Safety Services Guidance

Guidance on the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) in Laboratories

Key word(s) :	Fire, Explosion, Hazardous Area Classification, Laboratory, Solvent, Vapour, Flammable gas
Target audience :	Heads of School, Laboratory workers, Professional Support Service technical staff.

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Introduction

1. This is guidance is based on the HSE advice for laboratories working with flammable and explosive substance. It is to aid those in control of laboratory areas carry out the risk assessment required by the Dangerous Substances and Explosives Atmospheres Regulations 2002 (DSEAR), and to identify the circumstances in which controls to prevent the formation of explosive atmospheres should be improved, or the area should be classified.

2. It should be used in conjunction with the Safety Services guidance on the Dangerous Substances and Explosives Atmospheres Initial Screening Risk Assessment and Points to Consider.

3. The Dangerous Substances and Explosive Atmospheres Regulations 2002 require a risk assessment of the fire and explosion hazards at a much wider range of workplaces, including laboratories of all kinds. Specifically they require employers to classify areas where explosive atmospheres may form, using the principles of Hazardous Area Classification (HAC). No lower threshold for quantities of materials or risk for this is given. Instead, the requirement relates to places where special precautions are needed to protect the health and safety of employees. ‘Special precautions’ are taken to be design features of electrical and other equipment that prevent it creating an ignition source.

Responsibilities

4. **Head of Schools / Directorates** – to ensure that fire and explosion hazards are controlled in their area of responsibility

5. **Principal Investigators / Supervisors** –

    - to ensure risk assessments are undertaken for all procedures involving fire and explosion hazards, and ensure adequate control measures are used and maintained.
    - to ensure all in their area of responsibility receive appropriate training in use of dangerous substances and necessary control measures.

Guidance

6. **Hazardous area classification (HAC)** is a technique for assessing the probability of formation of a flammable atmosphere and its likely duration. It has long been a widely used in the chemical industry, as a step towards deciding whether electrical and other equipment needs special protective features in order to prevent it causing a fire or explosion.

7. The Regulations define 3 zones that can exist within a hazardous area.

   - Zone 0 - A place in which an explosive atmosphere is present continuously or for long periods.
   - Zone 1 - A place in which an explosive atmosphere is likely to occur in normal operation occasionally
   - • Zone 2 - A place in which an explosive atmosphere is not likely to occur in normal operation, but if it does occur, will persist for a short period only

8. For most laboratory operations there is no tradition of hazardous area classification or using ignition protected equipment (all electrical equipment, unless labelled 'ignition protected' is assumed to be capable of causing small sparks which can cause a fire), and the risks are usually controlled in other ways. Nevertheless, fires and occasional explosions do occur, and many of the principles used on larger scale operations to control the risks are relevant, even if the solutions are different.

9. Where an area is classified, DSEAR requires both electrical and non-electrical equipment to meet specific standards. It is helpful to analyse the risks systematically when reviewing whether existing equipment and systems of work are adequate.

The Basic Principles of DSEAR Risk Assessment – Identifying Hazards and Precautions Required

Primary and Secondary Sources

10. Area classification analyses the sources of gas and vapour release, looking at those that arise in normal operation, (primary sources) and those which only occur as a result of some equipment failure or operator error (secondary sources). Clearly, not all laboratory hazards will be covered by such an analysis, but it should be part of any overall risk assessment. The aim should always be to minimise releases into the general atmosphere of the laboratory.

11. On a laboratory scale, a primary source might be the vapour released when a volatile solvent is poured from one container to another, while someone knocking

the container off the bench to the floor creates a secondary source. Primary sources should normally be so small they can easily be controlled by adequate ventilation, and the extent of any explosive atmosphere is negligible.

12. Strictly, area classification takes no account of the consequences of a release, whether this is a fire or explosion, but selection of the necessary precautions must take the consequence factor into account, and this approach is recognised in DSEAR. If precautions already used are adequate to prevent fire and explosion risks to laboratory workers, then there is no need for zoning and ‘special precautions’ in terms of the ignition risk from equipment will not be necessary.

Types of Release

13. For laboratory work, it is helpful to consider separately releases which occur suddenly, but where the maximum release quantity can be specified, e.g. the fracture of a glass flask; and those where the release once started will continue until some corrective action is taken to shut off the release, e.g. closing a valve following failure of a plastic or rubber hose from a gas cylinder or mains supply.

Volatility and Temperature

14. The volatility of the product is also an important factor, but this must be considered in the context of the temperature at which it will be used. So if you are pouring a solvent from one open container to another at a temperature below its flash point, there should be no hazardous area, because too little vapour is present. If you then distil the same solvent and the condenser cooling fails, vapour will be released, and the risk is much greater.

