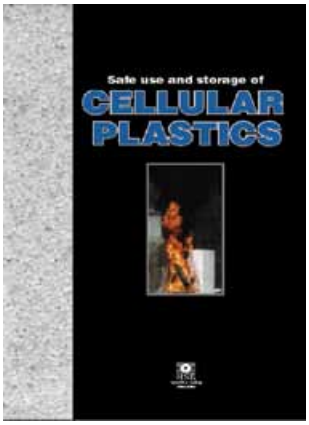
Safe use and storage of cellular plastics



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Cellular plastics include a wide range of polymers such as polyurethane and polyisocyanurate foams and expanded polystyrene. They are used mainly for upholstered furniture, packaging and insulation. Most are fire hazards and this booklet gives guidance on controlling the risk of fire. It is aimed at manufacturers, converters and users of cellular plastics.

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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the 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.

Contents

1 Introduction

1 The term cellular plastics (CP) covers a wide variety of products used in an even wider range of applications. It includes flexible, rigid and semi-rigid foams; materials made in large blocks (eg polystyrene) and others made in small discrete shapes; and cell sizes ranging from below 1 mm to 10 mm or more. This booklet concentrates mainly on process fire risks from the storage and use of cellular plastics. Advice on general principles is contained in the Health and Safety Executive (HSE) publication HS(G)64 *Assessment of fire hazards from solid materials and the precautions required for their safe storage and use*.[1]

2 The main types of polymer used are polyurethane (PU), polystyrene, polyethylene and polyvinyl chloride. The largest uses for these materials are as packing, in upholstered furniture and for insulation. Although the physical properties of these materials may seem diverse, manufacturing techniques have some common features, and create related hazards. Most cellular plastics are fire hazards. This booklet provides guidance on the control of such hazards and is aimed at manufacturers, converters, users and occupiers of storage premises.

3 Many cellular plastics may be ignited easily with a small ignition source, such as a match. Once established a fire will grow rapidly, often producing a large volume of thick, black, toxic smoke.

4 All smoke contains toxic and irritant components, but the smoke from some burning cellular plastics may be particularly dangerous. For example, polyurethanes release hydrogen cyanide and isocyanates, and acrolein is often present in the smoke from burning plastic. There is also concern that some fires involving plastic may produce small quantities of effluent that are not easily dispersed in the atmosphere and may damage the environment if allowed to enter water courses etc.

5 Much technical effort has been devoted in recent years to reducing the fire risk from cellular plastics. Particular emphasis has been placed on end use, eg furniture in domestic premises, and a wide range of fire-retardant additives are used. However, tests have shown that even foams containing fire retardants (eg combustion modified high resilience PU foam) can be ignited if the ignition source is large enough, and that large volumes of thick, black, toxic smoke may then be produced.

6 Nevertheless, much of the total production of cellular plastic is not treated in any way to improve its fire properties, and in manufacturing and user premises, where large stocks are held, strict fire hazard control is important.

7 It is important to recognise that in assessing what is a suitable standard of control of the fire risk, the differing responsibilities and interests of HSE, the local fire authority and any insurance company are all considered. A package of controls is needed, which will include measures intended to:

(a) prevent fires starting;
(b) restrict the rate of fire spread;
(c) ensure that in the event of fire everyone can escape safely;
(d) help fire brigades tackle any large fire; and
(e) reduce the cost of a fire.

8 Local fire authorities are responsible for enforcing general fire precautions, usually through the issue of a Fire Certificate. General fire precautions include: the

layout of the building (doors, stairs, corridors); the provision of adequate means of escape; fire safety notices and emergency lighting; fire alarm systems; provision of fire extinguishers; and staff training in fire safety. Advice is given in *Fire Precautions Act 1971: Guide to fire precautions in existing places of work that require a Fire Certificate*[2] *and Fire safety at work*.[3]

9 The guide,[2] gives advice on means of escape and related matters, which are controlled in most premises by the Fire Authority. In certain other premises, including those manufacturing more than 50 tonnes per week of cellular plastics, the Fire Certificate (Special Premises) Regulations 1976 will apply.[4] In this case, HSE will issue the Fire Certificate and enforce its provisions.

10 HSE is responsible for enforcement of what are termed 'process' fire precautions under the Health and Safety at Work etc Act 1974.[5] These include the storage and positioning of flammable material, the control of ignition sources and of fire hazards associated with particular processes. In some circumstances, the fire risks from CP mean that additional fire-resisting walls, floors or doors are needed to control the risks to a reasonable standard. This will normally involve consultation with the fire authority.

11 In HS(G)64 particular recommendation is given to assessing the fire hazard from bulk quantities of a flammable solid using the 'medium-scale room test'. In this test, a 5 kg sample of the material is burnt in a test rig designed to simulate a room connected to a corridor. Two parameters in particular are measured. These are the total volume of smoke produced and the maximum rate of temperature rise of the smoke. No single test can, however, give all the information required to predict the likely development of a fire in specific circumstances.

12 It is an important characteristic of many cellular plastics that, when tested in this rig, as the fire develops, the quantity of smoke produced rises sharply at the point when the air supply becomes inadequate for complete combustion. This phenomenon is known to occur in fires in buildings.

2 General safety principles

Segregation of stores from working areas

13 The first general principle relating to the storage of CP and of products incorporating CP is, as with all high fire-hazard materials in industrial workplaces, to segregate such stores from the areas where CP is to be used or processed. This principle is based on two assumptions. Firstly, many manufacturing processes create potential sources of ignition, or release easily ignitable vapours. Secondly, the number of people present in a production area is greater than the number who need to be in a storage area.

14 The separation of storage from production areas will consequently reduce the risk to personnel. In some premises, such as those used for conversion of PU foam, the quantity of material necessarily present may be very large, but it is normally reasonably practicable to arrange the CP so that there is not more than half a day's supply in the workroom at any one time. Where quantities of CP in use are very large, the safety of the operators will depend even more on the strict control of stacking, good housekeeping, fire precautions and the training of personnel in all aspects of fire safety.

15 In other cases, such as the manufacture of rigid PU foam laminates, the

process itself is not a particularly high fire risk, nor labour intensive, and there is less need for fire separation.

16 However, the recommendation for separate storage may be relaxed where an assessment of the risk shows this to be justified. This may be the case in detached, single-storey buildings, where the process creates no special hazards, where numbers of occupants are low and standards of other fire precautions, particularly means of escape, are very high.

Safe positioning of CP stores

17 The second general principle applicable to raw material and finished product stores is to position them so that they present the minimum threat of fire, heat and smoke spreading to occupied areas in the factory, workplace or to adjacent premises. This is important, irrespective of the degree of fire resistance of the structure of such stores.

18 Storage areas for cellular plastics may be used for storing other highly flammable solids such as polyester wadding, but should not be used for storing flammable liquids such as cleaning solvents or adhesives.

19 Loose materials such as foam crumb, fabric off-cuts or shredded packaging create a particularly high fire risk as they may spread around. Such materials should be kept in closed bags or packages when in store.

Finished product storage

20 Normally, a loading bay or store is provided for finished products awaiting despatch from the factory. Even though such goods may present a lower fire risk, eg because they are covered, fire-resisting separation from the process areas may be required. Such separation is likely to be required if the despatch bay or store contains significant quantities of easily ignitable materials, such as those described in paragraph 19, as these may be the initial fuel for a fire which subsequently involves the finished products.

New buildings

21 Standards of construction of new buildings and those undergoing major refurbishment or change of use are controlled under the Building Regulations,[6] enforced by the local authority. Among other things, these Regulations control standards of fire resistance of buildings, maximum compartment sizes, means of escape, travel distances and the separation of a building from the boundary of the premises. In England and Wales the same standards apply for all industrial and storage buildings. In Scotland, the Building Standards (Scotland) Regulations[7] apply and different standards are enforced for industrial use, storage, and storage of hazardous materials.

22 Different controls apply at premises subject to the Fire Certificates (Special Premises) Regulations. These Regulations allow HSE to require standards of construction higher than those given in the Building Regulations, where the nature of the process or use of the building is such that this is reasonable in particular circumstances.

