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To
Factory Inspectors
FCG Specialist Inspectors (Process Safety, Elec)

THE FILLING AND STORAGE OF AEROSOLS WITH FLAMMABLE PROPELLANTS

This OC updates and replaces the advice given in OC 278/34. It includes guidance on standards of segregation and enclosure of aerosol filling machines using flammable propellants, and invites inspectors to inform the Chemical Manufacturing (CM) NIG of any difficulties they have in enforcing them.

PROPELLANTS

1 Aerosol propellants may consist of liquefied petroleum gas (LPG), chlorinated carbons (CFCs), a mixture of the 2 or, for special purposes, other liquefied flammable gases, eg dimethyl ether (DME), difluoroethane (DFE) or carbon dioxide. The propellants most commonly used are blends of butane/ propane or CFC/LPG having vapour pressures in the range 2-7 bar at ambient temperature.

2 CFC/LPG mixtures are usually formed in the aerosol can during filling and are rarely stored as mixtures in bulk. They are normally supplied separately for filling as liquid from either bulk vessels or cylinders. DME and DFE are normally supplied from cylinders of up to 500-800 kg capacity; occasionally from bulk storage vessels.

3 As a result of the Montreal protocol, the use of CFCs will be phased out completely by 1 January 1995, when the use of various flammable propellants will predominate.

Liquefied petroleum gas

4 LPG is colourless and its density as a liquid is approximately half that of water. The gas or vapour is at least 1½ times as dense as air and does not disperse easily. It tends to sink to the lowest possible level and accumulate in any pit or depression.

5 The flammable range for LPG/air mixtures is approximately 2%-10%. This can vary if a mixed CFC/LPG propellant is used. Typically a 70:30 CFC/LPG propellant has a lower flammable limit (LFL) of about 4%.

6 For general use LPG is odourised to allow leaks to be detected by smell at low concentrations. However, the presence of a stenching agent is usually unacceptable in aerosols and so unstenched LPG is used. The use of odourless LPG calls for

particular vigilance and attention to potential sources of leaks throughout the process. Unless care is taken, escapes of vapour may go undetected and lead to the formation of flammable concentrations of gas.

Dimethyl ether

7 DME is a colourless, virtually odourless flammable gas with similar properties to LPG, including its density which is close to that of propane (see the appendix).

8 Its attractive distinguishing property is its water solubility. There are some doubts about the exact solubility of DME in water which are currently being explored, but it is generally agreed that the addition of 6% ethanol to any DME - water mixture will secure complete solubility. This feature could lead to some special problems in storage, should leaks occur or water for fire protection need to be applied (**see para 20 (2)**).

9 Both the liquid and the vapour are powerful solvents which means that care needs to be taken in selecting materials for valve gaskets. PVC, neoprene rubbers and other elastomers are likely to be attacked, and are unsuitable. Butyl rubber is generally recommended for aqueous DME mixtures and chlorobutyl rubber for non-aqueous. Materials used for other duties eg LPG, are likely to be incompatible, therefore, dedicated filling lines should be used for DME.

Difluoroethane

10 DFE is a propellant thought to be quite widely used in the UK. Its properties are again similar to LPG and the same general safety recommendations apply. The vapour is about 2½ times heavier than air and forms flammable mixtures in air within the range 3.9% - 16.9% by volume. Users of this material should consult the supplier for information on material properties and use, and the suitability of certain types of gas detection apparatus.

AEROSOL MANUFACTURING PROCESS

11 There are 2 methods by which aerosol containers may be filled. The usual method involves filling the can with propellant under pressure at ambient temperature after it has been filled with the product and the valve crimped into place. In the case of DME/DFE it is sometimes possible to mix the product and the propellant before filling the can. In an alternative method, rarely seen in the UK, both the product and propellant are refrigerated and the container filled at atmospheric pressure before the valve is fitted.

12 The pressure filling process involves the following stages:

- (1) the product is charged into the container;
- (2) the valve is fitted into the neck of the container and crimped into place;
- (3) propellant is pressure filled into the container through the valve;

- (4) the filled container is tested for leaks by immersing it in a heated water bath for several minutes;
- (5) the container is weighed for quality control purposes and to check for overfilling;
- (6) the button and outer cap are added;
- (7) the containers are packed, shrink-wrapped and palletised; and
- (8) the finished product is moved to the warehouse for storage;

13 Filling is a continuous process with the containers moving on a conveyor past the filling heads and on through the process. A number of filling heads may be used both for product and for propellant filling. Usually separate filling heads are provided to inject CFC and LPG into the containers. The filling heads may be mounted in a line or, more frequently, above a circular table. In some cases the propellants are premixed before being pumped to the filling unit. On small scale plant the filling operation may be carried out manually.