Ventilation

15. Most laboratories have good ventilation, but this is not primarily intended to limit the extent of any explosive atmospheres that may form. More localised extraction is needed for this.

Supervision

16. The degree of supervision of any continuous process should be considered:

- Would someone be constantly available to take action, if cooling water flow failed, a flask cracked, or a process boiled over?
- Would it be possible to safely and quickly isolate all electrical equipment? Turning off switches that are in the immediate vicinity of some releases might create the spark that needs to be avoided.

Training

17. Training is relevant to assessing the risk. Students and other young people may not have the experience in laboratory work that fully experienced staff have, but they can and should be given training in the actions that should be taken to prevent foreseeable problems, like small spills, and the action needed where simple problems arise.

Flammable Liquids

Very Small Scale Operations

18. Operations with flammable liquids - at the very smallest scale the consequences of a spill may well be trivial. Quantities up to 50mls can be mopped up or sometimes flushed away, and if they ignite, so long as the fire does not quickly spread, they may well burn out before anyone is at risk, or before a laboratory worker could take any action to extinguish a fire. If these are the conclusions of a risk assessment, formal zoning is clearly inappropriate, though it may well be appropriate to avoid the use of naked flames and other powerful or constant ignition sources in the immediate vicinity. Where the evaporation of a solvent is deliberately intended, e.g. from a coated surface, the operation may need to be carried out in a fume cupboard. In these cases, if the health risks under COSHH are properly controlled, there may well be no need for additional precautions to control the explosion risk.

Medium scale operations

19. Where quantities are larger but still manipulated on the open bench, for example up to 500mL, the risks are more significant. The actual extent of a flammable atmosphere following a spill may well be a radius of up to a metre, but only a very small height above the liquid level. Any ignition of a spreading pool will produce a fire that quickly extends to the whole area of the spill, and could cause a risk to laboratory staff. Particular dangers arise if the spill enters the drains, as an explosive atmosphere could then form in an enclosed space.

20. As with very small spills, obvious continuous ignition sources should be avoided, but the greatest risk probably comes from electrical equipment in use as part of the operation. Much of this cannot be avoided, and may well not be available in ignition protected form, e.g. hot plates, heating mantles, stirrer controllers.

21. Precautions are likely to include:

- good handling techniques to minimise spills,
- sills or other liquid retaining methods to minimise liquid spread,
- proper support for glass equipment,
- placing electrical equipment where it will not be splashed as a result of a spill as far as practical,
- constant supervision by trained staff, so that electrical equipment can be rapidly isolated, others warned of any dangers, and if safe to do so, first aid fire fighting started, and
- most importantly, the risk that a fire following a spill will rapidly involve other containers of flammable liquids or other dangerous chemicals should be considered, so work area should not be crowded.

22. Where these and similar precautions have been adopted, the risk assessment may conclude that there is no need for hazardous areas to be specified.

Fume Cupboards

23. Some work at the 2.5L scale may be done in a fume cupboard, and this will allow the screen to be closed to give some protection if a fire should start. In an ideal world work with larger quantities of flammable solvents would only be carried out in a fume cupboard with an automatic fire suppression system installed. The work should be arranged so that any foreseeable release of gas or vapour will be rapidly diluted below the explosive limit by the air flow through the cupboard. Precautions may still be needed to reduce the fire risk, such as retaining sills at the front edge, and extraction ductwork kept clear of flammable residues. In particular fume cupboards should not be used as storage facilities for toxic or flammable chemicals while they are also being used for experimental work. Rapid failure of stored bottles in a small fire could produce sufficient vapour to prevent the extract fan diluting vapours sufficiently even if the sash is closed and the purge button activated.

Liquefied flammable gases

24. These may be handled either under pressure, or in refrigerated form. A small release of liquid is likely to vaporise immediately creating a substantial sized

cloud of explosive gas air mixture. Pressurised systems need to be robustly constructed, and checks provided to ensure they are leak tight. Where liquids are handled in refrigerated form, the risks from loss of cooling or loss of insulation should be considered. Good ventilation around the apparatus will always be needed, but there may also be a need to designate a Zone 2 area. This will depend on the foreseeability of a release of liquid, how rapidly it might be detected, and the ability of the ventilation to disperse it quickly.

Flammable gases

25. Leaks that continue until some corrective action is taken are possible from piped gas sources. Low pressure mains gas pipes in domestic and similar premises are not considered to give rise to hazardous areas although explosions caused by gas escapes in private houses do occur from time to time.