23 If processes involving substantial quantities of CP are then started, internal upgrading of the structure may be needed, eg construction of a fire-

resisting storeroom. It is particularly important to maintain the standard of fire compartmentation originally provided, eg where lifts or hoists are used for movement of materials they should be enclosed to prevent smoke spreading through the building (see Figure 1). Where material is moved by conveyors or chutes, each opening in the floor should be provided with a fire-resisting shutter (see Figure 2). To achieve its purpose the shutter needs to close automatically in the event of fire, and be capable of being closed manually.

24 Openings in compartment walls for passage of services should be fire-stopped to maintain the standard of resistance of the original wall. The use of one of the proprietary fire-stopping compounds is recommended.

25 Where fire-resisting partitions are required, brick or blockwork construction is preferable to partitions of the studding and plasterboard type. In the factory situation they are much less prone to accidental damage which would destroy their fire-resisting properties. In addition, they will normally provide a longer period of fire resistance at little extra cost.

Figure 1 Internal lift

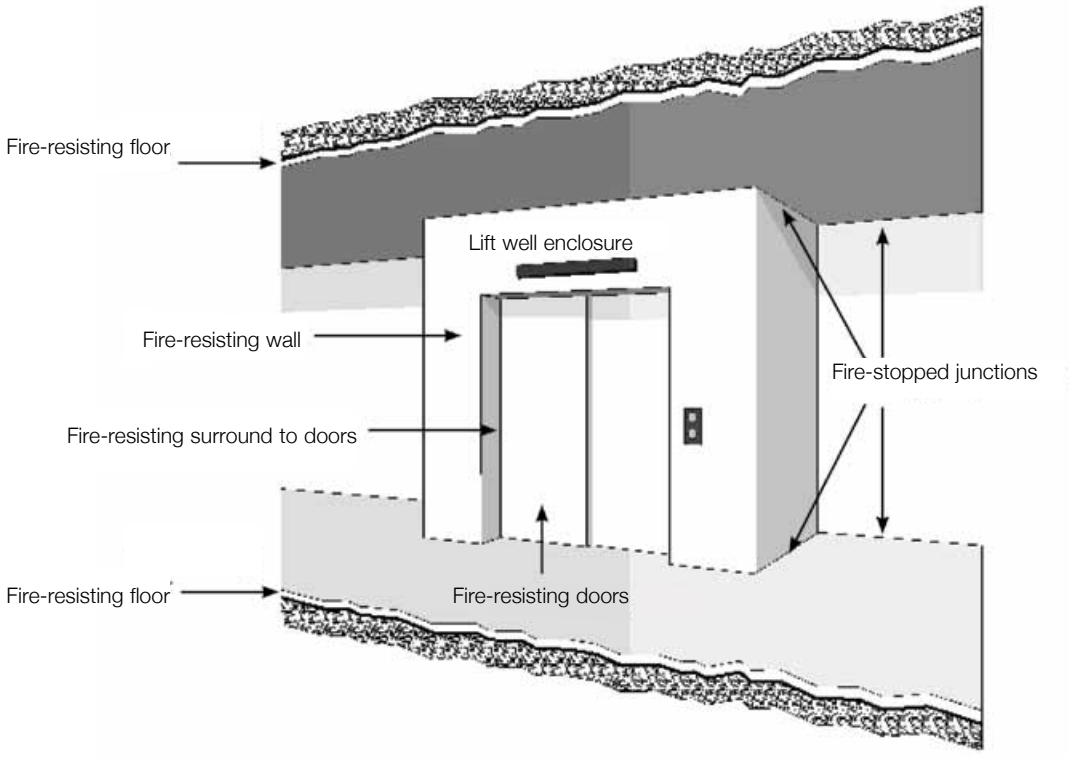
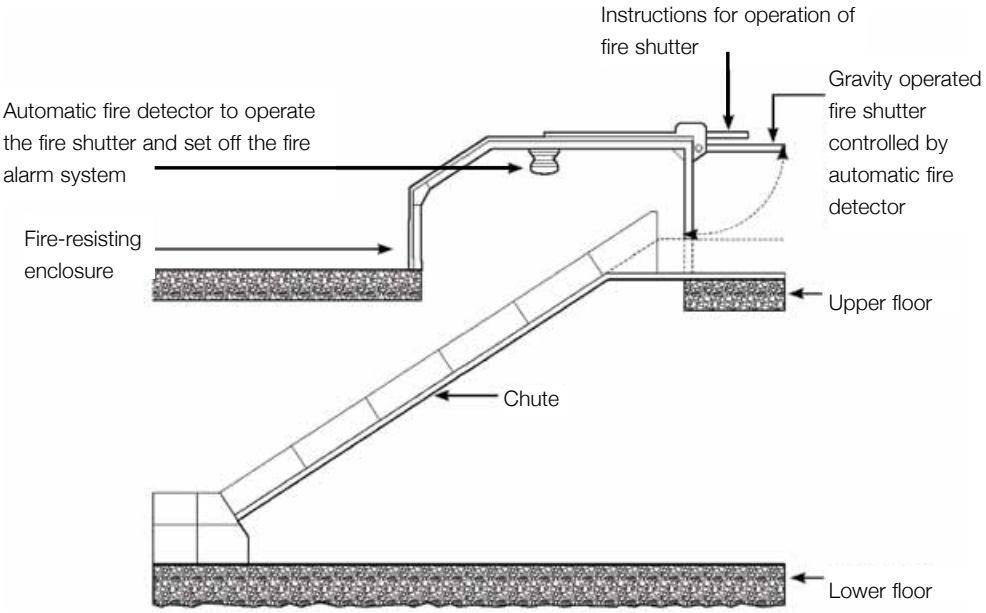


Figure 2 Enclosure for a chute between floors



Fire shutter can be closed manually, or by operation of the fire alarm system

This system requires a member of staff to be at the upper floor level to stop the movement of material down the chute which might prevent the closing of the fire shutter

Temporary storage

26 There are many situations where CP has to be stored for a short time awaiting use or disposal, at premises that are not designed or adapted for this purpose. Examples would be ships and buildings under construction or refurbishment where insulating materials are awaiting installation; places where there has been a delivery of goods packaged in a substantial quantity of CP; and places where redundant furniture, mattresses etc are being held awaiting disposal.

27 In such circumstances, the arrangements described in paragraphs 13 to 20 may not be practicable. CP awaiting disposal should preferably be stored outside occupied buildings, and always away from building exits and sources of ignition. If it is stored in an open skip, the risks associated with wilful fire-raising need to be considered. A good arrangement for temporary storage of either new or waste materials is to use a fully enclosed metal container, eg a freight container.

28 If substantial quantities of CP have to be held for short periods inside a building, where reasonably practicable, a room should be set aside for this purpose only, and kept locked except when access to the CP is needed. The quantities stored in this way should be kept to a minimum consistent with the work in hand.

Access through CP storage areas

29 It is always preferable to arrange premises so that no one needs to pass through storage areas to reach other parts of the building such as workrooms, offices or welfare facilities. Similarly, no one should have to pass through a foam storage area as their sole means of escape. These and similar measures will help to ensure that the number of people who need to enter storage areas are kept to a minimum.

3 Types of storage accommodation

30 In planning CP stores, or in assessing the suitability of existing stores in relation to the standards advised in this booklet, attention should also be given to the elimination of sources of ignition (see paragraphs 45 to 56) and recommendations as to travel distance etc.[2]

Storage in a separate building

31 The safest kind of store is a completely detached single-storey building. Such a store should be sited so that it does not create a danger to either the means of escape from the factory or the fire assembly points.

Storage in occupied buildings

32 Where the storage of CP in a separate building is not reasonably practicable, there may be no alternative to siting storage areas in a building containing workrooms, or offices. Such stores should be separated from other parts of the building by a robust partition giving at least half an hour fire resisting separation, eg a brick or blockwork wall. Doors into such stores should have a minimum of 30 minutes fire resistance and be self-closing. The use of fire doors held open by fusible links is not recommended as these do not close quickly enough to prevent the spread of smoke (see paragraph 74).

33 Storage in multi-occupancy buildings, or buildings containing residential or other sleeping accommodation, is not generally acceptable because of the difficulties of raising the alarm quickly in the event of fire. To minimise the hazard in case of fire in multi-storey occupied buildings, whenever possible, CP stores should not be sited below any occupied floor. The hazard in this situation is very high because the time to evacuate such buildings is likely to be longer than for single-storey buildings. There is also the risk of smoke and fire spreading rapidly from the stores to the upper floors and endangering protected escape routes.