14 On the larger, more modern filling machines, valves are inserted into the containers automatically and people do not need to be in the vicinity of the machine. With simpler, older machines the valves may be inserted by hand before the propellant is filled.

HAZARDS

15 Propellant is piped as a liquid under pressure from storage to the filling machine. The pressure used in a factory for propellant filling can vary between 7 and 34 bar depending upon the number and type of filling machines being operated. A leak in the supply pipe between the storage and filling areas can rapidly give rise to a large and potentially dangerous cloud of vapour.

16 The areas surrounding the propellant filling machine and the conveyor immediately after the filling point are potentially the most hazardous of the whole process because the hose connections at a filling machine and the piston seals on each filling head are likely sources of leaks. A small leak of propellant occurs each time a container leaves a filling head.

17 After the filling operation containers with faulty seams or valves, or those which are subsequently inadvertently damaged, may leak carrying the hazard along the production line (see **paras 72-75** concerning disposal).

PRECAUTIONS

18 The hazards associated with the production processes can be tackled by the application of standard principles for safeguarding any process involving flammable liquids or gases, namely containment, enclosure and ventilation, separation, and the exclusion of potential sources of ignition.

19 The degree to which each of these principles may be applied to a factory will depend on a variety of factors, including the age and size of the plant, and the size of potential escapes of propellant.

Propellant storage

20 The standards to be applied to cylinder and bulk storage of LPG, DME and DFE are those set out in Guidance Note CS4 and Guidance Booklet HS(G)34. However, inspectors should note the following in respect of DME:

(1) unlike LPG and DFE cylinders, DME cylinders currently supplied are not normally fitted with pressure relief valves. Until such time that any changes in practice have been agreed, the minimum separation distances in GN CS4 (Table 2) should be followed, and any DME cylinders kept apart from any containing LPG, in stacks separated in accordance with GN CS4 (para 76).

(2) the water solubility of DME and the consequent flammability of DME-contaminated water is currently under review. Until conclusions have been reached, there is some doubt about the flammable risks of any water used to deal with spillages or protect vessels from heat. For the time being inspectors should advise that DME-contaminated water should be diverted away from public drainage systems (eg to bunded enclosures away from DME storage areas) and that recirculating water cooling systems should not be used to protect bulk storage vessels.

21 Where a number of different grades of propellant are stored and used, particular attention should be paid to the marking of vessels and pipework to help prevent the possibility of mistakes being made. For the same reason the use of pipe cross-connections and manifolds should be avoided.

22 Close supervision and effective systems of work are essential during the delivery of a propellant to a bulk storage vessel to ensure that the grade to be transferred has been correctly identified and that it is compatible with both the design specification of the receiving vessel and any contents that may already be present. Similar precautions should be adopted during any product changeover on the filling line requiring a change of propellant.

Pipework and hoses

23 The propellant supply pipe from the storage area to filling plant should preferably be installed above ground. Adequate protection against mechanical damage should be provided where necessary. For pipes greater than 50 mm diameter welded or flanged connections should be used for pipe joints and fittings. The diameter and length of the pipe and number of joints should be as small as possible to minimise the size of any leak should the pipe fail.

24 Where a pipe has to be placed underground, it should be suitably protected against corrosion and placed in a shallow open masonry or concrete-lined trench protected against damage from above-ground loading where necessary. The route of

the pipe should be known and clearly marked. Further advice on underground pipework can be found in Guidance Booklet HS(G)34 and LPGA Code of Practice No 22.

25 The length of propellant supply pipes in buildings should be minimised and all joints should be welded, or welded and flanged.

26 Remotely operated emergency valves should be provided in the propellant supply pipe adjacent to, or in, the filling room or booth and on the liquid outlet from the bulk storage vessel immediately after the first manual shut-off valve. These emergency valves should close automatically on loss of actuating power or fire engulfment.

27 Actuation switches for these valves should be provided immediately adjacent to filling rooms and other locations which are sufficiently remote from potential leakage points so that they may be operated safely.

