundaries or against the walls of buildings.

### ***Reel storage***

57 Storage of paper reels can create particular fire hazards. Management should assess the risk arising from such storage and see that the necessary safeguards and controls are applied, taking account of information provided by the suppliers.

58 The most likely material to be ignited is loose paper material, eg discarded wrappers, loose ends, and loose paper on damaged reels. These problems need to be identified at an early stage. Damaged reels should be wrapped or taped on delivery.

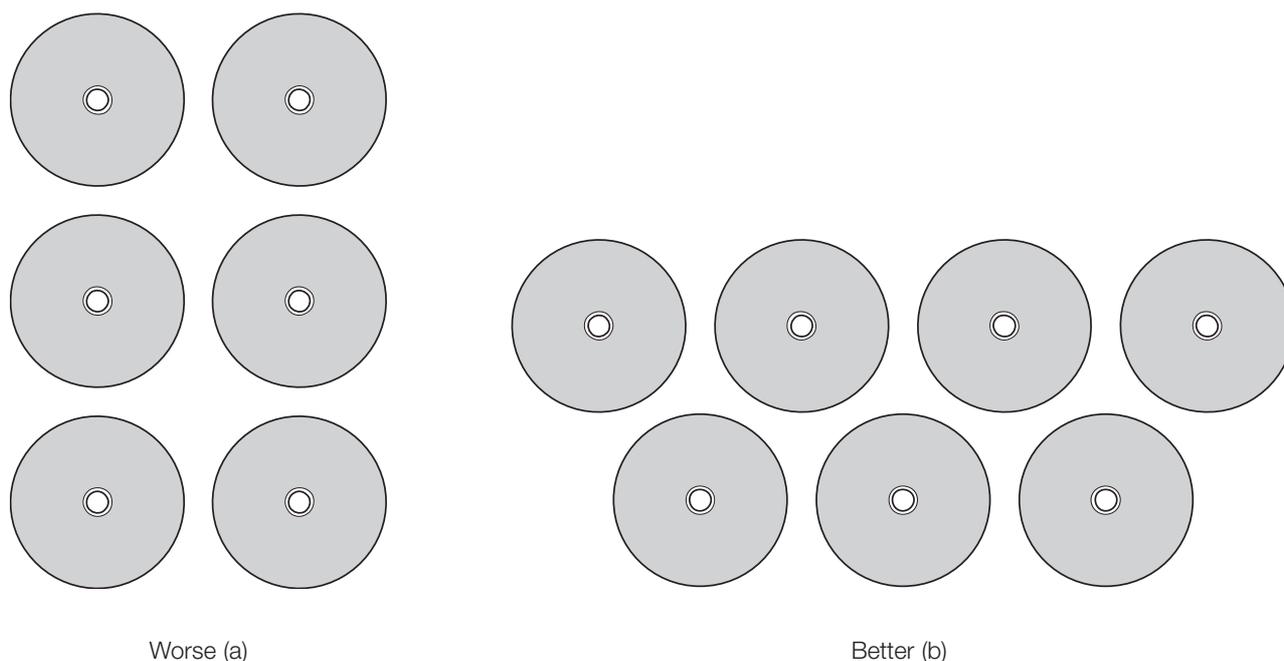
59 Where reels are stacked vertically in columns there will inevitably be gaps between the columns. In the event of a fire starting at the bottom of the stack the gap will constitute a chimney. Rapid burning will follow as air drawn in at the bottom will accelerate up the chimney, typically to a speed of approximately 15 metres per second. The rate of burning increases rapidly with increasing stack height. This rapid vertical flame spread is compounded by rapid horizontal spread when the layers of paper begin to unwind. This type of fire may be difficult or impossible to control with conventional sprinklers. The risk of rapid fire is therefore reduced if reels are not stacked on end.

60 The following special precautions are required in reel storage areas:

- Floors need to be kept clean and free of loose paper. Other combustible material should not be kept in the reel store.
- Damaged reels should be repaired by taping or rewrapping.
- Where reels are stacked vertically, the spaces between them should be as small as possible (less than 100 mm). This should help prevent the peeling off process that accelerates fire spread. If spaces are less than 25 mm, the flow is likely to be throttled and the rate of fire spread further reduced. Alternatively, spaces should be wide enough (more than 1.1 m) to allow normal access. Figure 2 shows two stacking arrangements. The arrangement in Figure 2(b) is preferable as the voids between reels are smaller and less well ventilated. Make sure that reels can be removed without disturbing adjacent stacks.
- Vertically stacked, banded reels in purpose-built separate buildings with proper

fire separation, venting and restricted access may be stacked as high as can be safely achieved with the stacking equipment. Information and advice will be required from the fire authority and insurers on fire detection, protection and extinguishing systems, dependant on the stacking height but especially if stacks are greater than 7.2 m high.

- Smoke venting etc (see paragraph 52).
- Frequent inspection and checks by supervision.



**Figure 2:** Patterns of vertical reel stacking. In (b) gaps between reels have been minimised so reducing the chimney effect in the case of fire

61 Stacked reels can present an unacceptable risk to people in inner rooms such as offices, storerooms, toilets etc. The presence of stacked reels in the vicinity of the only escape route from these rooms raises the outer room (ie store) to high-risk status. Unless reels are sufficiently remote from the escape route from any inner room, then the inner room should have an alternative exit either direct to open air or via a separate fire-resisting compartment.

62 Stacked reels can have an adverse effect on the audibility of the fire alarm system. If stacking is introduced into an area not previously used for that purpose or if there is any material increase in stacking, check that the alarm is still audible throughout the whole of the premises.

#### ***Bale storage – general***

63 Bales of paper, especially waste, present a high fire risk, as loose material is always present. Bales should be neatly stacked. Stacks should be limited in size to reduce the fire loading and laid out in straight rows with adequate gangways between stacks that allow easy access for fire fighting.

64 Gangways should be as wide as possible to prevent fire spread through radiated heat. Housekeeping should be to a high standard with regular sweeping up to prevent loose paper accumulating. Gangways should be kept clear of all debris or material that could impede escape or hinder fire fighting.

65 Local authority legislation may limit the size of stacks, and mills are advised to check with their local authority.

66 In all normal circumstances, the system of work should not permit pedestrians to enter bale storage areas.

67 Suitably trained staff should regularly check stacks that are not protected by a fire detection and alarm system.

68 Ignition sources should be kept away from stacks.

69 An adequate water supply must be available in the event of a fire, if effective fire fighting is to be undertaken.

### ***Indoor storage***

70 Fire in baled paper is difficult to extinguish and generates heavy smoke. In large storage areas automatic smoke venting is desirable to facilitate fire-fighting operations and to reduce structural and stock damage. As a rule of thumb, 1 m<sup>2</sup> of openable ventilation to 50 m<sup>2</sup> of storage is reasonable, **but it is advisable to seek specialist advice.**

71 Keeping piles as narrow as practicable, consistent with the building configuration, is good practice. Adequate main aisles (generally not less than 3 m) and cross aisles are necessary to provide means of access, as well as access for fire fighting. Aisles should be free from obstructions (eg fork-lift trucks) when the building is not in use.

72 Bales should ideally be protected by a sprinkler system, suitably designed to cope with the height of the bales. Bales should have a maximum height of 5 m and in all cases should be 3 m below the level of the sprinklers.

### ***Outdoor storage***

73 Stacks should not exceed 7 m in height.

74 Stacks should be separated from one another by gangways at least three times the height of the highest adjacent stack, with a minimum of 6 m between stacks. Note that providing the separation distances suggested would not necessarily prevent fire spreading from pile to pile, but the rate of spread will be reduced and, with time, the chances of early control increased.