34 If the storage of CP below occupied floors is wholly unavoidable, an automatic fire-detection system linked to the fire alarm should be installed in the store to give early warning of fire (see paragraph 161). The installation of an automatic sprinkler system should also be considered (see paragraphs 163 and 164).

Basement storage

35 If at all possible CP should not be stored in basement rooms. However, if there is no alternative, advice about the conditions required should be sought from the fire authority or HSE.

Positioning of stock

36 Within storerooms the following arrangements should be adopted so far as practicable:

(a) stacks of loose blocks should be stable. Racking may be needed for cut

pieces;

(b) gangways around stacks used for personnel access should not be less than 800 mm wide. Where vehicle access is required much wider gangways will be needed. The provision of floor markings is recommended as an aid to maintaining clear gangways;

(c) stacks should be arranged to avoid creating dead-end gangways, from which there is only one direction of escape;

(d) a minimum clear space of 1 m should be maintained between stack tops and ceilings, smoke detectors, or light fittings. Where sprinklers are fitted this clearance is particularly important;

(e) stacks should not be positioned directly below incandescent light fittings unless the bulbs are protected by robust covers;

(f) stacks should not be placed close up against a wall or pillar that supports steam pipes or electrical services;

(g) it is recommended that scrap material brought into the store in bins or bales is kept in a special area marked out and set aside for the purpose.

4 Housekeeping

37 Cleanliness and tidy working are vital to safety at all stages from receiving CP into store until the finished goods leave the factory.

Cleaning arrangements

38 Operatives will normally be made responsible for the tidiness of their own working areas unless cleaners are employed for this purpose. It is not sufficient merely to set aside time at the end of the day for cleaning-up. Good housekeeping requires continuous attention to cleanliness throughout the day as well as at the end of the working period.

Dusty processes

39 Cleanliness is particularly important in areas occupied by machines at which CP dust may be created and where crumb is handled. In dusty areas an industrial vacuum cleaner is recommended for cleaning.

40 Fires have occurred within the guards of equipment used for cutting CP. These and other places where dust can accumulate, for example under machines, on ledges and on roof beams, should be cleaned frequently. Particular attention should be paid to the cleanliness of electrical equipment including the bearings of electric motors. Where electric motors are situated in an environment containing flammable dust, they should be designed to BS 6467[8] or BS 7535.[9]

41 The dust created by cutting up rigid PU foam is normally flammable. If panels are cut up regularly, a fixed dust collection system will be needed. The filter or cyclone on such a system should be fitted with explosion relief, venting to a safe place normally outside the building. Further advice on this subject is contained in Safe handling of combustible dusts,[10] the three-part guide Dust explosion prevention and protection published by the Institution of Chemical Engineers[11] and BS 6467.

Scrap CP

42 Where CP in the form of slabstock, laminated material or moulded articles is cut, worked or used, the resulting scrap material should be collected and cleared from the workroom at least twice daily. Where the quantity of scrap material produced is small, it can be placed in a suitable receptacle, such as a metal bin fitted with a captive lid, pending its removal to a CP store. On a large scale, scrap material may be placed in skips or baskets for transfer to a store or to a baling machine.

Other waste material

43 Combustible waste material, such as packaging materials, rags used for cleaning and empty containers in workrooms, in storage areas or in the despatch bay, should be cleared at frequent intervals and placed in metal bins fitted with captive lids. These bins should be in addition to those used for scrap CP, unless the contents of all bins are regarded as waste and treated as such. Bins should be removed from the working areas and CP stores at frequent intervals and taken to a safe place.

Off-cut baling

44 The area where off-cuts are made into bales, preferably banded with steel straps or wires, should be tidy. Finished bales should not be allowed to accumulate in a workroom.

5 Sources of ignition and related fire hazards

45 Some CP may be ignited directly by a source of ignition of low energy such as a small flame. Combustion modified high resilience (CMHR) PU foams and other fire-resisting forms of CP are more difficult to ignite and may require a slightly larger and more intense flame. Many types of CP, however, will burn fiercely when involved in a fire which may well have resulted from the ignition of other more easily ignitable substances, such as loose paper, thin cardboard and some materials used for covering PU foam.

46 Some types of rigid PU and polyisocyanurate (PIR) foam do not burn to completion when involved in a fire. The volume of smoke produced then depends on the surface area of foam exposed. The volume of smoke produced in the medium-scale fire test can put such materials in the high fire risk category, and they may smoulder after the flames have been extinguished.

Naked flames

47 Any naked flame is a potential source of ignition and should not be permitted in storage areas or workrooms, other than in connection with properly controlled manufacturing processes such as flame-bonding (see paragraphs 88 to 94). Welding and cutting equipment which involves the application of heat should only be used under the conditions described in paragraphs 166 to 169.

Smoking

48 Smoking in premises in which CP is handled or stored should be strictly controlled. The best way is to impose a total ban on smoking throughout the premises, but the enforcement of such a rule may be difficult. An alternative method is to prohibit smoking in the CP storerooms and workrooms but allow smoking in designated safe areas. Suitable ashtrays should be provided in the designated areas. 'NO SMOKING' notices should be displayed in the areas in which smoking is prohibited.

Space heating systems

49 Areas in which CP is stored or used may be heated by hot water or low-pressure steam radiators, by indirectly-fired hot-air systems or oil-filled panel heaters. Fixed solid fuel, gas, or oil-fired heater units should be located in a safe place, preferably outside working areas and stores. Portable direct gas- or oil-fired heating appliances should not be used.

Electrical equipment

50 New equipment should be installed in accordance with guidance in the current edition of the IEE Wiring Regulations BS 7671: 1992.[12] Each circuit should be provided with over current protection. Additional protection is recommended using a residual current device rated at 100 mA for fire protection or, where feasible, 30 mA which also provides electric shock protection. New industrial machines should comply with BS EN 60204.[13] Existing machines should comply with BS 2771:1986.[14]

51 Electrical equipment should, when practicable, be totally enclosed and kept clean to ensure the normal heat transfer is not restricted by dust or crumb. Light fittings with incandescent lamps should have at least the protection of a wire cage. Dust or crumb should not be allowed to come into contact with the internal or external surfaces of apparatus whose temperature is likely to exceed 150°C (see also BS 6467, BS 7535, and BS 5958[15]). Most cellular plastics are good insulators, and if pressed close to electrical equipment are liable to cause overheating.

52 There is no need for electrical apparatus in CP foam stores or workrooms to be of special construction for use in flammable atmospheres unless necessary for other reasons, such as the use of highly flammable liquids. Advice on the choice and suitability of electrical equipment for locations where dangerous concentrations of vapour from highly flammable liquid are likely to be present is given in Code of Practice BS 5345: Part 1: 1989.[16]

53 Adequate protection against the possibility of the formation of incendive sparks arising from the discharge of accumulated electrostatic charges should be provided by efficiently earthing and bonding all metal parts of machines. The methods used for earthing and bonding should conform to standards detailed in BS 5958. Where it is not possible to earth effectively, consideration should be given to the use of an electrostatic eliminator. General advice on this subject may be obtained from HSE Inspectors.

Internal transport vehicles

54 Only those vehicles needed for movement of materials ought to enter workrooms or CP stores and they should not be allowed to become a short-cut for

vehicles between different parts of the premises. Unless they have been specially adapted, vehicles powered by internal combustion engines create a fire risk as hot parts of the engine and exhaust may ignite CP. It is preferable to exclude road vehicles from CP stores and to use electric vehicles or manual handling methods. The charging stations for battery-powered vehicles should not be located in areas where CP is stored or used.

Precautions outside working hours

55 After work has ceased for the day, a responsible person should inspect all areas to ensure that premises, plant and equipment have been left in a safe condition and particularly that there are no likely sources of ignition or signs of smouldering. Security arrangements, both during the working day and outside normal hours, should take into account the possibility of arson.

Maintenance of machinery and plant

56 Machinery and plant, especially those processing CP, should be maintained to a high standard by a competent person to eliminate inadvertent sources of ignition resulting from plant failure or poor maintenance (eg heat created by friction).