28 Flexible hoses should be as short as is reasonably practicable and only used where necessary. For LPG they should conform to BS 4089: 1966 and should be of rubber composite or flexible metallic construction. LPG hoses may not be suitable for use with DME. Where frequent line changes are made, self-sealing couplings between fixed pipes and flexible hoses should be provided.

Filling machines

29 Filling machines should be enclosed in close-fitting covers which are preferably non-combustible. This primary enclosure should be provided with local exhaust ventilation at high and low level to remove any LPG which may escape during the filling process. The exhaust air should be vented to a safe place in the open air.

30 In addition, a secondary enclosure (often called the "filling room" or "gassing room") should be provided to isolate the filling machine from the rest of the process plant. This can be achieved by siting the filling machine:

(1) preferably in a separate well-ventilated building used solely for the purpose or, if it can be argued that this is not reasonably practicable;

(2) in a well-ventilated room of half-hour fire resisting construction*, positioned against an outside wall. Access to the room should be through external doors and **not** directly from the process area.

*If tested in accordance with BS 476 Parts 20-23: 1987 (or BS 476 Part 8: 1972, which is superseded by the new standards).

31 All new or substantially redesigned filling lines should meet one or other of the standards described in para 30. However, many existing lines are housed in filling rooms which, though constructed to the half-hour fire resisting standard and well-ventilated, are positioned in the main body of the process area, away from external walls. Inspectors should not object to these, provided the other requirements in paras 33-41 are met.

32 Inspectors may occasionally find existing filling machines in process areas without any secondary enclosure. As an absolute minimum requirement, any such machines should be provided with close-fitting half-hour fire resisting covers (for this purpose the insulation requirements of BS476, Parts 8 or 20-23, may be waived). However, the HSE view is that the provision of a secondary enclosure is reasonably practicable, and should be pressed for. Under no circumstances should inspectors accept filling machines using highly flammable propellants with no primary or secondary enclosure. CM NIG, FOD C1 (Fire and Explosion), and THSD A3/C would all fully support the issue of a prohibition notice to prevent any such machines being used, if this was considered necessary.

33 The secondary enclosure should be as small as is reasonably practicable in order to minimise the volume that could be filled with a flammable gas/air mixture.

34 lightweight construction. The relief should vent to a safe place away from people and preferably to the open air.

35 practical to do so, doors should be located on external walls.

36 Where a door between the secondary enclosure and the remainder of the building cannot be avoided, the door should be half-hour fire resisting, self-closing and fitted with an interlock so that the filling line cannot be continuously operated with the door open.

37 Conveyor openings in secondary enclosure walls should be as small as possible, should not extend down to floor level without good reason, and should be located away from areas where people regularly work.

38 Ventilation of the filling process is essential and should be considered in 2 parts:

(1) the local exhaust ventilation required for the primary enclosure to the filling machine to collect vapour leaks at source; and

(2) the general ventilation required for the secondary enclosure at both high and low levels. This ventilation should be adequate to dilute any normal escapes of gas, such as those from leaking containers, to below 15% of the LFL, eg 0.2% -0.3% by volume LPG in air. The air intake should be arranged to provide a slight negative pressure in the room and to maintain reasonable velocities across openings (eg 0.75-1.0m/s).

Where pharmaceutical aerosols are filled it may be necessary to positively pressurise the secondary enclosure to exclude contaminants.

39 Care should be taken to separate the air inlet and exhaust ducts sufficiently to prevent the recirculation of air extracted from the plant.

40 The exhaust fan motor should be located outside the ventilation duct. The air flow in the ventilation duct should be monitored by a suitable air flow or differential pressure switch interlocked with the filling line start/stop sequence and with the

remotely operated emergency shut-off valve on the LPG supply line to initiate a shut-down in the event of ventilation failure.

41 In addition to these normal ventilation requirements the secondary enclosure should be provided with additional ventilation coupled to a gas detection system located in the secondary enclosure to operate automatically when the LPG concentration rises above a set point (**see para 50**). Interlocks should be incorporated to shut off the LPG supply, stop the conveyor and give an audible warning.