### ***Storage of gases***

75 Gases in cylinders can be flammable, toxic, corrosive or inert. Even cylinders of inert gases pose a hazard in a fire as they can become over pressurised and rupture violently.

76 All gas cylinders should be stored away from flammable liquids, combustible materials, corrosives and toxic materials. Cylinders containing gases of differing hazard, eg toxic, flammable, corrosive and oxidizing (including oxygen) should be stored separately from one another. The main points of note are:

- gas cylinders should preferably be stored in the open air in a lockable wire mesh cage for security;
- cylinders of liquefied petroleum gas, eg propane and butane, should be kept separately from other gases;
- if flammable gases are to be used in a building, the preferred arrangement is for the cylinders to be kept in the open air and piped into the workroom by permanent fixed metal pipe work at as low a pressure as is possible;

- bulk tanks of liquefied petroleum gas should be installed in accordance with current published standards.

### ***Storage of wood and woodchips***

77 Some mills have stocks of wood and/or woodchips. These should be stored separately from other materials. Stacks of wood should have good access for fire-fighting purposes. Woodchips could smoulder for some time if they have been on fire in the chipper or could spontaneously ignite if left for long periods in the open air. Piles of woodchips should be used in rotation and cleared so that the chips cannot stand for long periods of time. Ductwork and silos for woodchips will contain dust. They should be fitted with fire detection/suppression systems and, as appropriate, with adequate explosion relief panels.

### **Paper dust**

78 Paper dust presents a very high risk of fire and may, under certain conditions, be explosive. Although the problems are likely to be more extensive in tissue mills, all paper mills, especially if there are paper/dust collectors, could be hazardous. Flammable dusts are liable to explode if they are in a finely divided state and become airborne in a cloud. Paper dust is generated wherever certain processes are carried out, eg webs going over rollers, or being slit or cut, or sheets hitting stops. Dust should be collected as near to its source as practicable. Local exhaust ventilation (LEV) equipment should be provided wherever substantial quantities of dust are created.

79 LEV equipment should be designed to collect as much dust as practicable and remove it to a safe place. Ductwork should be made of fire-resistant material. It is preferable for dust collectors to be sited outside buildings and they should be fitted with adequate explosion relief. It may be appropriate to fit suitable fire/explosion suppression equipment. The design is highly specialised and advice should be taken from a competent supplier or consultant.

80 General housekeeping in areas where dust can settle needs to be of a very high order. Substantial quantities of dust should never be allowed to accumulate and regular cleaning will be needed to achieve this. Paper dust should be cleaned up with a vacuum cleaner except where it is not physically possible to do so (eg if it has coagulated). Air lines may be used for removing coagulated material as long as any loose dust has already been removed by vacuuming.

### **Fires in machine hoods**

81 Fires in machine hoods pose risks to those needing to be inside them as well as to the plant and surrounding structures. Access within the hood must be designed to facilitate emergency escape, and procedures in place so that when the hood is down and the machine is running, only the crew is permitted access. All other access must be authorised by local supervision. Specialist advice, including that of the local fire brigade and the company insurers, will be needed for the design of smoke and heat venting systems. Similarly, for existing hoods consider controlling a fire or reducing its effects by using any air circulation or venting systems or other controls. The advice should extend to whether the machine should be stopped or kept running in the event of fire. The procedure should also indicate when the decision to evacuate overrides the machine condition so that crews are not put at risk. An example of one mill's arrangements is given in Appendix 5.

## Starch

82 Many mills have bulk starch handling facilities, often with large silos for storage. Starch presents an explosion hazard and the following precautions should be taken:

- storage silos should be provided with adequate explosion relief panels and properly earthed;
- the silo should preferably be fitted with fixed lighting, suitable for use in explosive dust, to remove the need to introduce temporary lighting. If temporary lighting has to be used it should be protected to a suitable standard;
- pipes should either be able to contain an internal explosion or be able to vent any explosion safely;
- the transfer system should be electrically bonded throughout its length. In particular, earthing straps should be provided across points of discontinuity such as a sight glass or a section of plastic pipe;
- if any hose or pipe is made of insulating material incorporating metal reinforcement on the inside surface, the reinforcement should be electrically bonded to the end couplings;
- where possible metal pipe couplings should be used.
- at the transfer point, the delivery vehicle must be electrically bonded to the receiving installation, preferably by using hoses of all-metal construction or low electrical resistance material;

### *Responsibility of tanker operators*

- any non-return valve fitted on the vehicle downstream of the air compressor should be inspected regularly for effective operation. Where reasonably practicable such a valve should be fitted;
- combustible foam or wadding should not be used inside silencers fitted on the outlets of vehicle air compressors;
- to avoid the back flow of powder, the operating instructions for tanker discharge should clearly indicate that before the compressor is turned off, all vents in the downstream system should be opened for long enough to depressurise the tank and discharge equipment. Alternatively, positive isolation of the air supply downstream of the compressor should be specified. In this case, protection of the compressor to prevent overheating while working against a closed pipe is likely to be needed.

83 A likely cause of explosions is maintenance or repair work involving hot work (eg burning, welding or grinding). For precautions see paragraphs 103-106.

## Hydrogen sulphide

84 Although hydrogen sulphide is primarily a toxic hazard, there have been a number of explosions in chests and tanks during shuts in foreign mills. Hydrogen and hydrogen sulphide (both flammable gases) generation results from an aerobic bacterial action on paper fibre or other organic material. The necessary growth conditions are undisturbed organic material in a warm aqueous system at a near-neutral or slightly alkaline pH. These conditions are increasingly likely to occur during mill shuts where neutral or alkaline papermaking conditions apply. Note that if hydrogen formation occurs in stagnant conditions, it may remain attached to paper fibres until agitation is recommenced; hydrogen could then be released into the air.

85 At the start of mill shuts or other sustained breaks in production (eg a weekend), it is preferable to empty and thoroughly clean all chests and white water storage.

86 If there is provision for agitation of stock, the following options may be considered if there are exceptional reasons to do so:

- continue agitation to prevent aerobic conditions and maintain an adequate level of biocide; or
- add sufficient biocide, agitate fully and allow to stand. Consult the biocide supplier to determine how much and how often biocide should be added to give adequate protection;
- in either case, ensure that the chest or tank is adequately ventilated, so that any traces of flammable gases are dissipated;
- in addition, carry out tests to confirm the absence of hydrogen and hydrogen sulphide before hot work is permitted nearby or on the chests etc, or if there are any ignition sources in the locality;
- tanks should be cleaned regularly. Even if there is ample agitation of stock, debris can remain undisturbed, allowing bacteria to breed;
- for any entry to chests and tanks, a confined-space permit-to-work must be issued.

87 Note that hydrogen sulphide can also be generated in effluent plants and appropriate precautions should be taken to prevent risk.

### **Charging of electrically operated lift trucks**

88 If a metal tool or other electrically conducting object short-circuits the terminals of a cell or cells, it will become hot and may cause burns. In addition, sparks and molten metal may be ejected. Insulated tools should always be used and, before working on a battery, people should remove any metallic items from hands, wrist and neck, together with any metallic items that may fall from their pockets.