Highly flammable liquids

57 Highly flammable liquids are easily ignited and should be kept and used separately from CP except when unavoidable, eg the need to use highly flammable adhesives. Processes involving adhesives are described in paragraphs 95 to 112. Smoking should not be permitted in areas where highly flammable liquids are used or stored.

Flammable blowing agents

58 A variety of low boiling point liquids have been used as blowing agents, and as the use of chlorofluorocarbons (CFCs) has decreased for environmental reasons, the use of flammable blowing agents has increased. Flammable blowing agents such as pentane, which is widely used in making expanded polystyrene, are capable of forming an explosive mixture with air. To be capable of exploding, the concentration must fall within a flammable range which for many of these products is roughly 2-10% volume in air. The blowing agents used are not stenched, so dangerous concentrations cannot be detected by smell.

59 Where polystyrene beads containing a flammable blowing agent are transported in a freight container, incidents have occurred. Dangerous quantities of vapour can accumulate during transport and ventilating the container to a safe place before entering will reduce this risk.

60 To avoid the explosion hazard it is essential that flammable vapours released are dispersed to a safe place in the open air. The stages at which vapours may be released should be identified, and this will depend on specific process details. Estimates should be made of the amount of vapour evolved at different stages. Where flammable blowing agents are piped at high pressure into a workroom, any failure of the system could cause a flammable concentration of gas to be reached very quickly. A risk assessment of such a system should be carried out, which should consider the possible causes and consequences of a sudden release. It is important that any leak is detected quickly, and the source is isolated promptly.

61 Dispersion of the vapours may be by good natural ventilation, or by forced extraction. In either case it should be noted that the vapours are heavier than air and may accumulate at low levels if air movements are inadequate. If forced ventilation is used, the fan motor should not be within the ductwork.

62 A zoning exercise should be carried out to assess the concentration of vapours likely to be present in normal operation, or in the event of abnormal conditions. Measurements with a flammable gas meter will help to establish the extent of any zones and whether ventilation levels are adequate. The meter should be calibrated to the type of gas likely to be present. The results of the zoning exercise should be used to specify the areas where protected electrical equipment is needed.

63 Where cellular plastics blown with flammable liquids or flammable gases are held for more than 24 hours as part of the process, fire-resisting separation from other areas should normally be provided.

6 Flexible polyurethane (PU) foam

Freshly manufactured PU foam

64 Foam manufacture is an exothermic reaction and the foaming process needs to be carefully controlled to prevent the foam reaching excessive temperatures. The highest temperatures will normally be in the centre of a block. The temperature at which degradation or charring of the foam begins should be known. Checks may need to be made on the quality of chemicals used in foaming, and there should be periodic measurements of the temperatures within large blocks. Written procedures should be developed, setting out the action to be taken in the event of an overheating block, eg transfer to a safe place outside the building.

65 Fixed fire protection may usefully be incorporated within the casing or housing of the foaming machine. Consult the machine maker or suppliers of fixed fire protection equipment for advice.

Process handling

66 Flexible PU foam is widely used in upholstered furniture. Regulations designed to improve fire safety in the home mean that nearly all of the foam now made in Britain is CMHR. This is harder to ignite than the older types, but it must be recognised that the fire safety of a particular piece of furniture depends on the covering as well as the foam. In factories and other places where the foam is handled loose, the same high standard of fire precautions should be adopted for all types of flexible PU foam (see paragraph 5).

Process hazards

67 Although fire is the main risk associated with the processing of flexible PU foam, there are also risks to health and safety from dust explosion, and mechanical or toxic hazards that may arise singly or in combination in varying degrees of severity, according to the particular process being undertaken. A description of the

processes, the related fire hazards and the precautions necessary are set out in paragraphs 75 to 128.

Layout of process areas and workflow

68 The location of PU foam in workrooms will depend on the layout of process areas and on the position of process areas in relation to the bulk store and the finished goods store. In particular, the workflow should be carefully planned so that the minimum amount of PU foam is present at all times. As the material is light and easily transported, frequent replenishment of foam stocks in the workrooms is usually quite practicable. Similarly, finished goods should be removed as soon as reasonably practicable to the store or despatch area. In multi-storey factories, safe conditions are best achieved by having a downward workflow, with the bulk store above any workrooms. Additionally, where an operation with PU foam in a multi-storey building involves the large-scale handling of very easily ignitable substances, such as a highly-flammable liquid or crumb, it should preferably be carried out in a fire-resisting enclosure on the top floor.

Limitation of quantity of PU foam in workrooms

69 The extent of the fire hazard in any process area depends on the total stock of PU foam in that area. This may include PU foam awaiting processing, partly processed material or finished goods. Subject to general advice on stacking (see paragraph 70), every area occupied by PU foam should be as small a proportion of the total area of the workroom as is practicable. Preferably, the proportion should not be more than 10% of the total area, but there will be cases where the articles being manufactured will consist almost entirely of PU foam, eg in conversion processes and cushion filling, when the area occupied by foam may be greater than 10%. An increased proportion is acceptable, provided that there is the highest standard of compliance with the recommendations of this publication and provided that the area occupied by PU foam is kept to the minimum practicable. For the purpose of determining the occupied area, all PU foam, for example that stacked on work benches, should be taken into account.

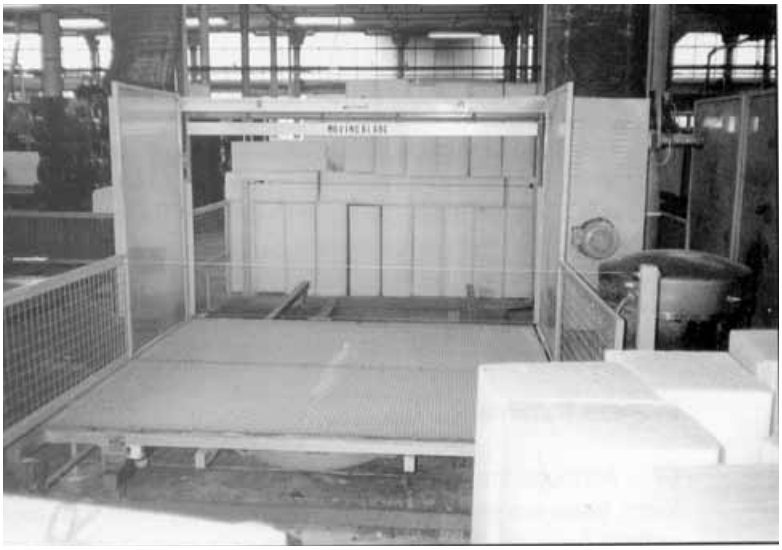
Stacking arrangements

70 Flexible PU foam awaiting processing, and shapes, such as finished cushions and slabs after conversion, should be arranged in stable stacks using pallets or racks where necessary (see Figure 3). Rolls of laminated material should be kept in racks. Upholstered furniture may be kept in single units, in racks or stable stacks as appropriate. All materials should be kept in well-defined areas separated by marked gangways as recommended in paragraph 36. PU foam and work-in-hand incorporating PU foam should be stacked in workrooms under the same limitations of stack area and height set out for storerooms in paragraph 36. Furthermore, PU foam or finished articles should not be kept against internal glazing or directly under any elevated working area. Elevated working platforms and galleries are not recommended in PU foam workrooms. Where these exist, PU foam should be kept as far as possible away from them and adequate fire protection and means of escape must be provided. Materials in workrooms should not be stacked within 1 m of any part of a fire exit.

