Fire Safety

Module 3

ROYAL SOCIETY OF CHEMISTRY

Health & Safety Essentials

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Risk management: Stage 1 identify the hazards

Ignition sources

Naked flames or static electricity sparks are the most obvious and visible forms of ignition of combustible or flammable materials in laboratories yet they often get overlooked. The Bunsen burner or furnace being used some distance away from a flammable material or an electric motor above a reaction vessel both present risk of ignition and extra consideration is needed. Typical alternatives are having one specially designed location/fume cupboard for naked flame work or using magnetic stirrer or specially designed ('Ex' rated) stirrer motors for agitating flammable solvents.

Electrical malfunction is a likely ignition source in premises where installation standards or routine maintenance have not been adequate. A routine inspection and test of portable appliances on an annual basis does not provide sufficient protection, and you should check that your equipment is adequately rated and in good order before its use each time.

The reaction of certain substances with air is not uncommon in laboratories: the appropriate control measure is usually to put the substance under inert gas or oil. Pyrophoric materials clearly require an extra level of vigilance when handling and storing.

Oxygen sources

Whilst air is the most likely source of oxygen when considering fire safety, the laboratory environment presents other sources such as oxidising materials, compressed gas cylinders of oxygen and even liquid oxygen.

Allowing the oxygen from air to condense inside cryogenic cooling systems where organics residues are present has been responsible for a number of explosions in laboratories.

Once a fire has started, the thermal convection currents will draw air from the surroundings and so it is important to understand how to shut-down fume cupboards and other natural/forced ventilation systems.

Storage and handling of flammable liquids

A number of simple definitions of terms were provided in the under-pinning knowledge section and some are further developed here in relation to storage and handling of hazardous substances

Flammable liquids are actually liquids that generate enough flammable vapours to flash or sustain a fire but this depends upon the amount of vapour mixed with air. If there is not enough or too much fuel vapour, the fire or explosion cannot occur. The minimum concentration of fuel in air is called the lower explosive limit (LEL) and the maximum is the upper explosive limit (UEL).

In normal use, it is the LEL that is important as leaks and spills need to be diluted by good workplace ventilation to avoid the immediate risk of ignition and fire. Generally, organic solvent vapours are denser than air and will fall to the lowest point and pass across benches and floors without being noticed. The consequence is that an ignition source quite some distance away presents a risk of a fire starting.

Storage

You should follow all requirements for isolation, segregation, separation and keeping materials apart, so that they are stored properly. Storage requirements for materials will be noted in the safety data sheet, provided by the manufacturer.

Flammable liquid stores are usually separated from other buildings by several metres and have a number of design features, which improve the integrity of the store. Common to all stores is the provision of a bund or other enclosed base such that any leaks or spillages remain inside the store. These can take the form of racking with lipped shelving or a tanked base inside a building. In all cases, you should not store containers so that they take up the containment volume of the bund, thus compromising it.

Transporting flammable liquids

The risk of fire from ignition of flammable materials generally occurs when there is a loss of containment. These losses arise from many lab activities such as failure to fully condense vapour from a distillation, overheating processes and so on but events are not confined to the lab location. In fact, one of the most difficult spillages to deal with is when flammable materials are being transferred from storage, normally outside, to the laboratory. Spillages en route expose other people to the risks from hazardous substances as well as fire from the many ignition sources outside the lab. Most labs have purpose made crates and carriers for transferring chemicals around the facility and these must be used to minimise the likelihood of spillages.

Decanting/transferring

Transferring flammable liquids from drums or other large containers to lab sized bottles present a significant risk of loss of containment and fire. A number of techniques are available from pouring and pumping through to using a pipette but spillages of various sizes are common to all.

During transfer of flammable liquids, it is possible to generate static charges that could discharge, usually to metal drums causing an ignition. However, this risk is low unless pumping at speed or spraying flammable liquids. The more likely source of static charge is from the person as they have walked to the store. The control measure is to have a store that is correctly earth-bonded with earth clamps available for the person to apply to metal containers before opening them.

Flammable gases

Other than gases generated during chemical processes, flammable gases are available in labs through gas supply pipelines or pressurised cylinders. Specific training is available for those that routinely handle cylinders as correct connection of regulators and flexible connection is vital if leaks are to be avoided.

A wide range of flammable gases are used in labs from propane for glass blowing and heating, to hydrogen and acetylene for instruments, and ammonia which is both toxic and flammable (explosive range 16-25%).

The natural gas which is normally piped directly to fume cupboards (employed for teaching and where Bunsen burners are required) is primarily methane with explosive limits between 5% and 15 % in air so any leak is likely to pass through this range at some point.