Use of electrical equipment in hazardous areas

42 The hazardous area classification (BS 5345: Part 2: 1983) should be applied to the plant and production areas to at least the following standard:

Zone 0	within LPG storage vessels and pipework ;
Zone 1	within the primary enclosure;
Zone 2	within the secondary enclosure and an area extending to at metre around the outside of the secondary enclosure. Incidents have occurred where containers have been punctured at capping machines and these should also be classified as Zone 2 areas.

Inspectors should note that DME is a group IIB flammable gas and is more easily ignitable than LPG (Group IIA flammable gas). Electrical equipment associated with DME lines should be selected to take account of this.

43 The British Aerosol Manufacturers' Association (BAMA) publication referred to in para 76 recommends that the area within the secondary enclosure should be classified as Zone 1 and there is of course no objection to this higher standard being adopted. In view of the complexity of this topic many firms simply designate the entire production area as either Zone 1 or 2. This approach is often beneficial for operational convenience including maintenance and supply of common equipment and parts throughout the area so designated. The main drawback is that this often leads to "overclassification" of zones and complacency about the hazardous areas and their limits.

44 Wherever practicable, electrical equipment should be installed outside the hazardous areas indicated above. Where it is necessary to use such equipment in these areas, the apparatus should be selected, installed and maintained in accordance with the relevant parts of BS 5345. In particular, check weighers should be located at least one metre down the exit conveyor from the secondary enclosure if not constructed to a protected standard.

Static electricity

45 Consideration should be given to the possible generation of static electricity during production and the precautions required to minimise any ignition risk.

Measures should be taken to reduce the generation of static electricity and for safe discharge to earth including the use of electrical continuity bonding for flexible hoses, conductive conveyor chains and guide rails, and earthing of all equipment. Comprehensive advice on this subject can be found in BS 5958: Part 1: 1980 and BS 5958: Part 2: 1983. Further advice on antistatic products can be found in BS 2050: 1978 and BS 5451: 1977.

Leak testing

46 After filling, all aerosol containers should be tested for leaks. This is normally done by immersion in a heated water bath. Temperature controllers with high and low temperature alarms should be fitted to the bath to ensure that pre-set limits are not exceeded. The plant shut-down system should be designed to empty the bath of containers whenever the line is stopped for prolonged periods, eg during lunch breaks or at the end of production. The water temperature and dwell time for submersion should be sufficient to raise the temperature and internal pressure according to the requirements for the container set out in BS 3914: Part 1: 1974. Typically, this temperature will be about 55°C and the containers should be submerged for 3-4 minutes.

47 The water bath should be shielded to contain exploding containers and to guard the inspection point. Adequate exhaust ventilation will be required over the water bath to remove any propellant gas and product escaping from leaking containers.

48 Inspectors may encounter alternative methods of leak testing, eg the use of induction heaters to heat the cans slightly, with gas detectors to register any leaks. Such methods should not be precluded provided it can be demonstrated that they are reliable and suitable.

Gas detectors

49 Test methods for the long-term storage testing of aerosols are contained in the British Aerosol Manufacturers' Association Code of Practice (5th Edition 1988).

50 Gas detectors should be installed at low level in the secondary enclosure and adjacent to the conveyor opening into the primary enclosure around the filling machine. The detectors should cause an alarm to be sounded when the gas concentration reaches 25% of the LFL. At 40% LFL the secondary ventilation should operate, the LPG supply to the filling machine should close automatically and an evacuation alarm should sound.

51 The problems of "poisoning" of gas detectors by silicons and CFCs have been reduced but not eliminated. Detectors should be regularly maintained and calibrated to ensure adequate accuracy and sensitivity. It may not be possible to use gas detectors on a small number of filling lines because of poisoning. Further details on flammable gas detectors may be found in GN CS1.

Fire precautions

52 At least one 9 kg dry powder fire extinguisher should be provided and located on the outside wall of and immediately adjacent to the door to the filling room or building. A further 2, 9 kg dry-powder extinguishers should be located adjacent to the filling line; one of them should be located near the shrink-wrapping machine.

53 Explosion suppression systems can be provided in secondary enclosures. An interlock should be provided with the LPG supply which causes the supply to be cut off if the system operates. The system should be isolated when the secondary enclosure is occupied.

Additional precautions

54 To ensure the effectiveness of the safeguards provided, process interlocks should be fitted to check that all the required systems are operational before the production line can be started (eg ventilation system, compressed air supply, water protection system, gas detection system etc). Once the line is running, an alarm signal from any of the safety systems should automatically shut down the line and close the safety shut-off valve on the propellant supply pipeline. A manual re-set button should be provided to ensure that after such a plant shut-down the fault has been corrected before the production line is restarted.