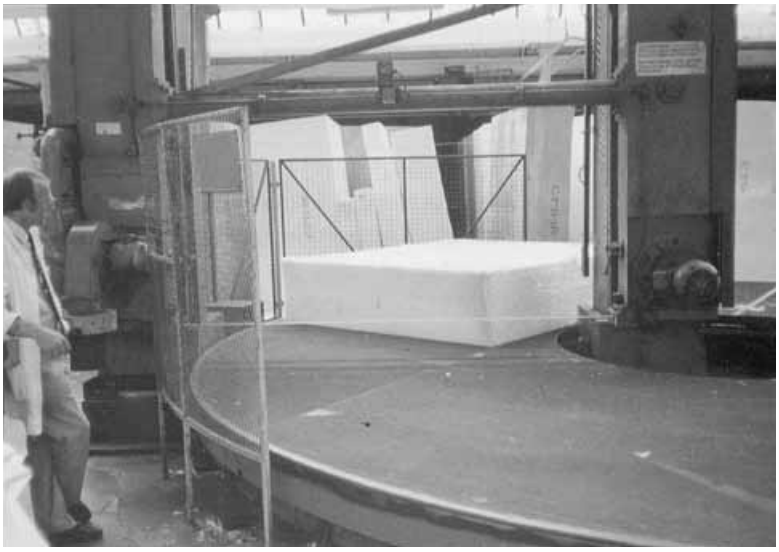
Figure 3 Examples of stacking arrangements

Vertical bandknife (automatic)

Profile splitting machine



Rotating table bandknife



Material handling

71 The transfer of material between floors should be subject to the recommendations set out in paragraph 23. Small amounts of flexible PU foam may be carried up and down stairs as required, provided that the building can always be evacuated quickly by means of an alternative suitable protected route. Access doors to staircases should never be secured in the open position and PU foam materials should not be left, even for short periods, on stairs or landings.

72 See paragraph 54 for advice on the use of powered vehicles to transport materials in process areas.

Fire separation between processes

73 In general, where a number of different operations involving the use of flexible PU foam are carried out in a large workroom, compartmentalisation of each operation within a fire-resisting enclosure need not be considered unless any of them present an increased risk of fire. Such higher risk work operations include flame bonding (see paragraphs 88 to 94), large-scale use of highly flammable liquids (see paragraph 108) and crumbing and filling (see paragraphs 122 to 128).

Openings in fire-resisting compartment walls

74 Openings may be needed in compartment walls for doors for personnel access, vehicle movement or services such as ventilation ducting. Personnel doors are normally provided with self-closing devices, whereas doors for vehicles or hand-propelled trucks are commonly held open by a mechanism designed to allow the door to close automatically in the event of fire. Where such doors are provided, they should preferably be linked to automatic smoke detectors, and not on fusible links, as smoke detectors react more rapidly in the early stages of a fire involving PU foam. It should be possible to close manually any door designed to close automatically. Similarly, fire dampers in service ducts should preferably be operated by automatic smoke detectors which operate much faster than fusible links.

7 PU foam conversion processes

General

75 The following processes are usually carried out at factories handling flexible PU foam in large quantities. A description of each process is given and the hazards likely to be encountered are listed. The precautions advised in this section should be regarded as additional to and not as a substitute for those contained in other sections of this publication.

Cutting

Knife cutting

76 Horizontal, vertical or inclined cutting machines (band knives) are used to cut blocks into sections and to make finished components from PU foam. Where the cutting knives run in fixed guide sheaths, the passage of the PU foam past the guide may be helped by a lubricant. There may be multiple knives which have their cutting edges continuously sharpened by grinding wheels; also, several sheets may be cut at one time. Other machines, used mainly for radius cutting, have a thin

reciprocating blade carried in a sheath which is shaped to give the required contour when PU foam is pushed against the blade by hand. On a still smaller scale, machines with twin oscillating saw blades, moving out of phase, can be used.

Peeling

77 Peeling may be regarded merely as an extension of horizontal cutting. A cylinder of PU foam is cut into veneer by rotating it against a continuously sharpened band-knife which can be adjusted to give a veneer of uniform thickness.

Press cutting

78 Complex shapes of uniform thickness are made from sheet material by using cutters consisting of strip steel set into wooden blocks in either hydraulically- or mechanically-operated presses.

Rotary cutting

79 Strips of PU foam may be cut from sheet material by rotary cutting, in which the material is fed through a number of rotating circular knives whose spacing determines the strip width.

Hazards in cutting processes

80 PU foam is not likely to be ignited as it is cut, but ignition may be caused in other ways, eg dust accumulations inside the guards of band knives may be ignited by sparks from the grinding wheels used to sharpen the blades.

81 Cutting lubricants may contain highly flammable liquids, the vapour from which could be ignited by a number of means including the discharge of static electricity.

82 There is a risk of ignition when cylinders of PU foam are prepared for peeling, if the central hole is bored by means of a heated rod. A rotating tube bit is a safer option.

Precautions for cutting processes

83 Frequent cleaning inside machine guards is necessary, and the fitting of a water tray under the grinding wheels is advisable.

84 See paragraphs 124 to 128 for necessary precautions relating to dust and crumb, and paragraphs 50 to 53 for precautions applicable to electrical equipment on, or near, cutting machines.

85 Precautions should be taken when lubricants containing highly flammable liquids are used. All machines should be effectively earthed and situated in well-ventilated areas. Lubricants in aerosol containers should be stored in a suitably placed steel cupboard or bin with a lid, and proper arrangements made for the safe disposal of empty aerosol containers from the building.

86 All off-cuts should be dealt with as in paragraph 42.

87 Portable fire extinguishers should be provided within easy reach of all cutting machines. The Home Office Guide[2] gives detailed advice.

Flame bonding

88 The technique of flame bonding involves passing a PU foam surface across a naked flame to produce a layer of semi-molten polymer which forms a bond when brought into contact with another material, usually a fabric. The heat source usually consists of a number of gas jets.

Hazards in flame bonding

89 Should the PU foam passing through the flames be slowed or stopped, it will become overheated, with the obvious risk of fire. In normal operation there is also a toxic risk from the evolution of significant quantities of fume containing free isocyanates, and this should be dealt with under the Control of Substances Hazardous to Health Regulations 1994 (COSHH).[17] Flame bonding is a prescribed process under the Health and Safety (Emissions into the Atmosphere) Regulations 1983[18] which are enforced by HM Inspectorate of Pollution.

Precautions for flame bonding

90 The process should, if practicable, be separated from other operations and be contained within a fire-resisting enclosure as recommended in paragraph 73.

91 The gas supply to the burner should incorporate a flame failure device and be electrically interlocked with the machine drive motor so that, if the machine is stopped after bonding has started, the burner is automatically extinguished. By this means, prolonged exposure of the PU foam to the heat source can be prevented. In addition the system should be installed and serviced annually by a competent gas fitter with experience in industrial gas-fired plant.

92 Escape of fume into the workroom atmosphere should be prevented by enclosure and exhaust ventilation of the laminating sections of the machine. In addition, a local exhaust ventilation system should be installed to remove fumes generated near the burner and in the laminating nip. Exhaust ducts should terminate outside the building at a sufficient height and in a suitable position for fume to be effectively dispersed, eg discharge points should be sited away from opening windows through which fume could re-enter the premises.

93 There should be adequately sized fresh air inlets to ensure combustion of the gas and to provide a high standard of ventilation in the workroom.

94 Newly-bonded materials should be transferred to a well-ventilated area and kept there until they stop fuming.

Adhesive lamination

95 For bonding laminates on a large scale, the adhesive is applied by rollers at the coating head of a machine and the coated surface of the material is then brought into contact with another material, often a fabric. The machine may incorporate a drying section. The manual application of an adhesive by brush or scraper is dealt with in paragraphs 103 to 112.

Hazards in adhesive lamination

96 The presence of flammable solvent in the adhesive will enhance the risk of the PU foam igniting and may increase any toxic risk; this should be dealt with following a risk assessment under COSHH.

Precautions for adhesive lamination

97 To reduce the overall fire risk, non-flammable adhesives, which are available for most applications, should be used whenever practicable. When the use of highly flammable adhesives cannot be avoided, additional precautions will be necessary, eg their use and storage may be subject to the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972 (HFL)[19] and possibly the Petroleum Consolidation Act 1928[20] (storage only). Fire separation between adhesive lamination and other processes is recommended (see paragraph 73).

98 To prevent solvent vapour entering the workroom atmosphere, the bonding machine should be enclosed to the maximum practicable extent, and local exhaust ventilation applied at points of solvent evaporation, principally at the coating head. An inward airflow at each opening of at least 0.7 m/sec (approximately 140 ft/min) will be needed to control vapour release but this may need to be increased significantly in the case of a particularly toxic solvent.