Risk management: Stage 2 identify people at risk

It is to be expected that staff, students, visitors and contractors are present in or near laboratories, but the fire safety risk assessment has to take into account their interaction within the workplace and the work activities.

Staff and students are likely to be familiar with the layout of the premises and exit routes but depending upon the means of raising the alarm, some people may need early warning about the need to leave an area.

Do any of the people you work with have limitations to their sight, hearing or mobility?

The people especially at risk are those with impairments to mobility, sight or hearing and lone workers.

The fire alarm system should have audible as well as visual warning to ensure that everyone present receives the early warning they need. In the case of people with mobility impairment, a personal emergency evacuation plan (PEEP) should be developed for them.

A final group of people requiring special consideration are lone workers. To avoid these workers being at a higher risk than other employees doing routine activities, a review of the risk assessments may be needed. Risks that may be considered acceptable during the working day may need to be restricted when people are working alone possibly because help is not immediately 'at hand'. This may, for example, be the case with hot-work where a second person is assigned on fire watch for the duration of the task. It is good practice for laboratory workers to be in 'line of sight' or earshot of another when handling hazardous materials or conducting higher risk operations.

Risk management: Stage 3 assessing the risk & developing control measures

Having identified the hazards and people that may be affected, an evaluation of the risk is required to decide which control measures are most appropriate. In line with other risk assessment and control methodologies, the hierarchy of control should be used so that the most robust controls are considered and applied before moving on to select less effective means.

Typical scenarios are considered when assessing the likelihood of a fire occurring. Some time should be spent examining the activities in the lab/workplace and the potential causes of fire. Think through the likely outcome from laboratory work; an unattended experiment 'not going to plan', the effect of cooling water failure on a distillation of flammable solvent and an unexpectedly large exothermic reaction from an experiment with consequential loss of containment.

Do you consider the effect of a failure of services on your experiments?

Once every effort has been made to eliminate or reduce the likelihood of a fire occurring, attention is directed to assessing the scale/consequence of the event followed by a review of the control measures already in place.

Have you minimised the inventory of flammable liquids in your lab?

A significant portion of the rest of this module is to help you recognise fire safety features already in place and how they are designed to protect life and property. Understanding how they work will help you recognise when they are faulty or not being used correctly so that remedial actions can be taken.

Passive protection

The passive protection described earlier is likely to be in the form of 'compartments' made from fire resisting materials. In principle, a compartment should stop the spread of fire, heat and smoke from the area where the fire first started. There clearly need to be openings in walls to accommodate doorways but where these form part of the compartment, fire doors are fitted which are designed and constructed to hold-back a fire for a specific period, usually 30 or 60 minutes. If the compartment is working correctly, a person escaping a fire area should be able to go through a fire door, close it behind them and be in a 'place of reasonable safety', which provides at least 30 minutes of protection.

Are your fire doors being used correctly?

Warning systems

These normally take the form of automatic fire alarm (AFA) systems with detectors and manual (break-glass) call-points located around the premises. Smoke detectors are common throughout many buildings but 'heat detectors' are used where aerosols, steam and other fine particles may gave false alarms. These detectors are actually 'rate of temperature rise' detectors so they work just the same in warm or cool rooms.

Manual break-glass call-points are located at fire exits from a floor level and at exits from the building. This ensures that the person raising the alarm has moved towards a place a reasonable safety to raise the alarm, and collect an extinguisher, rather than staying where the fire is and attempting first-aid fire fighting without ensuring back-up is on the way.

Once the fire has been detected, it is necessary to give a warning to those that need to prepare for, or start an evacuation. In addition to audible alarms, it is best practice to provide some coverage of visual alarms/flashing beacons to alert those with hearing impairment.

It is common to have the AFA connected to a bureau service for automatically calling the fire service. Whilst this is a recommended practice, this alone should not be relied upon and a separate phone call to 999 should also be made.

Fire fighting

The basis of fire safety planning is that there is a need to provide a means of escape, a means of raising the alarm and a means of fighting the fire. When this is achieved, any person discovering a fire should be able to turn their back on the fire, look up and see a fire exit sign (running-man pictogram), walk to that exit to identify fire fighting equipment and 'break glass alarm point'. Once the alarm is sounding, the person can decide if they can carry out first-aid fire-fighting or if they should continue to the final exit from the building.