89 Hydrogen and oxygen gases are emitted from a battery when it is being charged. Hydrogen/air mixtures produce violent explosions if ignited and it has to be assumed that this mixture is present in the immediate vicinity of the cell tops at all times. To minimise the risk of explosion:

- charging should be carried out in an area used only for that purpose which is not near any combustible materials (see also paragraph 56);
- the charging area should have good natural high-level ventilation immediately above the batteries;
- light fittings should be of a totally enclosed industrial type, eg bulkhead fittings, and preferably not positioned directly above the charging area;
- smoking or naked lights should be prohibited in the area. Appropriate notices should be displayed;
- anything capable of causing a spark should not be used in the vicinity of the cell tops;
- a proper plug and socket arrangement should normally be used for routinely connecting the charger to the batteries – the charger should be switched off before making or breaking the connection;
- battery covers may be open or removed during charging but all vent plugs should be in position;
- when carrying out maintenance on the battery, all electrical circuits, including the charger, should be switched off before making or breaking connections at the battery terminals. The lead connected to the vehicle framework should always be disconnected first and reconnected last.

90 Appropriate fire-fighting equipment should be readily available.

## Flammable liquids

### *General*

91 The main hazard in the storage of flammable liquids is fire involving either bulk liquid or escaping liquid or vapour; the vapours are usually heavier than air and can travel long distances so that any major spillage will almost inevitably reach a source of ignition. Such incidents may be caused by inadequacies in design, manufacture, installation, maintenance, or by equipment failure or bad operation, together with exposure to a nearby ignition source. Ignition of flammable liquid vapour remains a possibility until the vapour concentration is reduced below the lower flammable limit. The lower flammable limit of a material is the concentration (usually expressed as the percentage, by volume, of the material mixed with air) below which the mixture is too lean to undergo combustion; this varies with different materials but it is usually about 1.5% in air.

### *Use*

92 The following general points apply wherever flammable liquids are used or kept:

- stocks of flammable liquids and empty or part-used containers should be properly stored. Except when actually in use, containers should be kept closed in an appropriate secure and properly bunded storage area;
- the quantity of flammable liquids in workrooms should be kept to a minimum, normally to no more than a half-day's supply;
- flammable liquids should be conveyed and handled in enclosed systems where possible, eg by piping supplies from the storage location to the point of use; where a connection is frequently broken and remade, a sealed-end coupling is preferred.
- Containers should be kept covered. Proprietary safety containers with self-closing lids and caps should be used where possible for dispensing and applying small quantities of flammable liquids. The lids and caps of containers should be replaced after use. No container should be opened in such a way (eg by punching a hole or cutting off the top) that it cannot be safely reclosed.
- the store should be used exclusively for the storage of flammable liquids and should not normally be used for dispensing;
- rags impregnated with flammable solvents should be kept in metal bins with well-fitting, preferably self-closing lids and removed from the workroom each shift;
- sources of ignition should be controlled;
- flammable liquids should be stored and handled in well-ventilated conditions. In some cases it may be necessary to use exhaust ventilation to control flammable vapour.

93 One of the major uses of flammable liquids in the paper industry is the coating or laminating processes. Guidance on some particular hazards and precautions is given in Appendix 6.

## Electricity

94 Electricity can cause fires or explosions in a number of ways. The principal causes are:

- overheating of cables and electrical equipment due to overloading of conductors;
- leakage currents due to damaged or inadequate insulation;
- overheating of flammable materials placed too close to electrical equipment which is otherwise operating normally (eg equipment covered in flammable dust);

- ignition of flammable materials by arcing or sparking of electrical equipment.

95 Explosions can occur in switchgear, motors or power cables if they are subjected to excessive currents or suffer prolonged internal arcing faults.

96 Electrical systems should be designed, constructed and maintained to prevent danger. The Institution of Electrical Engineers' Wiring Regulations give much practical guidance for systems up to 1000V. There are many British Standards that give information on how electrical equipment can be safely constructed and maintained. It is important that electrical systems should be adequately rated for the job they have to do.

97 It is essential that competent people are used for installation and maintenance of electrical equipment.

98 To prevent the ignition of flammable materials, there should be good housekeeping standards.

## **Maintenance of plant**

99 Poorly maintained plant is a cause of fires. In a survey carried out by one local authority fire brigade, 60% of all fires were due to poor maintenance of plant or premises. It is usually a combination of circumstances that leads to fires. Typically, circumstances that contribute to the start of fires are:

- poor housekeeping, eg build-up of dust or paper causing overheating (see paragraphs 32-36);
- lack of bearing lubrication. Especially where there are many bearings, it is easy for some to be overlooked, leading to frictional heating;
- friction heating (eg due to drive belts rubbing);
- electrical malfunction (see paragraphs 94-96);
- flammable materials used in contact with hot surfaces (eg lagging materials not properly separated from steam pipe flanges);
- leaking of flammable liquids or gases from valves or flanges (note that most oils and greases will burn vigorously in elevated temperatures);
- static sparks (eg from inadequate earthing of solvent tanks).

100 You may need a formal planned maintenance programme to ensure plant is properly maintained. If instrumentation is used to monitor the condition of the machine, the information gained (eg bearing temperatures) may be of use in reducing the chances of fire.

## **Engineering and construction work**

101 Engineering and construction operations can significantly increase the risk of fire. Extra precautions are needed to control processes such as welding and cutting, and where there are likely to be people (such as contractors) who are unfamiliar with the site, systems of work or hazards. Guidance on hot work is given in paragraphs 103-106.

102 Assess engineering and construction operations, identify the range of hazards and make plans to control them. These hazards will include the risks of materials used in the work that are stored on site during the work. Methods of work and storage facilities, including those for contractors, need to be clearly specified and monitored, especially if contractors are bringing equipment or flammable materials onto site. Control fire hazards introduced by contractors and make provision for the storage and disposal of waste materials. Temporary storage areas for flammable

liquids and gases should be set up in safe places. Management need to oversee the work to ensure the risk of fire is minimised.

### **Hot work**

103 Certain activities need to be strictly controlled, eg the use of welding, flame-cutting blowlamps or portable grinding equipment in areas where paper or flammable liquids are stored or used. This must be done through a written permit to work for the people involved. This should apply both to in-house and contractors' staff.

104 Any employees and outside contractors who are to take part in such activities should be left in no doubt that work may not begin until the person who is to issue the permit has fully explained the safety precautions that must be observed. It is imperative that a written handover procedure is adopted. Appendix 3 gives details of the principles to be applied.

105 The permit should include details of:

- preliminary measures to ensure the area is free from combustible materials;
- the fire-fighting equipment that should be at the site of the work;
- the supervision needed; and
- the measures required on completion of the work, and for checking that an incipient fire cannot break out at a later time.

106 Fuel, gas and oxygen cylinders should not be taken into a confined space unless this is unavoidable because of the risk of leakage. All cylinders, hoses and torches should be removed from a confined space on completion of work and when there is any substantial break in the work activity, eg more than half an hour.

## **GENERAL FIRE PRECAUTIONS**

107 The role of general fire precautions in the management of fire risk and the need for written emergency arrangements are introduced in paragraph 23. Their application in detail is set out in paragraphs 100-122.

108 Most paper and board mills will require a fire certificate because of the numbers of people employed and presence of highly flammable materials. If material changes have taken place since the certificate was issued then a new or amended certificate will be required. Application should be made to the fire authority. The fire certificate sets out minimum standards of precautions in case of fire so that people inside the mill are able to go to a safe place if a fire occurs. If significant changes are planned then prior consultation with the fire authority is required. The local authority should also be consulted to determine whether building regulations approval is needed.

### **Means of escape**

109 In all premises, there must be means of escape appropriate to the risk. All means of escape provided should be kept unobstructed and available for use all the time when the premises are occupied. It should be possible to open doors easily and immediately from the inside without the use of a key.