99 Adequate air inlets should be provided. Exhaust ducts should terminate outside the building at a sufficient height and in a suitable position for fume to be effectively dispersed, eg discharge points should be sited away from opening windows through which fume could re-enter the premises.

100 Where electrical equipment is used in the presence of flammable vapours see paragraph 52.

101 If drying ovens are used, their heating units should be sited in a safe position remote from any source of flammable vapours. A recirculatory system may be employed to conserve heat but a minimum volume of 60 m^3 of fresh air should be introduced into the oven for every litre of adhesive used. Such dilution is necessary to ensure that the concentration of vapour within the oven does not exceed 25% of the lower flammable limit. To monitor the air flow, a suitable flow switch or other device, which is interlocked with both the supply of heat to the oven and also with the feed mechanism which conveys the work through the oven, should be installed. This should be positioned either in the fresh-air inlet duct or in the exhaust duct. Explosion relief should be provided for the oven. New European standards for machines of this type are being written, which will describe other ways of meeting the required level of safety.

102 Highly flammable adhesives should be kept and/or used in accordance with statutory requirements.[18, 19]

Fabrication

103 In this publication, fabrication is considered to be the process by which an article or component is made from sections of PU foam manually bonded together, or to other materials, normally by an adhesive. Complex shapes comprised of different grades of PU foam may be joined, or alternatively the foam may be bonded to backing materials such as hardboard, cardboard, plywood, rigid foam etc. Many converters and upholstery manufacturers undertake this process.

Hazards in fabrication

104 There may be a toxic hazard and/or a fire hazard from the considerable quantities of vapour given off whenever large areas of freshly-applied adhesive are exposed. These are particularly acute when solvent-based adhesives are sprayed and the COSHH and HFL Regulations may apply.

Precautions for fabrication

105 Low toxicity, non-flammable solvents and adhesives should be used where possible (see paragraph 96).

106 In all cases, fabrication should be carried out in a well-ventilated workroom. Generally, the ventilation should ensure that the concentration of vapour in the atmosphere is kept well below the accepted occupational exposure (or maximum exposure) limit for the mixture of solvents contained in the adhesive. Improved control can be achieved by use of a non-flammable booth provided with local exhaust ventilation. This will not only reduce the toxic risk from solvent vapour, but because the occupational exposure standards are below the corresponding lower

flammable limits, will also reduce the risk of fire posed by the use of flammable solvents. Any ventilation system provided for a flammable atmosphere should comply with BS 5345.

107 The flow of work through fabrication workrooms should be planned to minimise, as far as is practicable, the total exposed surface area of freshly applied adhesive prior to bonding.

108 Where highly flammable adhesives are used on a large scale in fabrication, the process should be separated from other conversion activities and be contained within a fire-resisting enclosure (see paragraph 73).

109 Where solvent-based adhesives are sprayed, stringent precautions will be necessary. This operation should be carried out, as far as is reasonably practicable, inside a spray booth or a spray enclosure constructed of sheet steel and provided with effective mechanical exhaust ventilation (see paragraph 106). Where this is not reasonably practicable and the operation is carried out at fixed locations such as work benches, effective mechanical exhaust ventilation should be applied as near as possible to the source of vapour emission. There should be a minimum air flow rate of 0.7 m/s (approximately 140 ft/min) at collecting points, which should be positioned so as to draw the vapours away from the operator.

110 To control ignition sources, the extent of any hazardous area caused by the spraying operation needs to be assessed. Standards BS 5345 and BS 5501[21] give advice on selection and use of electrical equipment that may be used in the hazardous area, eg lighting.

111 A non-flammable solvent of low toxicity should normally be used for cleaning. If a flammable solvent must be used, its flashpoint should be as high as practicable.

112 Materials such as cotton, rayon, jute and some traditional stuffing materials are sometimes used in conjunction with PU foam in upholstery. They may add to the fire hazard in factories because small incandescent sources will generally ignite them more easily than they will ignite PU foam. Consequently particular attention needs to be given to housekeeping (see paragraphs 37 to 44) and to eliminating sources of ignition (see paragraphs 45 to 56).

Shaping

113 The shaping of sections of flexible PU foam can be carried out mechanically by grinding with coarse, abrasive wheels revolving at high speeds. The alternative technique of routing, where the unwanted material is removed by a vertically mounted high-speed rotating cutter, is usually employed when articles with cut-out portions of varying depths are required.

Hazards in shaping

114 In addition to the obvious mechanical hazards from the cutters and the moving parts of the machines, shaping processes produce dust and granular material. If not controlled, this will create an increased fire hazard and, if sufficient fine material is produced, a dust explosion hazard. The particles are often electrostatically charged and can be strongly attracted to certain surfaces, forming a continuous layer of material along which the rate of flame spread is likely to be rapid. The fine material tends to penetrate motor casings and bearings and can cause electrical equipment to become overheated, thereby increasing the risk of fire (see paragraphs 50 and 51).

Precautions for shaping

115 Dust and fine particles produced during grinding and routing operations should be controlled by effective enclosure and the provision of mechanical exhaust ventilation as near as possible to the points of dust emission. A dust collector such as a dry filter and/or a suitable cyclone should be provided in accordance with the recommendations contained in the booklet HS(G)103 *Safe handling of combustible dusts*. Where dust penetration of electrical equipment is a problem, dust-tight casings to IP6X standard (BS 6467) should be provided. The effects of electrostatic static discharges should be considered (see BS 5958). The classification system is described in BS EN 60529,[22] the Index of Protection (IP).

116 A high standard of housekeeping is essential (see paragraphs 37 to 44).

Hot-wire cutting

117 In this process, blocks of flexible PU foam are cut as they travel, either by gravity or by a mechanical conveyor, through an assembly of flat-sectioned, heated resistance wires.

Hazards in hot-wire cutting

118 Normally the risk of ignition is low, but fires may result if the temperature of the wires is initially set too high or if the wires are short-circuited in use. Ignition may also occur if the feed to the machine is stopped so that foam remains in contact with the hot wire. In both these situations the foam may be heated to temperatures above 300-400°C when chemical breakdown can occur causing toxic fumes and flammable vapours to be emitted. Hot wire cutting is a prescribed process under the Health and Safety (Emissions into the Atmosphere) Regulations 1983 enforced by HM Inspectorate of Pollution.

Precautions for hot-wire cutting

119 The machine should be properly set up by a trained operator and should not be left unattended while in operation.

120 Any off-cuts that are produced should be dealt with as in paragraph 44, and appropriate fire extinguishers should be provided.

121 To prevent atmosphere contamination, freshly-cut PU foam sections need to be allowed to cool within a suitable ventilated enclosure for an adequate period of time before they are moved into the general area of the workroom.

Crumbing

122 Crumbing is the reduction of pieces of PU foam to produce material of a size suitable for reuse, eg as a cushion filler, as stuffing for soft toys or as a constituent of bonded slabstock. Several types of machine are used for the process, the most common being a rotary cutting machine known as a granulator. In addition, modified rag-pulling machines which tear the off-cuts to fine shreds, and hammer mills, which grind the material, are used. Crumb produced in large quantities is usually passed through a sieve and transferred to a storage hopper by a pneumatic system. It is preferable to minimise the amount stored by using crumb as soon as it is produced.

Hazards in crumbing

123 The production and use of PU foam crumb gives rise to a very high fire hazard unless the operations are strictly controlled. If not contained, the crumb is likely to spread; the resulting deposits on floors and other surfaces will increase the risk

of spread of fire in a workroom. In addition, the dust and fine crumb produced in some plant, particularly hammer mills, may give rise to the risk of a dust explosion (see paragraphs 39 to 41).

Precautions for crumbing

124 The crumbing machine and any adjacent crumb-handling and/or utilising plant should be separated from other operations and, where practicable, be contained within a fire-resisting enclosure as recommended in paragraph 73.

125 To control crumb and dust, the crumbing machine should be enclosed as fully as is practicable and air should be drawn through the working opening of the machine at a rate sufficient to remove all crumb/dust and to prevent them entering the atmosphere of the workroom. Ducting of sound construction with efficient joints should be used to link the crumbing machine with the receiver, which may be a storage hopper or a cyclone.