PACKAGING

55 After the final quality control checks have been made, the filled aerosol containers will either be packed into cartons, or more often collated onto cardboard trays and shrink-wrapped (see para 56). By the time the containers reach this stage, the risk of a flammable vapour leak is quite small. This operation is often carried out in an area separated from the rest of the production operation by a half-hour fire resisting wall; such separation is recommended.

Shrink-wrapping

56 The remaining potential hazard is associated with the conveyor-fed shrink-wrapping machine which is electrically heated. If the conveyor stops for any reason with trays of aerosols inside, the containers will begin to heat up and if not promptly removed they may explode, spilling their contents. Provided that the operators have been adequately instructed, trained and supplied with suitable protective equipment and fire extinguishers, eg 9 kg dry powder, a breakdown on the shrink-wrapping machine should not normally create a serious hazard. A means should be provided for removing aerosol dispensers from the shrink-wrap tunnel, eg a long-handled pusher. The shrink-wrap tunnel should be empty of dispensers before it is started.

Warehousing

57 Finished aerosols should not be allowed to accumulate in production areas or around the shrink-wrapping machines. The quantities in these areas should be kept to a minimum, the finished goods being removed to a fire-separated store.

58 Particular care over good housekeeping is required to prevent the accumulation of rubbish, packaging materials and fallen aerosols to minimise the fire hazard from these sources.

59 Fires involving aerosols with flammable contents are severe and spread very quickly. Warehouses and stores containing aerosols should therefore be separated from process areas by a robust construction which is at least half-hour fire resistant. The stores should be well ventilated, particularly at low level. The natural ventilation in a large open-plan warehouse building will normally be adequate.

60 Sliding doors are often provided between the warehouse and production area to allow easy access for fork-lift trucks. These doors are frequently one or 2-hour fire resisting and held open by a fusible link. The doors should be at least half-hour fire resisting and should be interlocked with the fire alarm so that they will close if the alarm is operated.

AEROSOLS WITH A HIGH LPG CONTENT

61 Some types of aerosols, particularly dry air fresheners are predominantly composed of LPG, ie greater than 90% by weight. It may be appropriate to aggregate these with other products of similar fire risks such as aerosols containing highly flammable liquids.

62 The contents of any aerosols, such as those for lighter fuel, which are essentially 100% LPG, will need to be taken into account when deciding whether or not the 100 tonne LPG threshold for application of the Fire Certification (Special Premises) Regulations 1976 has been exceeded. However, the contents of other aerosols using LPG as a propellant can be discounted for this purpose.

Existing premises

63 At new manufacturing premises storage should be considered in accordance with GN CS4 paras 90-114, in particular the provision of a separate purpose designed storage building. These are good standards of general application for these products which are similar to LPG cartridges but should not be generally applied to other aerosol products. However, where these standards are not reasonably practicable storage should be in accordance with the standards given below for existing premises. Occupiers should be advised to contact the fire authority about general fire precautions and means of escape, unless the Fire Certificate (Special Premises) Regulations apply, and HSE is the enforcing and certifying authority.

64 At existing factories it may not be reasonably practicable to provide a separate store for these aerosols. If that is so the following standards should be adopted:

(1) the aerosols should be stored in one part of the warehouse;

(2) rows of pallets should be no more than 2 pallets wide and 4 pallets high unless rack storage is used in which case the height limitation does not apply;

(3) gangways at least one metre wide should be provided between rows of pallets and storage should be arranged to avoid dead-ends;

(4) automatic fire detection should be provided above the storage area. The operation of the detectors should sound the fire alarm and cause the doors separating the warehouse from the rest of the factory to close; and

(5) water sprinklers should be provided above the storage area with a minimum discharge rate of 12.5 litres/m²/min.

65 Where aerosols are stored shrink-wrapped or boxed and have been leak tested during manufacture it is difficult to justify the zoning of the whole of the warehouse as Zone 2. Any Zone 2 area will extend only a short distance (0.5 m) from the stacks. It is therefore not necessary to protect fork-lift trucks in such warehouses.

SYSTEMS OF WORK

66 The provision of adequate training, supervision, systems of work and operating procedures are essential for the safe operation of an aerosol filling plant.