110 Circumstances in premises will vary, but a person should be able to turn away from a fire and reach a place of safety, in the open air, within a reasonable distance and without outside assistance. Arrangements for people with disabilities should be carefully considered.

111 Officers of the local authority fire brigade consider the following when assessing the means of escape (detailed information on these is also given in the relevant Scottish Executive guidance documents):

- fire hazards and fire risks in the premises;
- the indication of exits and escape routes;
- the protection of escape routes;
- building construction;
- building occupancy;
- number of exits available;
- number of people involved;
- travel distances to a place of safety (these are prescribed for particular circumstances);
- provision of emergency lighting.

112 Pending the issue of a fire certificate, the existing means of escape should be maintained so that they can be safely used, eg free from obstruction, doors capable of being easily and immediately opened without the use of a key.

## **Fire alarms**

113 A fire alarm gives early warning of the outbreak of fire so that people can leave buildings and reach a place of safety before the fire endangers them. Modern systems can operate in a variety of modes. In some cases, it is not necessary to evacuate the whole premises if only part is affected and fire cannot spread. Some sites have a two-stage system where occupants not immediately at risk are alerted to a fire but not immediately evacuated. Provision of these systems requires expertise, and the local authority fire safety officer must be consulted.

114 A fire alarm system will normally be required in all paper mills.

115 Among the matters to be determined are the provision and siting of fire alarm call points, the siting of alarm sounders and of control and indicating equipment. If alterations to plant or buildings are made, the audibility of the alarm should be checked. Alarm systems should take account of the problems involved in noisy environments, especially where hearing protection is being worn. Consideration may need to be given to using visual indications as well as audible alarms. Fire alarms will need to be tested regularly. Fire certificates will generally specify the tests that should be carried out.

116 Automatic fire detection (eg smoke and/or heat detectors) is desirable as a means of protecting the property by ensuring early warning of any fire. Where manual and automatic systems are installed in the same building, they should be incorporated in a single system. However, it is only likely to become a requirement under the terms of a fire certificate where the fire risk assessment indicates that the premises or part of the premises are of high fire risk.

## **Training**

117 To minimise the risk to people in case of fire, it is essential that they all receive adequate fire safety training appropriate to their role. Fire safety training can be broadly divided into four types – induction, basic, refresher and training of key workers.

### ***Induction training***

118 Induction training should be given to all new staff (including contractors) before they start work and should include an explanation of evacuation procedures,

method of raising the alarm and any rules concerning smoking. They should be made familiar with the escape routes from any place where they have to work to specified assembly points. This could be done by walking along the routes or by adequate signs and written information.

### ***Basic and refresher training***

119 Basic and refresher training should be given to all staff, preferably at least twice a year, but at least once a year. The training should cover the following points:

- the action to be taken on discovering fire;
- the action to take on hearing the fire alarm, including evacuation and roll-call procedures;
- the location of fire alarm call points and how to raise the alarm;
- how the fire brigade is called (unless this is to be done only by designated staff);
- the location and use of fire equipment and the dangers of using the wrong type of extinguisher;
- knowledge of escape routes including the operation of any special emergency door fastenings and any stairway not in regular use;
- location and identification of fire doors and their importance in restricting fire spread and protecting escape routes;
- stopping machines and processes and isolating power supplies where appropriate (each mill needs to draw up its own procedures – see Appendix 5 for an example from one mill). Personal protection must be paramount;
- warning against stopping to collect belongings or re-entering buildings.

### ***Training of key workers***

120 Training of key workers should apply to certain categories of staff. Every person identified in the emergency plan as a person responsible for supervising and controlling putting the emergency plan into effect and conducting fire drills should have access to the risk assessments and to the emergency plan. They should also be given additional instruction in matters that will be their particular responsibilities over the above basic training. Specific aspects of training will include the supervision of evacuation and roll-call procedures, the control of contractors and the safety of visitors in the event of fire and liaison with the local authority fire brigade. These key personnel need to be clear how they fit into the overall emergency plan. Key personnel covered by this section will include:

- heads of departments;
- engineering and maintenance staff;
- boiler house crews;
- supervisors;
- security staff;
- mill fire teams;
- wardens/marshals;
- safety representatives;
- receptionists;
- tour guides.

121 Key personnel should receive refresher training at appropriate intervals.

122 Mill fire teams are likely to need a continuous programme of training to ensure they are, and remain, competent to carry out their duties.

123 Changes in procedures, any new hazards or any lessons learned from fire incidents or drills should be taken into account in refresher training.

124 A practice fire drill should be carried out twice a year. It is a good exercise to simulate conditions in which one or more exits or escape routes from the building are obstructed. During these drills the fire alarm should be operated by a member of staff, who is told of a supposed outbreak of fire. The fire routine should then be followed as fully as circumstances permit. The special needs of employees who have disabilities and/or sensory impairments should receive particular attention. The practice fire drill should be part of management's consideration and scrutiny of the quality of training.

125 Keep records of any maintenance done to ensure that means of escape, fire-fighting equipment, fire detection and warning equipment remain in efficient working order. You should also keep records of the instruction and training provided and specifically of every fire drill. All training and drills should be based on written instructions and be recorded in a logbook. The records should include:

- the date of the training or drill;
- duration of training;
- fire drill evacuation times;
- name of person giving instruction;
- names of people receiving instructions;
- the nature of the instruction or drill;
- any observations/remedial action.

126 Printed fire instruction notices should be displayed at conspicuous positions in the building stating in concise terms what staff and others should do if a fire is discovered or if they hear the alarm. The notices should be permanently fixed in position and suitably protected to prevent loss or defacement. The fire certificate will normally specify the content of the notice.

### **Automatic sprinklers and automatic smoke control systems**

127 For complex or high fire-risk premises, a greater emphasis is now being given to a range of specialised protection measures. These include automatic fire detection techniques, life safety sprinkler systems and smoke management, as well as passive fire defence such as compartmentalisation and the fire resistance elements of structure. A total fire defence package will, in addition to providing the life safety measures to satisfy legislation, afford a high level of property protection.

128 Installation of such systems is usually a specialist job and mills should seek advice from the local authority fire safety officer, their insurers, and firms having the appropriate expertise. If sections of such systems are closed down, the fire risk may be increased.

### **Gas-flooding fire-extinguishing systems**

129 These may be used to protect certain processes, eg computer suites and data stores, from fire. Exposure to the extinguishing agents may be hazardous in the event of accidental discharge. Exposure to the agent and products of combustion during discharge in a fire may also be hazardous. Some systems may be local, only protecting individual machines and not presenting a hazard to individuals. Others flood larger areas, and workers need to be protected against asphyxiation or the effect of toxic fumes.

130 Suitable safeguards should be incorporated where there is a need to protect people. Such systems should be under manual control when people are present and could be affected. Warning signs should be provided and in the case of a total flooding system there should be an indicator showing whether the system is on

manual or automatic. Adequate means of escape should be provided and maintained. The system itself should be well maintained.

### **Extinguishers and hose reels**

131 All premises should be provided with means for fighting fire. The aim is to provide people with the means of extinguishing small fires in their early stages. They are only of use for first-aid fire fighting. The location of such equipment should be identified in accordance with published standards.

132 In selecting appropriate means for fighting fire, the nature of the materials likely to be found should be considered. These and the appropriate extinguishing agents are described in Appendix 3.

133 People on the premises should be aware of the dangers and limitations of fighting a fire with fire extinguishers.

134 The fire certificate will specify minimum life safety requirements; employers may wish to make additional provision (in consultation with their insurers) for the protection of property.