126 Crumb of the size usually manufactured does not normally present a dust explosion hazard because the amount of fine dust produced in this operation is usually small. However, if it is allowed to accumulate in the workroom or is collected in dust-collecting plant, a dust explosion hazard will exist. The advice given in paragraphs 134 and 135 is also relevant.

127 Accumulations of fine dust in the workroom can be prevented by regular cleaning, preferably with a suction cleaner, and any plant associated with the collection of fine dust should be constructed in accordance with the recommendations contained in HS(G)103.[10] The finer the crumb, the further it will spread, increasing the need for effective cleaning. Advice on particular installations where this hazard is likely to be present can be obtained from HSE.

128 Large piles of loose off-cuts on the workroom floor should not be allowed to accumulate. Bales of off-cuts awaiting crumbing should not be opened until required.

8 Expanded and extruded polystyrene

129 All expanded polystyrene samples will soften, melt and depolymerise if involved in a fire and a pool fire may develop at the base of the sample.

130 Expanded polystyrene is normally made from polystyrene beads which are first blown, then reheated to form blocks. These blocks are usually cut by hot-wire cutting processes (see paragraphs 117 to 121). They can also be shaped using routing machines and advice is given in paragraphs 113 to 116.

131 Expanded polystyrene is also recycled from block form into expanded crumb form or into unexpanded chips. Paragraphs 122 to 128 describe some of the problems. Polystyrene crumbing machines may generate dust fine enough to explode and, if fresh blocks have to be crumbed, flammable vapours may be released depending on the blowing agent. Where flammable vapours/atmospheres are present, all electrical equipment should comply with BS 5501, or equivalent, and BS 5345.

132 It is important to avoid sources of ignition in the crumbing unit. Foreseeable sources are frictional hot spots caused by tramp metal or stones embedded in the blocks fed to the machine, or electrostatic discharges.[15]

133 The possibility of frictional heating may be reduced by visual inspection of all material fed to the crumbing machine. Such machines should also be supervised adequately so that they may be shut down promptly if there is any indication of an unusual noise or fire coming from the machine.

134 If fine dust is formed by the crumbing machine, any extraction system should be protected against the possibility of a dust explosion.[11]

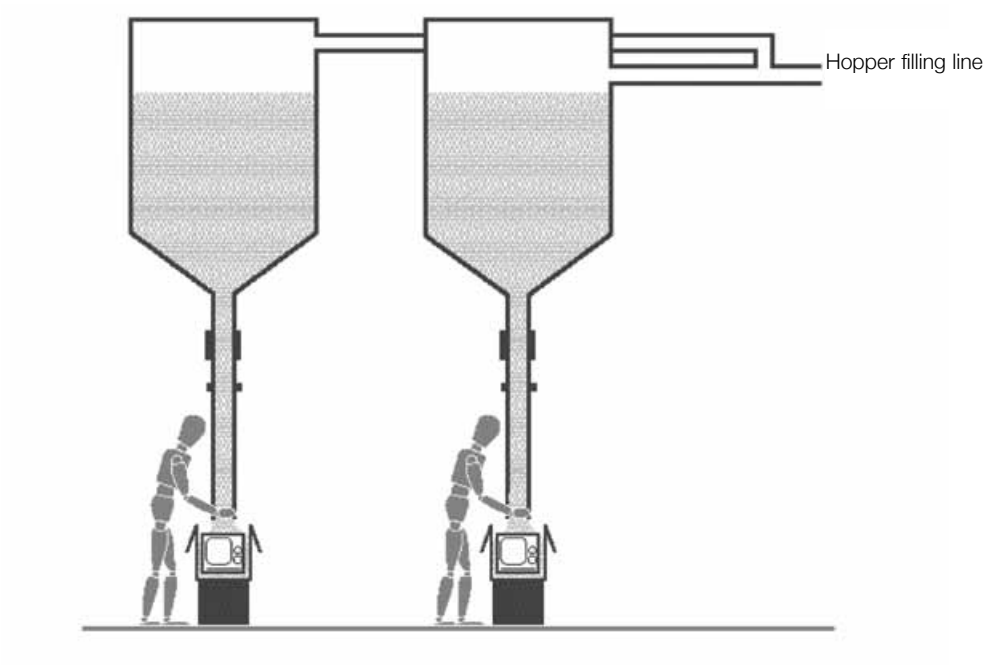
135 To prevent electrostatic discharges all metal parts of the crumbing plant and collection system should be bonded and earthed.[15]

136 If heat shrink-wrapping of finished blocks is carried out it should take place in an area which is separated from storage areas.

EPS loose-fill packaging

137 Expanded polystyrene loose-fill material is usually supplied to users in either standard polythene bags of about 0.5 m^3 capacity or in bulk. The material may be used directly from the bags, or more conveniently transferred into overhead fabric hoppers in the packing room where it can be dispensed as required under gravity (see Figure 4). This application requires keeping bagged material in a store, plus 'in use' material in the work area.

Figure 4 Dispensing system for loose-fill from overheard storage hoppers



138 For larger users, systems are available that allow the EPS loose-fill to be delivered in bulk transporters from where it is transferred pneumatically to a storage facility within the factory. The storage facility, of any size but normally about 50 m^3, can be a purpose-built storeroom in or away from the workroom, or may be a large suspended fabric or plastic hopper sited in any appropriate work space in the factory. The EPS loose-fill is distributed pneumatically from the bottom of the storage facility along metal ducting to conveniently sited packing points. At the packing point, vertical flexible ducting and a manual control allow the EPS loose-fill to be dispensed as required.

Hazards in storage and use of EPS loose-fill

139 The handling systems described are an aid to good housekeeping, but tend to increase the quantity of high-hazard material present in the workroom or in store. However, provided the precautions given in paragraph 142 are followed, the bulk loose-fill in an overhead fabric hopper is unlikely to be involved in the early stages of a fire.

Precautions for storage and use of EPS loose-fill

140 All expanded polystyrene loose-fill packaging should be considered a high- hazard flammable solid by the standards set out in HS(G)64,[1] unless the manufacturer or user has test results which indicate the contrary.

141 Bagged EPS loose-fill in the workroom should be restricted to one bag, or the quantity used in a day or shift. Quantities above this should be stored in a separate storeroom. The fire danger of bagged EPS loose-fill in the workroom is most easily controlled if it is kept in designated areas, at least 2 m from obvious sources of ignition, and away from all escape routes.

142 The danger of rapid fire spread is reduced if overhead hoppers are separated from other flammable materials on racking, mezzanine floors etc. A 2 m horizontal and vertical separation is recommended. Such hoppers should not be directly beneath incandescent light fittings or close to radiant heaters or other ignition sources.

143 Purpose-built storerooms for holding bulk EPS loose-fill should follow the guidance in paragraphs 30 to 36.

144 Smoking and naked flames should be excluded from areas where EPS loose-fill is stored or used. Where it is necessary to introduce a source of ignition near to storage hoppers or rooms, eg for maintenance, the EPS loose-fill should normally be removed first. In all cases close supervision is needed and a permit-to-work system is recommended (see paragraphs 166 to 169).

145 Spilt EPS loose-fill and combustible waste should be removed regularly.

146 Where transfer ductwork passes through a fire compartment wall, any fire protection will be lost unless an automatic fire damper capable of closing, even in the presence of loose-fill material, is provided. The local fire authority should be consulted for further advice.

9 Rigid urethane and polyisocyanurate (PIR) foam

147 Rigid urethane and PIR foam may be made as large blocks, but is more commonly laminated directly to facing materials such as metal, plasterboard, plywood or roofing felt.

148 Many of these products are used as components of walls and roofs. They are accordingly tested to the appropriate parts of BS 476[23] and may achieve Class 0 or Class 1 fire rating. The BS 476 tests are not intended to indicate how a fire will develop in a large stack of panels. The medium-scale room test will give some useful information, but the assessment of the fire risk of stacked composite panels is not straightforward.

149 In general, PIR foams burn less readily than PU foams, even if the latter contain fire-retardant additives. Both types of foam tend to char and not burn to completion. The extent of the fire may then depend on the surface area of foam exposed to a fire. The volume of smoke produced by some types of rigid PU foam is sufficient to put them in the high fire risk category (as defined in HS(G)64).