First-aid fire fighting with a portable extinguisher is intended to enable trained staff to stop a small fire developing into something bigger. There is limited time in the escalation of a fire to do this so the 'first-strike' has to be very early and as effective as possible using only one extinguisher. A general guide provided during fire safety/extinguisher training is that when the fire is as big as you, turn around and leave. The design of the workplace should be such that you *always* have a permanent escape route without having to take any action other than walk to the exit.

There are several types of extinguishers available based on the type of fire to be dealt with. For convenience, these are categorised by class, as shown below;

Classes of Fire (according to BS EN 2)

BS EN 2 is the very brief British Standard that specifies the "classification of fires".

The classifications are as follows:

- **Class A - fires involving solid materials, usually of an organic nature, in which combustion normally takes places with the formation of glowing embers.**
- **Class B - fires involving liquids or liquefiable solids.**
- **Class C - fires involving gases.**
- **Class D - fires involving metals.**
- **Class F - fires involving cooking media (vegetable or animal oils and fats) in cooking appliances.**

Note that there is no definition of a Class E in this standard, although the phrase "class E" is often misused to describe fires associated with electrical hazards. It is important to note that, as electricity does not burn, fires involving electrical hazards are in fact always fires of another class with the additional complication of the presence of an electrical hazard.

Could you select and use a fire extinguisher correctly?

The extinguishers available and their strengths and weaknesses:

In the UK all fire extinguishers are coloured red now: what distinguishes them is the coloured triangle.

Water extinguishers
This type of extinguisher can only be used on Class A fires. They allow the user to direct water onto a fire from a considerable distance. A 9-litre water extinguisher can be quite heavy and some water extinguishers with additives can achieve the same rating, although they are smaller and therefore considerably lighter. This type of extinguisher is not suitable for use on live electrical equipment.

Water extinguishers with additives
This type of extinguisher is suitable for Class A fires. They can also be suitable for use on Class B fires and where appropriate, this will be indicated on the extinguisher. They are generally more efficient than conventional water extinguishers.

Foam extinguishers
This type of extinguisher can be used on Class A or B fires and is particularly suited to extinguishing liquid fires such as petrol and diesel. They should not be used on free flowing liquid fires unless the operator has been specially trained, as these have the potential to rapidly spread the fire to adjacent material. This type of extinguisher is not suitable for deep-fat fryers or chip pans.

Powder extinguishers
This type of extinguisher can be used on most classes of fire and achieve a good 'knock down' of the fire. They can be used on fires involving electrical equipment but will almost certainly render that equipment useless. Because they do not cool the fire appreciably, it can re-ignite. *Powder extinguishers can create a loss of visibility and may affect people who have breathing problems and are not generally suitable for enclosed areas*.

Carbon dioxide extinguishers
This type of extinguisher is particularly suitable for fires involving electrical equipment as they will extinguish a fire without causing any further damage (except in the case of some electronic equipment, e.g. computers). As with all fires involving electrical equipment, the power should be disconnected if possible.

Special Class D Extinguishers for Metal Fires can be sourced for sodium, lithium, manganese and aluminium when in the form of swarf or turnings.

Class 'F' extinguishers

This type of extinguisher is particularly suitable for kitchens with deep-fat fryers but is not designed to work with mineral oil heating baths found in laboratories.

Escape routes

The purpose of the escape route is to lead people from the fire location to a place of total safety and an evacuation assembly area once away from the building structure. To achieve this goal, it must be used correctly. In practice, people rarely use their nearest exit when an evacuation alarm is sounded unless training and fire drills are used to maintain standards. It is a normal reaction for people to walk along their normal exit route from a building but this is not acceptable as the fire may be located somewhere along that route.

Do you know where the evacuation assembly area is?

The final exit to a Place of Total Safety is often the last door on the exterior of a building and leads to fresh air, a 'place of total safety' and an evacuation assembly area. A serious failing with arrangements at this location would be the final exits being locked as it is usually the security perimeter of the building. The exit routes from the building must remain available at all times when the building is occupied unless other special arrangements have been made. Once again, those at particular risk are lone workers where they enter buildings or stay late and normal out-of-hours security measures are put in place.

Emergency lighting

Emergency lighting is required for workplaces that are used during the hours of darkness and for most premises used during winter months after 4pm, that's just about everywhere. The purpose of emergency lighting is to allow people to find their way out via fire exit routes even if there has been an electrical power failure. The secondary purpose is to help the fire and rescue service enter the premises to carry out their duties. The emergency lighting must illuminate the entire route from the workplace all the way to the evacuation assembly area.