26. Laboratory work presents a wider range of hazards:

- many gases used are not odorised; some may be lighter than air, while others are heavier
- gas pressures may be significantly higher than the 75mbar pressure typical of mains gas
- many temporary connections are made, using flexible rubber or plastic hose, which can fail from age, or by attack from solvents
- equipment could fail from overpressure, if a regulator is wrongly adjusted
- gas taps on open benches can easily be knocked open inadvertently

27. The risk assessment needs to consider:

- the ventilation provided, its reliability and the size of leak that could be controlled in this way;
- what can be done to minimise the risk of a gas leak, and how any such leak would be identified promptly, so that appropriate action could be taken. Particular account should be taken of the out of hours risk if ventilation is shut down, or systems have to be left under pressure.

28. Small leaks may well be dispersed safely by good ventilation, but the consequences of a release that builds up and then finds a source of ignition are likely to be severe.

Releases into enclosed spaces

29. Where vapours or gases may escape into an enclosed space like an oven, or refrigerator, the consequence of an ignition is more likely to be an explosion than a fire. Refrigerators have exploded in laboratories, where the light switch or thermocouple sparked when opening or closing. The solution is a unit designed for this purpose, with any spark producing electrical equipment sealed from contact with the internal atmosphere, rather than a designation of the inside of unit as zone 1 or 2. In the case of an oven, it may be possible to keep heating elements below the ignition temperature of any vapour likely to be used, or to provide adequate ventilation to prevent the build-up of vapours, but some risks will remain unless close control is maintained over products and quantities that can be placed inside.

Larger scale laboratory work

30. Laboratory work involving equipment above a 2 litre scale, and pilot scale plants need more careful consideration. Pilot scale is taken to mean equipment with a capacity of 50-100 litres or more.

31. Particular risks come from the use of all glass equipment that may be fractured by impact, thermal shock or overpressure, poor handling techniques in open containers, use of temporary hoses for flammable or other hazardous materials.

32. Perhaps the most useful approach to controlling the ignition risks, is to limit the extent of any flammable atmosphere formed as a result of a release, by a combination of semi-enclosure, forced ventilation, and then to place all electrical equipment outside the enclosure, so far as possible. This may allow a hazardous area study to conclude that any zones are of very small or even negligible extent. Direct heat sources, like an electric mantle may nevertheless need to be used, and could be exposed to flammable vapours following a major failure of a glass vessel. In this case the risk assessment should consider if the laboratory worker and any others nearby could be expected to escape safely, and how any subsequent fire could be prevented from spreading to affect other people and facilities.

Conclusions

33. Where flammable liquids or gases are handled in laboratories, it is always necessary to control sources of ignition, even if there are no formally designated hazardous areas.

34. Whether work is done on the open bench, in a fume cupboard or a dedicated facility for larger scale work, any decision in a written risk assessment not to zone the laboratory must be based on arguments that any incident will be of limited scale and could be quickly controlled by those present; or that they could escape very quickly without leaving others in the building at risk. A high standard of controls, of the type described above will help justify this assessment.

35. There are circumstances, in particular with equipment at the pilot scale, where hazardous area classification, and the associated use of explosion protected (Ex) equipment should be adopted.

Appendix 1 Examples

	Laboratory Scenario	Suggested Controls (subject to risk assessment)
1	Very small scale use of flammable solvents in analysis equipment cells (mg/ml). Decanted from 0.5 or1 litre storage vessels in a fume cupboard. Transferred from the fume cupboard to equipment with secure stoppers in place	No need to classify laboratory. Implement good laboratory practices (tidy workplace, sufficient clear working space, use fully functioning fume cupboards which have been maintained and examined in accordance with COSHH requirements). In these circumstances, no need for zoning even in close proximity to work
2	Hydrogen cylinder in use in a large laboratory, with good general ventilation, including ventilation at high level. Connected to equipment with no hot surface or flame, although electrical (PC) equipment nearby	For long term experiments, pipe gas in from outside or a fire resisting enclosure. Requirement will depend on exact circumstances, but probably should have a zone 2 classification of 1-2m around valve and outlet (and possibly areas where gas could collect in the event of leakage). In practice, rearrange experimental set up to avoid electrical equipment within this zone if possible. Use Ex sign to indicate hazard. Implement good practice procedures for checking gas cylinder safety and all hose connections. Be aware of typical gas usage, and be able to identify unusual rate of use. Consider risks due to leakage when equipment not attended
3	25 litre drum of mixed waste solvents (likely to be flammable or highly flammable) stored in general lab under bench	If possible reduce scale. Use plastic containers to segregate halogenated/non-halogenated wastes, keep on spill tray and dispose of regularly. Requirements will depend on detailed circumstances, but probably will justify classification of zone 2, 1-2m around container opening. If possible, store container >2m from any ignition source (including electrical equipment) and in well ventilated area. If metal drum used, take precautions against static discharges.

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