### ***Access for fire appliances and assistance to the fire brigade***

135 There needs to be a good means of access for fire appliances, both into the mill and to all parts of the mill site. Consult your local fire brigade for minimum sizes of entrances and roadways etc. For new or altered premises these distances are now specified under the Building Regulations. Information that will be of help to the local authority fire brigade should be readily available at the entrance to the site (eg site plan, location of water supplies, main plant isolation points, register of hazardous substances on site).

136 There also need to be adequate water supplies for the fire brigade to use. Hydrants need to be sited and identified so that fire fighters can easily reach any part of the mill site with adequate supplies of water. They should be sited so that fire fighters are not likely to be at risk from a fire while using them. Regular tests should be carried out to ensure the hydrants remain operational. The fire authority should be consulted.

## SUMMARY

137 In recent years, few people have been injured by fires in paper mills, but every year there are a number of fires requiring the attendance of the fire service and causing considerable financial loss. There are also hundreds more which are adequately dealt with by paper mill first-aid fire fighters. It must not be forgotten that the potential for multiple fatalities in a major fire remains.

138 It is vital that senior managers are committed to preventing fires and explosions and ensuring that workers are not put at risk should either occur. The risks require assessment and managing to ensure effective control. Written emergency arrangements are an essential part of such control. Key staff should be fully involved and safety representatives consulted.

139 The aim is to stop a fire starting and, if one does occur, to enable people to escape safely and to prevent it spreading. Day-to-day control is essential to keep the quantity of flammables to a minimum, to ensure safe handling of flammable materials, to exclude sources of ignition and to keep up standards of housekeeping. Means of escape need to be identified and kept free of obstruction; exits need to be immediately available for use in emergency.

140 All staff need to be adequately trained so that they are able to play their part in minimising fire risks and know what to do if fire breaks out or other emergencies occur.

141 Everyone needs to be vigilant in their own interest and that of other people.

## APPENDIX 1: CASE STUDIES

The following case studies summarise some fire-related incidents that have occurred in the paper industry.

### Case study 1

Contractors were using oxy-acetylene cutting equipment on a papermaking machine that was being modified. They had been using foam polystyrene slabs as kneeling pads. These had been ignited by sparks and half an hour after the contractors had left for a tea break, a fire was discovered at the base of the paper machine. As the felt was dry and as the drying hood and roof linings were also flammable the fire spread rapidly. There were no injuries but there was considerable damage to the building, paper machine and computer control equipment.

### Case study 2

About 2500 tonnes of waste paper in bales were stacked in an open yard, to a height of about 5 m. A fire was discovered in one corner, and was attacked unsuccessfully by employees with water extinguishers.

The case was recorded as spontaneous combustion. Paper itself will not ignite spontaneously unless its temperature rises to 200°C or more in a substantial quantity of material, ie many tens of kilos. Waste paper bales contain impurities, sometimes quite a lot of them, and it is possible that a quantity of reactive material was trapped inside a bale, eg paint or linseed oil-soaked rags. In such a situation, the high wind on the day of the fire could have been enough to convert a slow smouldering inside a bale into flaming combustion.

### Case study 3

More than 10 000 tonnes of newsprint were destroyed in a warehouse fire. The reels were stacked on end to a height of around 6 m. Paper reels in good condition present a hard surface that is difficult to ignite. However, reels often sustain minor damage making fire easier to start. Once a fire has started, the 'chimneys' between reels enhance the speed and spread of it. Air enters at the bottom at high speed due to the small gap and the chimney effect of the spaces between reels gives very rapid burning. It is estimated that peak heat outputs in this fire were in excess of 1000 MW. It is estimated that a 7 m high stack would burn roughly four times as fast as a 5 m stack.

In this case, the roof was breached at an early stage allowing heat and smoke to vent upwards. If this had not occurred, the hot gases would have travelled sideways under the roof giving a rapid sideways spread of fire that would have been difficult to control.

### Case study 4

A tissue mill warehouse sustained severe damage when a propane-fuelled fork-lift truck caught fire. Pieces of paper were caught beneath the truck and sparks and heat from the truck's exhaust system ignited the trapped paper. The fire burnt through the hydraulic oil hoses and the propane feed pipe, with subsequent ignition of escaping oil and gas intensifying the flame. The fire spread to the nearby large reels of tissue paper.

Earlier the same day, another propane-fuelled fork-lift truck had caught fire. The fire had started in the engine compartment of the truck when arcing (due to a short circuit) ignited the electrical insulation covering the wiring. This fire was successfully put out using dry powder and CO<sub>2</sub> extinguishers.

### **Case study 5**

A contractor was burning and cutting off redundant steelwork adjacent to a papermaking machine. There was inadequate segregation from the machine or control of sparks. Paper in the calender pit was ignited and the fire spread to the roof of the building.

### **Case study 6**

There was a solvent explosion and fire in a coating laminator. The initial explosion was followed by a sequence of explosions in the evaporating ovens and extraction ducting with a small fire at the coating head. The ignition source was unknown but solvent levels were above the lower explosive limit. There was no monitoring of the airflow.

### **Case study 7**

Two paper machine crewmen were detained in hospital for 36 hours as a result of inhaling smoke and other combustion products while using hoses to fight fire in the drier hood of a papermaking machine. The cause of the fire was not established but the copious quantity of smoke appeared to result from rapid burning of the synthetic textile drier felt. One of the men affected had previous fire-fighting experience; the other had no previous experience or training in fire fighting.

### **Case study 8**

Two operatives engaged in first-aid fire fighting on a papermaking machine suffered breathing difficulties after another operative attempting to fight the fire released the contents of a dry powder extinguisher into their faces. This latter operative had not apparently been trained in the use of such extinguishers.

### **Case study 9**

There was a fire and explosion in a de-inking switchroom. This was caused by a contractor's electrician attempting to replace fuses into a live switch cabinet on completion of testing work. The interlock on the isolator handle was faulty.

### **Case study 10**

The following example from the USA is included as it illustrates the extreme consequences that can arise from a paper mill fire.

Employees were using an abrasive wheel grinder to cut a small hole in the steel roof of a bale storage building. Welding, using an arc and oxygen acetylene torch, was also used in the work. A fire started in the 9 m high by 7 m thick by 1.2 m long compressed waste tissue paper bales weighing 225 to 320 kg which were located in the building. The bales were stacked five high. The company's fire department was called and the 36 heads of the sprinkler system were activated. The community fire company also responded.

A fire fighter and the fire captain advanced into the fire area with a charged hose line. The water sprayed on to the stacked bales rendered them unstable and

caused them to topple, trapping the two employees. Seven others entered the building in a rescue attempt. Three of these were also trapped by additional falling bales. Fork-lift trucks were used to remove the bales, and lumber pieces were used to shore up other bales. Three fire fighters, including the captain, died as well as two other employees.

## APPENDIX 2: SELECTING THE APPROPRIATE EXTINGUISHER

1 There are four main classes of fire classes - A, B, C and D. Only classes A-C will be relevant for the paper industry.

### **Class 'A' fires**

2 Fires involving solid materials, usually of an organic nature, (eg wood or paper) in which combustion normally takes place with the formation of glowing embers. Class A fires occur frequently and it will be appropriate to provide fire-fighting equipment suitable for this class of fire. Water, foam (other than protein foam) and multi-purpose powder are the most effective media for extinguishing these fires. Water and foam are usually considered the most suitable media, and the appropriate equipment would be hose reels or water-type extinguishers or extinguishers containing fluoroprotein foam (FP), aqueous film protein foam (AFFF) or film-forming fluoroprotein foam (FFFP).