67 Operators, supervisory and maintenance staff should be familiar with the properties and hazards of the materials they are working with. Adequate instructions should be provided on the hazards of LPG, highlighting the dense nature of the gas, its flammability and the need for proper control over its use. Operators should be aware of the form a serious propellant leak normally takes (an opaque white cloud) and the actions to be taken in the event of such a leak.

68 Written operating instructions should be provided for operators detailing the correct procedures to be followed in operating the filling plant. These instructions should include emergency procedures. Operators should be trained in the emergency procedures and should be familiar with:

(1) the method for safely isolating the LPG supply to the filling machine in the event of a leak;

(2) the evacuation procedure to be followed; and

(3) the procedures to follow in the event of a fire.

69 In the event of a major leak of LPG the building should be evacuated, the source of LPG isolated by using the remotely operated isolation valves and the plant left until the LPG has dispersed safely.

70 An adequate number of staff should be instructed in the use of the fire extinguishers provided. Fire-fighting training should be provided, with refresher courses as necessary.

71 A proper system of work should be prepared for all inspection, maintenance and testing of the aerosol filling plant. A permit-to-work system should be used for work involving plant handling LPG or other hazardous materials.

SAFEGUARDS FOR THE DISPOSAL OF REJECT CONTAINERS

72 Containers rejected from the filling process should be placed in specially provided closed receptacles which are mechanically ventilated to remove any escaping vapours. The receptacles should be earthed to avoid the build up of static electricity which might become a potential source of ignition. To prevent the accumulation of large numbers of rejects within the building the waste receptacles should not be oversized and should be regularly emptied. Rejects collected for disposal should be stored in a well-ventilated place in the open air. The reason for the production of excessive numbers of rejects should always be examined without delay so that the necessary corrective action may be taken.

73 Reject containers may be disposed of by an independent contractor who should be made aware of any hazard from leaking containers and their contents. In certain cases, the local authority may also have to be consulted.

74 Special container-shredding equipment is available for a manufacturer or disposal contractor who regularly handles a large number of reject containers. The general principles for such a unit are:

- (1) the machine should if possible be sited outdoors away from other buildings, boundaries or sources of ignition. If sited indoors, the building should be constructed of a lightweight material and be well ventilated at both high and low level. One side of the building should preferably be completely removed to prevent the build-up of a flammable concentration of gas and to act as explosion relief;
- (2) all the electrical equipment used in the area should be constructed to BS 5345 as suitable for use in the presence of flammable vapours;
- (3) the start/stop switch for the shredder should be sited in a safe position at least 6 m from the machine;
- (4) the mechanical exhaust ventilation system on the shredder should be sufficient to dilute the flammable vapour produced to below 25% LFL;
- (5) all duct work provided for the ventilation system should be at least half-hour fire resisting except for the insulation requirement and be strong enough to withstand any pressures which could be generated either in normal operation or in an emergency, eg as the result of an explosion of flammable mixture in the system; or explosion relief may be provided in accordance with the advice given in HS(G)11;

(6) the shredding machine and associated duct work should be provided with sufficient explosion relief to prevent the build-up of excessive pressures should an explosion occur;

(7) airflow switches should be provided in the duct work and interlocked with the shredding machine motor so that the shredding plant cannot be started until the ventilation system is running;

(8) the use of dampers in the duct work should be avoided. Where they are provided, they should be partly cut away or fitted with stops to prevent them from being closed accidentally whilst the machine is operating; and

(9) the rate at which containers are fed to the machine should be controlled to prevent the ventilation system from being overloaded by the release of excessive quantities of flammable vapour. This can be achieved by slowing down the shredding rate by the use of a timer fitted to the drive motor which intermittently starts and stops the shredder.

Disposal of residues

75 The methods used for the disposal of any residues produced in the shredding process will depend upon the properties of the products being handled. Where flammable liquids are involved these may be collected in suitable containers which can be closed, labelled and stored in a well-ventilated place preferably in the open air until arrangements can be made for their safe disposal. Care should be taken to ensure that such containers cannot be subsequently overpressurised by any highly volatile compound which may still be present in the residues.