150 In storage, separation should be provided between stacks of foam, and easily ignitable materials such as paper, polythene sheeting or other types of cellular plastics used as packaging. Off-cuts and waste should be kept outside.

10 Fire precautions

General fire precautions

151 These are normally the responsibility of the fire authority in all premises except those to which the Fire Certificate (Special Premises) Regulations apply (see paragraph 9).

Means of escape

152 Detailed information can be found in the Home Office booklet *Fire Precautions Act 1971: Guide to fire precautions in existing places of work that require a Fire Certificate*.[2] Most premises making or using substantial quantities of CP should be considered high-risk premises, and the higher standards of means of escape set out in the guide will apply.

153 The purpose of requiring adequate means of escape from a building is to ensure that, in the event of an outbreak of fire in any part of the building, each occupant should be able to reach safety unaided and without being placed at risk while doing so. The guide[2] gives advice on assistance for people with disabilities.

154 When considering means of escape it is helpful to have some understanding of the nature and predictable behaviour of fire. Fire is usually associated with flames, but it also produces smoke and toxic gases and it is these which present the major dangers to life; the majority of fire fatalities follow asphyxiation or the effects of toxic gases and are not due to people being burned.

155 When a fire occurs in an enclosed space, a column of smoke and hot gases rises and, on reaching the ceiling, spreads laterally, eventually filling the whole enclosure. If there is an unprotected opening in the enclosure, smoke and hot gases will rapidly spread to other parts of the building. A study of human behaviour in fire conditions has shown that the presence of smoke will often deter people from using otherwise safe escape routes. For the safety of occupants, therefore, the means of escape should be designed and constructed in such a way that the spread of smoke, hot gases and subsequent fire into and along these routes is prevented or delayed.

156 When a room or building becomes smoke-logged, ie filled with smoke to the extent that vision is obscured, the lives of people caught in these conditions are seriously threatened. Burning CP produces smoke so fast that a room in which it catches fire will very rapidly become smoke-logged and for this reason any people will have to be evacuated extremely quickly. This can only be achieved through the provision of a high standard of means of escape that is properly maintained at all times.

157 Most premises using CP will require a Fire Certificate. The only exceptions would be where the materials involved are of such a kind and quantity that the

fire authority has determined they do not constitute a serious additional risk to workers. All users of CP should apply to the local fire authority for a Fire Certificate if the premises do not have a current certificate, unless the conditions for the Fire Certificate (Special Premises) Regulations 1976 apply, in which case HSE should be contacted.

Structural fire precautions

158 Internal subdivision of a building by fire-resisting walls, floors and doors is an important way of preventing smoke spreading through a building, and delaying the spread of fire from one part to another. Earlier sections describe where this is needed. The degree of fire resistance required will depend on the floor area of the room or storey of a building. In multi-occupancy buildings, a minimum of 1 hour fire-resistant separation between parts under different control is likely to be needed. Where large blocks of foam are moved, openings in walls may also have to be correspondingly large. Selection and correct installation of large fire doors requires specialist advice. Where fire doors are normally held open to allow easy movement of goods, automatic closing controlled by smoke detectors is strongly preferred to heat sensitive devices like fusible links, which respond more slowly.

Smoke control

159 Rooms, corridors and stairs may be affected by smoke at an early stage in a fire involving CP. Spread of smoke beyond the room in which a fire started will seriously reduce the chance of escape for people in the building. A regular check that all fire doors are not obstructed and are in good repair is necessary.

160 Advice on ways to prevent smoke being spread rapidly round the building in ducted heating or ventilation systems is given in BS 5588[24] Part 9.

Automatic fire detection

161 In many circumstances, automatic fire detection systems will give an earlier warning of a developing fire than a manually-operated system. The linking of an automatic fire detection system to a manual system should be seriously considered in:

(a) multi-storey premises;
(b) buildings where CP is kept in areas not in constant occupation, other than dedicated storage buildings;
(c) other circumstances where the rapid evacuation of all personnel may be difficult;
(d) areas where vision is limited and a developing fire may not be noticed.

162 Any automatic detection system should comply with BS 5839, Part 1 1988.[25]

Automatic sprinkler installations

163 Automatic sprinkler systems are effective in detecting, giving warning of, and controlling fires. When they are fitted, new installations should comply with BS 5306.[26] High-racked storage of highly flammable CP will require sprinklers both at ceiling level and intermediate (lower) levels for effective control of fire.

164 Sprinkler systems are of particular value in controlling fires which occur outside normal working hours and, where they are installed, fire insurance premiums may be reduced.

Smoke ventilation systems

165 Automatic smoke ventilation systems are sometimes installed and, where provided, these will delay the build up of heat and smoke within a building. The design of such systems and their interaction with sprinklers is not straightforward and expert advice should be sought. This may be available from equipment installers or the local fire authority.

Maintenance involving hot work

166 Maintenance work involving the use of naked flames, eg welding, use of blow lamps, and work which produces frictional sparks, eg grinding and disc cutting, should be closely controlled. Where outside contractors are used, written procedures should be developed to ensure that the responsibilities for adopting safe systems of work are clearly set out.

167 When hot work is carried out, either by employees or outside contractors, a permit-to-work procedure should be used. An example form of such a permit is given in Figure 5.

168 Whenever hot work is carried out, it is always preferable to remove all easily ignitable material such as CP or packaging from the vicinity of the work rather than try to screen it off. The safe distance around hot work will depend on the nature of the operation, but it is generally recommended that the clear distance should not be less than 5 m; where work is carried out at high level a substantially greater clear distance is needed.

169 The area around the site of hot work should be carefully checked for signs of ignition/smouldering immediately after the work has been completed, and at intervals for up to an hour after that.

Figure 5 Example of a permit-to-work for hot work

PLANT DETAILS (Location, identifying number etc)

WORK TO BE DONE

EQUIPMENT TO BE USED (eg electric arc welding set, abrasive cut-off disc)

CLEANING LOCATION
The area has been cleared of flammable and combustible materials which could be ignited by the activity, falling slag or sparks, and/or suitable coverings have been provided (specify which)

FIRE FIGHTING
Suitable fire extinguishers/hoses have been placed adjacent to the work (specify which)

Persons doing work have been adequately trained in their use/trained fire watcher present (specify which)

CONDITIONS
Work should cease in the event of the following:

I CERTIFY THAT I HAVE PERSONALLY EXAMINED THE PLANT DETAILED ABOVE AND SATISFIED MYSELF THAT THE ABOVE PARTICULARS ARE CORRECT.

Signed Date Time

ACCEPTANCE OF CERTIFICATE
I have read and understood this certificate and will undertake to work in accordance with the conditions in it.

Signed Date Time

COMPLETION OF WORK
The work has been completed and all persons under my supervision, materials and equipment withdrawn.

Signed Date Time

REQUEST FOR EXTENSION
I have re-examined the plant details above and confirm that the certificate may be extended to expire at:

Further precautions:

Signed Date Time

INSPECTION OF LOCATION IMMEDIATELY AFTER WORK

I have examined the work location and there is no sign of ignition/smouldering of any substance.

Signed Date Time

INSPECTION OF LOCATION ONE HOUR AFTER WORK

I have examined the work location and there is no sign of ignition/smouldering of any substance.

Signed Date Time

THE PERMIT TO WORK IS NOW CANCELLED. A NEW PERMIT WILL BE REQUIRED IF WORK IS TO CONTINUE.

Signed Date Time

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12 BS 7671: 1992 *Requirements for electrical installations: IEE Wiring Regulations 16th Edition*

13 BS EN 60204 *Electrical equipment of industrial machines*

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15 BS 5958 *Control of undesirable static electricity*

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20 *Petroleum* (Consolidation) Act 1928 Ch 32 HMSO

21 BS 5501 *Electrical apparatus for potentially explosive atmospheres*

22 BS EN 60529:1992 *Specification for degrees of protection provided by enclosures (IP code)*

23 BS 476 *Fire tests on building materials and structures*

24 BS 5588 Part 9:1988 *Code of Practice for ventilation and air conditioning ductwork*

25 BS 5839 Part 1: 1988 *Fire detection and alarm systems for buildings - Code of Practice for system design, installation and servicing*

26 BS 5306 Part 2: 1990 *Fire extinguishing installations and equipment on premises: Specification for sprinkler systems*

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