3 If hose reels are installed they should be located where they are conspicuous and always accessible. Their distribution should be such that with not more than 45 m of hose, no part of the area to be protected is more than 6 m from the nozzle of the reel when the hose is fully run out. Hose reel installations should conform to the appropriate British Standards.

4 If portable fire extinguishers are installed, they should be provided and allocated in accordance with the recommendations contained in the current British Standard.

### **Class 'B' fires**

5 Fires involving flammable liquids or liquefiable solids (greases and fats). In buildings or parts of buildings where there is a risk of fire involving flammable liquid, it will usually be appropriate to provide portable fire extinguishers of foam, carbon dioxide (CO<sub>2</sub>) or powder types. Take care when using gaseous extinguishers, as the fumes and products of combustion may be hazardous in confined spaces.

### **Class 'C' fires**

6 Fires involving gases: No special extinguishers are made for dealing with fires involving gases. While dry powder extinguishers are capable of putting out small fires, normally the only effective action against such fires is to stop the flow of gas. There would be a risk of an explosion if a fire involving escaping gas were to be extinguished before the supply could be cut off.

### **Fires involving live electrical equipment**

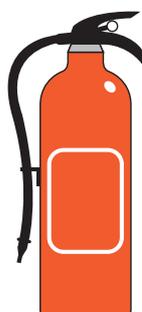
7 Extinguishers provided specifically for the protection of electrical risks should be of the dry powder or CO<sub>2</sub> type.

### **General**

8 In some circumstances it may be more appropriate to use a fire blanket rather than an extinguisher, eg to deal with a cooker fire in the early stages, or to smother a fire involving a person's clothing. Such blankets should conform to the current British Standard and should be asbestos free.

9 Staff who receive training in use of hand-held fire-fighting equipment should be instructed on the different types of fire described above and the appropriate type of equipment.

**Figure 3:** Fire extinguishers



**Water**  
RED

**EXTINGUISHING ACTION**

Mainly by cooling the burning material.

**Class of fire**

Class A

**DANGER: Do not use on live electrical equipment, burning fats or oils.**

**Method of use**

The jet should be directed at the base of the flames and kept moving across the area of the fire. Any hot spots should be sought out after the main fire is out.



**Foam (Protein P) type**  
CREAM

**EXTINGUISHING ACTION**

Forms a blanket of foam over the surface of the burning liquid and smothers the fire.

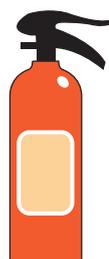
**Class of fire**

Class B

**DANGER: Do not use on live electrical equipment.**

**Method of use**

The jet should not be aimed directly onto the liquid. Where the liquid on fire is in a container the jet should be directed at the edge of the container or on a nearby surface above the burning liquid. The foam should be allowed to build up so that it flows across the liquid.



**Aqueous film-forming  
foam (AFFF)**  
CREAM

Film-forming fluoroprotein  
foam (FFFP), fluoroprotein  
foam (FP)

**EXTINGUISHING ACTION**

Forms a fire-extinguishing water film on the surface of the burning liquid. Has a cooling action with a wider extinguishing application than water on solid combustible materials.

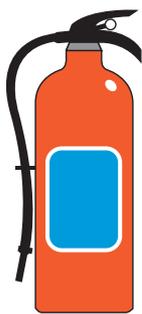
**Class of fire**

Classes A and B

**DANGER: Some extinguishers of this type are not suitable for use on live electrical equipment.**

**Method of use**

For Class A fires, the directions for water extinguishers should be followed. For Class B fires, the directions for foam extinguishers should be followed.



Powder  
BLUE

#### EXTINGUISHING ACTION

Knocks down flames.

#### Class of fire

Class B

Safe on live electrical equipment although does not readily penetrate spaces inside equipment. A fire may re-ignite.

#### Method of use

The discharge nozzle should be directed at the base of the flames and with a rapid sweeping motion the flames should be driven towards the far edge until the flames are out. If the extinguisher has a shut-off control, the air should then be allowed to clear; if the flames reappear, the procedure should be repeated.

**WARNING: Powder has a limited cooling effect and care should be taken to ensure the fire does not reignite.**



Powder (multi-purpose)  
BLUE

#### EXTINGUISHING ACTION

Knocks down flames and on burning solids melts down to form a skin, smothering the fire. Has some cooling effect.

#### Class of fire

Classes A and B

Safe on live electrical equipment although does not readily penetrate spaces inside equipment. A fire may reignite.

#### Method of use

The discharge nozzle should be directed at the base of the flames and with a rapid sweeping motion the flames should be driven towards the far edge until the flames are out. If the extinguisher has a shut-off control, the air should then be allowed to clear; if the flames reappear, the procedure should be repeated.

**WARNING: Powder has a limited cooling effect and care should be taken to ensure the fire does not re-ignite.**



Carbon dioxide (CO<sub>2</sub>)  
BLACK

#### EXTINGUISHING ACTION

Vapourising liquid gas which smothers flames by displacement of oxygen in the air.

#### Class of fire

Class B

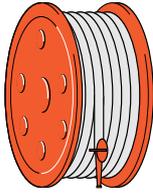
Safe and clean to use on live electrical equipment.

#### Method of use

The discharge horn should be directed at the base of the flames and the jet kept moving across the area of the fire.

**WARNING: CO<sub>2</sub> has a limited cooling effect and care should be taken to ensure the fire does not re-ignite.**

**DANGER: Fumes from CO<sub>2</sub> extinguishers can be harmful to users in confined spaces. The area should therefore be ventilated as soon as the fire has been extinguished.**



Hose reel  
RED

**EXTINGUISHING ACTION**

Mainly by cooling the burning material.

**Class of fire**

Class A

**DANGER: Do not use on live electrical equipment.**

**Method of use**

The jet should be aimed at the base of the flames and kept moving across the area of the fire. If an isolating valve is fitted it should be opened before the hose is unreeled.



Fire blanket  
RED

**EXTINGUISHING ACTION**

Smothering.

**Class of fire**

Classes A and B

**Light duty:** Suitable for burning clothing and small fires involving burning liquids.

**Heavy duty:** Suitable for industrial use. Resistant to penetration by molten materials.

**Method of use**

The blanket should be placed carefully over the fire and the hands shielded from the fire. Care should be taken that the flames are not wafted towards the user or bystanders.

## APPENDIX 3: PERMIT TO WORK

1 When operating a permit-to-work system:

- the information given in the permit should be clear and unambiguous;
- it should specify precisely and in detail the item of plant on which work is to be carried out, the nature of the operations, the point at which welding or hot work is to take place and the precautions which should be taken to ensure people's safety;
- the permit should specify the time at which it comes into operation, the time by which it expires and any particular conditions under which all work should cease even though the time limit for the certificate has not expired;
- the person issuing the permit should be satisfied, by personal inspection, that all the action specified as necessary has in fact been taken;
- the person issuing the certificate should have the technical knowledge to appreciate the existence of hazards and the precautions to be taken, and also have the authority to require responsible people to make safety recommendations on matters of which they have special knowledge, and to co-ordinate the duties of all concerned;
- permits should be monitored by management to ensure that they are being correctly issued and the conditions are being complied with.