FURTHER GUIDANCE

76 Further detail on the safeguarding of aerosol filling plants is contained in *A guide to safety in aerosol manufacture* published by the British Aerosol Manufacturers' Association (BAMA) Ltd, Kings Buildings, Smith Square, London SW1P 3JJ. In addition, general guidance on the storage of aerosols, including flammable aerosols, can be found in the BAMA publication *A guide to good practice for the storage of aerosols in manufacturing, wholesaling warehouses and retail stores*.

Action by inspectors

77 Inspectors are asked to inform CM NIG, Area 17 of any problems they encounter in applying this guidance, in particular that related to the segregation and enclosure of filling machines (**paras 29-41 refer**).

References

paras 20 and 63	Guidance Note CS4	<i>The keeping of LPG in cylinders and</i>	(file 286)
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		<i>similar containers</i>	
paras 20 and 24	Guidance Booklet HS(G)34	<i>Storage of LPG at fixed installations</i>	(file 286)
para 24	LPGITA Code of Practice No 22	<i>LPG Piping system - design and installation</i>	(file 286)
para 28	BS 4089: 1966	<i>Specification for rubber hose and hose assemblies for LPG lines</i>	
para 30	BS 476: Part 20: 1987	<i>Method for determination of the fire resistance of elements of construction (general principles)</i>	
para 30	BS 476: Part 21: 1987	<i>Methods for determination of the fire resistance of loadbearing elements of construction</i>	
para 30	BS 476: Part 22: 1987	<i>Methods for determination of the fire resistance of non-loadbearing elements of construction</i>	
para 30	BS 476: Part 23: 1987	<i>Methods for determination of the contribution of components to the fire resistance of a structure</i>	

para 32	BS 476: Part 8: 1972	<i>Test methods and criteria for the fire resistance of elements of building construction</i>	
paras 42, 44 and 74(2)	BS 5345: Part 2: 1983	<i>Classification of hazardous areas</i>	
para 74(5)	HS(G)11	<i>Flame arrestors and explosion relief</i>	(file 283)
paras 43, and 78	British Aerosol Manufacturers Association (BAMA)	<i>A guide to safety in Aerosol Manufacture</i>	(file 278)
para 45	BS 5958: Part 1: 1980	<i>Code of Practice for the control of undesirable static electricity - general considerations</i>	
para 45	BS 5958: Part 2: 1983	<i>Recommendations for particular industrial situations</i>	
para 45	BS 2050: 1978	<i>Specification for electrical resistance of conducting and antistatic products made from flexible polymeric material</i>	
para 45	BS 5451: 1977	<i>Specifications for electrically</i>	

		<i>conducting and antistatic rubber footwear</i>	
para 46	BS 3914: Part 1: 1974	<i>Non-returnable metal containers up to 1400 cm³ and 85 mm diameter</i>	
para 49	British Aerosol Manufacturers' Association	<i>Code of Practice (5th Edition 1988)</i>	HSE, Bootle Information Centre
para 51	Guidance Note CS1 (Rev)	<i>Industrial use of flammable gas detectors</i>	(file 286)
para 76	British Aerosol Manufacturers Association (BAMA)	<i>Guide to good practice for the storage of aerosols in manufacturing wholesaling warehouses and retail stores</i>	(file 278)

Cancellation of instructions

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ASI headings

Aerosols: difluoroethane: dimethyl ether: electrical equipment: fire: fire and explosion: flame arrestors: flammable liquids: gas(es): LPG.

APPENDIX
(para 7)

PROPERTIES OF DME, DFE, PROPANE AND BUTANE

Physical Property	Butane	Propane	DME	DFE
Relative Density of liquid at 20°C	0.58	0.50	0.66	0.90
Relative Density (to air) of vapour at 20°C	2.10	1.56	1.64	2.39
Ratio of gas to liquid volume at 15.6°C and 1015.9m bar	233	274	324	
Boiling point °C	-2	-45	-24	-25
Vapour pressure at 20°C (bar)	2.5	9	4.5	4.3
Lower flammability limit (%v/v)	1.8	2.2	3.4	3.9
Upper flammability limit (%v/v)	9.0	10.0	18.2	16.9
Cubic coefficient of expansion at 15°C (°C ⁻¹)	1.2 x 10 ⁻³	1.5 x 10 ⁻³	2.36 x 10 ⁻³	
Solubility in water by weight at 20°C (%)	Immiscible	Immiscible	35	0.28
Latent heat of vaporisation (KJ/Kg)	372	358	466	
Flash Point (°C)	-74	-187	-41	-50