2 The permit-to-work procedure outlined above is for general guidance and should be adopted to suit particular needs. A suggested layout is given in Figure 4.

|   |   |  |
|---|---|--|
| <p><b>Plant details</b><br/>(Location, identifying number etc)</p>  | <p><b>Acceptance of certificate</b></p>   | <p>I have read and understood this certificate and will undertake to work in accordance with the conditions in it.</p>   |
| <p><b>Work to be done</b></p>   |   | <p>Signed _____<br/>Date _____ Time _____</p>  |
| <p><b>Equipment to be used</b><br/>(eg electrical arc welding set, abrasive cut-off disc)</p>   | <p><b>Completion of work</b></p>  | <p>This work has been completed and all persons under my supervision, materials and equipment withdrawn.</p> <p>Signed _____<br/>Date _____ Time _____</p>                                 |
| <p><b>Cleaning location</b><br/>The area has been cleared of flammable and combustible materials that could be ignited by the activity, falling slag or sparks, and/or suitable coverings have been provided (specify which).</p> <p><b>Fire fighting</b><br/>Suitable fire extinguishers/hoses have been placed adjacent to the work (specify which). People doing work have been adequately trained in their use/trained fire watcher present.*</p> <p><b>Conditions</b><br/>Work should cease in the event of the following:</p> <p><b>I certify that I have personally examined the plant detailed above and satisfied myself that the above particulars are correct.</b></p> <p>Signed _____<br/>Date _____ Time _____</p> | <p><b>Request for extension</b></p>   | <p>I have re-examined the plant details above and confirm that the certificate may be extended to expire at:</p> <p>Further precautions:</p> <p>Signed _____<br/>Date _____ Time _____</p> |
|   | <p><b>Inspection of location immediately after work</b></p>   | <p>I have examined the work location and there is no sign of ignition/smouldering of any substance.</p> <p>Signed _____<br/>Date _____ Time _____</p>                                      |
|   | <p><b>Inspection of location one hour after work</b></p>  | <p>I have examined the work location and there is no sign of ignition/smouldering of any substance.</p> <p>Signed _____<br/>Date _____ Time _____</p>                                      |
|   | <p><b>This permit to work is now cancelled. A new permit will be required if work is to continue.</b></p> <p>Signed _____<br/>Date _____ Time _____</p> |  |

\* Delete option not applicable

**Figure 4:** Suggested layout for permit to work

## APPENDIX 4: FIRE-RESISTING STRUCTURES

### Functions of fire-resisting construction

- 1 The provision of fire-resisting construction to appropriate standards, and properly located, can contribute greatly to the safety of life and property in the event of fire. There is the added advantage that successful containment of any fire will minimise any subsequent loss of production.
- 2 Among the specific uses of fire-resisting construction are:
  - the protection of escape routes from the effects of fire to enable people to leave the building safely;
  - the division of the building into compartments in order to contain any fire that may occur;
  - the separation of areas of high fire risk from the remainder of the building; and
  - the protection from fire of load bearing and structural members to minimise the risk of early collapse of the building.

### Test standards

- 3 Fire resisting or fire resistance means the ability of a component of building construction to satisfy, for a stated period of time (eg 30 minutes), some or all of the appropriate criteria (ie integrity, insulation and stability/load bearing capacity) specified in the relevant British Standards.
- 4 In existing premises, it may not be possible to ascertain the fire resistance of some elements of structure and a judgement will need to be made on whether the fire resistance is acceptable in the particular circumstances.

### Circumstances under which fire-resisting construction may be required

- 5 Fire-resisting construction will generally be required by the Building Control Authority in new or materially altered premises.
- 6 Fire-resisting construction may be required by the fire authority to protect the means of escape in existing buildings (but not in excess of that required by Building Regulations unless the means of escape are not satisfactory by virtue of matters not required to be shown for the purposes of Building Regulation approval).
- 7 Fire-resisting construction may be required by HSE in order to separate high fire-risk storage areas from the remainder of the building.
- 8 Fire-resisting construction may be required by the insurers to provide fire-resisting compartmentalisation to limit the spread of fire and consequent property losses.

## APPENDIX 5: EMERGENCY PROCEDURES

1 When fire breaks out or the fire alarm sounds, people need to be clear about the procedures to be followed. Fire fighters are at increased risk if they have to enter a smoke-logged building with machinery still in motion. However in some circumstances, there can be increased risk from workers stopping to shut down large machinery.

2 Mill workers should not be put at risk. Where a fire is immediately threatening, the mill must be evacuated as quickly as possible. Only if it can be done safely should personnel stay to shut down the paper machine. The decision on what action to take should be made by a designated person who has the knowledge and authority to make an appropriate decision.

3 Mills will have to draw up their own procedures, taking into account the physical environment of the paper machine, the type of fire alarm provided and the level of supervision that is available. An example of the emergency procedure drawn up by one mill is follows this paragraph. This example is intended to be illustrative and should not be considered as a model procedure. Individual arrangements are likely to vary from mill to mill.

### **Example of an emergency procedure**

## FIRE ACTION – PAPER MACHINES

### **Emergency evacuation procedures for crews**

#### ***Continuous alarm***

The sounding of a continuous alarm is intended to warn you that a fire has started in your department. In the event of a continuous alarm sounding, the following action should be taken:

Either:

1 Shut down the paper machine in a controlled manner prior to evacuation if safe to do so:

- closing down all extraction fans;
- flushing stock and starch lines;
- parting rolls;
- setting down steam pressures to minimum.

Or:

2 Crash shut the paper machine in the event of extensive fire in danger of rapid spread but only if safe to do so.

Or:

3 In the event of a fire in the dryer section take the following action prior to evacuation if safe to do so:

- set cylinders to crawl on all sections of the machine;
- reduce steam pressures to minimum.

**OR, IF IT IS NOT SAFE TO DO ANY OF THE ABOVE:**

4 Evacuate with the machine left running and report this fact as a priority at the assembly point.

***Intermittent alarm***

The sounding of an intermittent alarm is intended to warn you that a fire has started in another department. In the event of an intermittent alarm you should prepare to evacuate if necessary under the instruction of your shift supervisor.

***Duties of the machine shift supervisor***

In the event of the alarm sounding, the machine shift supervisor should:

- control evacuation of the area and ensure the safety of the crews;
- advise workers in the boiler house.

## APPENDIX 6: COATING AND LAMINATING PROCEDURES

- 1 These processes almost always use flammable solvents and they therefore pose serious fire/explosion risks. Ignition sources should be avoided and smoking strictly prohibited. Wherever possible, substitution with non-flammable or less flammable materials should be considered, taking into account any health hazards.
- 2 Machines on which flammable solvents are used should be separated from storage areas and other parts of the building by partitioning with a fire resistance of not less than half an hour.
- 3 Where mixing has to be done in-house this should normally be carried out in a special-purpose fire-resisting room (separate from the storage area) provided with mechanical ventilation.
- 4 Where vapour may enter the atmosphere, local exhaust ventilation should be provided to remove the vapour from as close to the source as possible, to reduce the risk of fire and explosion and to reduce employee exposure to solvent vapours. The workroom itself should have a good standard of general ventilation.
- 5 To reduce the amount of solvent vapour entering the room and minimise possible spillage, supply containers etc should be kept covered. It is preferable to pump solvent to machines and to return any excess solvent to storage via an enclosed system. Where it is necessary to break and remake a connection frequently, eg when making a colour change, a sealed-end coupling is preferred. Where possible, pipe runs should be in the open air and suitable shut-off valves should be provided. A manual emergency shut-off valve is recommended where a pipe enters a process building. Pipe work and fittings should be to a suitable standard and arrangements should be made for routine maintenance including leak testing of pipe work, fittings, storage tanks etc.
- 6 Highly flammable liquids should not be kept or moved in open-topped vessels. Only properly constructed vessels should be used for mixing and dispensing. Empty or partly used drums of solvent are still hazardous and should not be allowed to accumulate around the machine. Highly flammable liquids such as toluene should not be used for floor cleaning.
- 7 The amount of vapour produced by coatings increases rapidly with temperature so they should be used at as low a temperature as possible. The normal working temperature for a coating should not be exceeded.
- 8 Any electrical equipment on the press or in the surrounding area should be constructed to a suitable explosion protection standard to avoid any risk of ignition. Powered lift trucks should not be used close to machines unless suitably protected. Where a local exhaust ventilation system is provided for the removal of solvent vapour, the fan motor should not be located in the path of the vapour and the ductwork should be fire resistant.

### **Static electricity**

- 9 The generation of static electricity is a problem, especially at those laminators/varnishers that handle plastic or other insulating materials, including many papers. In particular, charging of unearthed metal parts as the web passes over cylinders and rollers etc can lead to spark discharges liable to ignite volatile

solvents, and people may become charged by induction and by transfer of charge from the web. They may also become charged by walking on an insulating floor or by removing an outer garment. Operations such as pouring, mixing and pumping organic solvents can also generate static electricity.

10 Minimise generation of static electricity from solvents and other low conductivity liquids by avoiding free-fall of liquids and restricting pumping speed. For liquids with conductivity up to and including 50 picosiemen per metre (pS/m) the flow velocity in a pipe should not exceed 1 metre per second if a second phase (commonly water) is present. Water may be present even if not deliberately introduced (eg condensate) and so a flow velocity above 1 metre per second should only be considered if there is no possibility of this; only in these circumstances should velocities up to 7 metres per second be considered. Consider the use of anti-static additives to increase conductivity; these reduce the likelihood that a solvent will accumulate a static charge but they will not control static electricity from other sources such as those mentioned above.

11 Vessels, containers, pipe work, hoses and plant etc that may become electrostatically charged, either directly or by induction, should be conductive and bonded together and/or earthed. On fixed plant, the resistance to earth of all metal or conducting parts should be checked at the commissioning stage and regularly thereafter.

12 All people who may come into contact with a potentially flammable atmosphere should wear anti-static footwear; the resistance of footwear while being worn may be measured by a personal resistance monitor. Preferably only outer clothing made from natural fibres should be worn, as synthetic fibres can generate static. Although there is no evidence that wearing synthetic underwear can cause a static problem, natural fibres are recommended because injury in the event of fire or explosion is likely to be less severe. Outer clothing such as pullovers and overalls should not be removed in areas where flammable vapours may be present. Remember that even at a level where electrostatic charges cannot be felt, they are capable of igniting some solvent vapours.

13 Floors in hazardous areas should not be highly insulating, eg concrete would be suitable. They should be kept free of insulating deposits.

14 Electrostatic eliminators, of a design incapable of producing incendiary sparks, should be used on any insulating web-fed material; passive, high voltage and radioactive types are available. This equipment should, where relevant, be constructed to a suitable explosion protection standard to avoid a risk of ignition, and it should be kept clean and properly maintained.

15 Devices for applying a high electrostatic charge are sometimes used, normally in conjunction with a static eliminator to neutralise the charge before the web moves forward. These devices should be incapable of producing sparks, be constructed to a suitable explosion protection standard, and be kept clean and properly maintained.

16 To avoid the possibility of incendiary sparks, avoid the use of highly insulating plastic materials in hazardous areas. In particular, powders should not be discharged from plastic bags or liners in the vicinity of flammable atmospheres.

17 Manual addition of powders or low conductivity liquids to vessels containing a potentially flammable atmosphere should be avoided.

18 Fixed fire detection and extinguishing systems, such as carbon dioxide systems designed for both manual and automatic operation, are recommended (see paragraphs 129-130). When such equipment is operating, further flammable solvents should be prevented from entering dryers/extract ducting, and dampers should normally be fully shut to prevent the extinguishing medium being removed.

19 Particular care should be taken to ensure that dryers incorporate all necessary safeguards to minimise the risk of solvent/air or gas/air explosions, and to mitigate the consequences of an explosion, should one occur.

20 Solvent concentrations in dryers and associated ductwork should not exceed 25% of the lower flammable limit (LFL) under all operating conditions (but see paragraph 24). This can normally be achieved by airflow of 60 m<sup>3</sup> at 16°C for every litre of solvent evaporated. The concentration should be checked by calculation and measurement during commissioning or if the operating conditions are altered. Also, instruments can be used to continuously monitor the solvent concentration in the dryer. The exhaust or inlet ventilation rate, and where appropriate recirculation rate, should be monitored by a differential pressure device or airflow switch. Detection of inadequate exhaust should automatically stop the process and safely shut down the means of heating. In addition, a clear, audible warning should sound automatically. Visible warning may also be provided.

21 Operation of an emergency stop button should safely shut down the means of heating, but the exhaust ventilation should continue to operate.

22 The movement of the coated web (not a dry web) should be possible only if adequate exhaust ventilation has been proved.

23 Adequate explosion relief should be provided on dryers and on associated large-scale ductwork.

24 Exceptionally, some dryers have been designed to operate above 25% of the LFL where there is continuous monitoring. Operation above 25% of the LFL should not be attempted unless the nature of the process ensures that vapour concentrations within the dryer change slowly relative to the effective detection and activation times of the continuous monitor and safety-shutdown interlock systems. Under no circumstances should a dryer be operated above a solvent concentration of 50% of the LFL. Such fixed vapour detection equipment should:

- be suitable for the solvents to be measured;
- be calibrated for the solvents concerned, regularly tested and recalibrated, and well maintained;
- normally sample at points within the dryer and/or duct work where the vapour concentration is likely to be highest;
- operate an audible and visible alarm if the solvent vapour concentration at separate sampling points exceeds the normal operating limit;
- have two independent reliable instruments measuring the solvent concentration at separate sampling points, each of which can safely shut down the process and the dryer's means of heating before the solvent vapour concentration rises above a predetermined maximum (which should not be above 50% of the LFL);
- be arranged to open any modulated dampers fully in the event of a malfunction in the continuous monitoring system;
- automatically and continuously monitor and record the progression of solvent vapour concentration with time.

25 Where there is a solvent recovery unit, a damper should be provided in the dryer extract duct to isolate the unit from any fire on the machine or in the ducting.

26 Vapour detection equipment is sometimes provided near machines in order to detect escapes of solvent into the general atmosphere of the workroom. Where such equipment is not provided, regular routine measurements should be considered to ensure that the atmosphere is maintained below 25% of the LFL. One method of doing this would be to use a portable flammable gas detector to check for escapes of vapour at flanges, valves, pump seals and other potential sources of leaks.

27 Where appropriate, automatic viscosity measuring equipment should be provided on the machine or it should be possible to take samples from a position at the side of the machine rather than from between the units.

28 Where highly flammable liquids are used to clean rollers, cylinders and ancillary equipment, the operation should preferably be done in a proprietary solvent-cleaning machine fitted with exhaust ventilation. In other cases, cleaning should take place in a purpose-designed booth; the enclosure and extract ducting should be fire resisting and the electric motor driving the extraction fan should not be in the path of the vapour. Where rollers/cylinders are cleaned by hand on the machine, only small volumes should be applied in well-ventilated conditions. The solvents should be kept in non-spill containers.

## FURTHER INFORMATION

HSE produces a wide range of documents. Some are available as printed publications, both priced and free, and others are only accessible via the HSE website, [www.hse.gov.uk](http://www.hse.gov.uk).

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA Tel: 01787 881165 Fax: 01787 313995 Website: [www.hsebooks.co.uk](http://www.hsebooks.co.uk) (HSE priced publications are also available from bookshops and free leaflets can be downloaded from HSE's website: [www.hse.gov.uk](http://www.hse.gov.uk).)

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This document contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

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