Signs and notices

Fire safety signs are standardised to comply with the Safety Signs and Signals Regulations and the relevant British Standards. The principle is that the colour informs you of its purpose and the pictogram provides the detailed information as shown below:

Mandatory signs are white on blue and prescribe behaviours that must be followed.
An example for fire safety would be 'Fire Door – Keep Shut':

Safe Condition / Safe Place signs are white on green and show location of safe places such as Emergency Escape route or first aid.

Warning Signs are black on yellow with a fire example being "flammable material":

Fire equipment signs are white on red. This example is the location of an extinguisher:

Inspection, testing and maintenance

There is a considerable amount of inspection, maintenance and testing required on all the fire safety provisions. Routine workplace inspection should detect the accumulation of combustible rubbish, the blocking of fire exit routes, missing labels and signs or poor standards when handling flammable materials. Other checks include Compartment Integrity, Fire Doors, Fire Detection and Alarm, Escape Routes, Final Exits and Assembly Areas, Emergency Lighting, Change of Use or Occupancy Profile and Evacuation Drills. Inspections and maintenance work often trigger reviews of the fire safety management arrangements when it is revealed that there has been a change in use or occupancy profile.

The most common failing in compartment integrity is fire doors being wedged open or their self-closing mechanisms being disabled. In some cases, the fire doors are actually removed from frequently used doorways. Some fire doors, such as on cupboards under stairways on a protected escape route, have mandatory signs showing 'keep locked shut'. This instruction needs following to reduce the risk of combustible material being stored becoming involved in a fire either by accident or by arson as it will compromise this exit route.

A weekly test of the fire alarm system is normally specified in the emergency plan. The purpose of this brief test is to check audibility in all areas so some staff will need to be given precise duties to be present at certain locations when the test is due.

Do you know when the fire alarm is tested?

Can you hear the alarm clearly in all locations?

Fire evacuation drills are intended to check the complete evacuation system from audibility of alarms, peoples' use of their nearest exit, the speed of evacuation and roll call and the accounting for missing people.

Fire safety risk management: stage 4 recording, emergency plans and training

The recording of the significant findings and review of the existing control measures will allow the development of an appropriate fire emergency plan. The plan should include simple but clear information on a wide range of headings:-

- Action on discovering a fire
- Procedure for calling the fire service
- How people are warned of emergency
- Action on hearing an alarm
- Procedure for shutting down work and equipment
- Fire equipment provided
- How evacuation is carried out
- Fire evacuation assembly point
- Liaison with the fire service
- Key escape routes
- Nominated staff with key roles
- Procedures for checking successful evacuation
- Safe evacuation of special needs, contractors and visitors

The plan may also include drawings showing the location of flammables' storage, gas isolation points and evacuation assembly areas so that fire service or other first responders gain the information they need.

Information, instruction and training

Once the fire safety risk assessment has been completed and emergency plans developed, then information, instruction and training needs to be provided to employees, contractors and visitors so that everyone knows the part they play. In particular, local rules need developing for what should be done before leaving the laboratory in response to an evacuation alarm. If they are not automatic, shutting down cupboards and closing windows would be expected.

Do you know the fire evacuation procedure for your lab?

Nominated persons

A number of people are required to ensure that the emergency response goes as planned and these are detailed below.

Fire wardens are appointed to help the organisation ensure that the building has been successfully evacuated. Fire wardens normally walk through their own area to check that everyone has heard the alarm and that they are making their way to roll call. Fire wardens are also expected to ensure that those with mobility impairments are taken to a refuge area or otherwise assisted in their escape.

Roll call officials have the job of checking off names of persons at the assembly area against some form of register. This is a particularly difficult task in buildings where there is no access control and people move freely in and out. If you have information about the location of somebody that is on the register but not at the roll call point, you should make this information known to the roll call official.

Cooperation with emergency services

Someone should have been appointed to act as liaison with the emergency services and you need to know who this person is in case you have information about the fire (or false alarm) that would help them in their work. You may have specific knowledge about special hazards that the fire officer may face when entering the laboratories. You should also inform the Emergency Services about experiments that have been left running, and advise on whether it would be necessary to shut the experiment down.

Risk management: Stage 5 reviews

Like all other risk assessment processes, the results need to be reviewed at intervals or after changes to ensure that the findings and precautions remain valid. There are many triggers for review and you may know of reasons why the control measures are no longer adequate or appropriate in some way.

Learning assessment 2

Are the statements below true or false?		true	false
1.	Air is the only source of oxygen to consider when assessing fire safety in the chemical laboratory.		
2.	Mixtures of flammable vapours will only burn if the fuel concentration lies within certain limits.		
3.	There are some risks that may be considered acceptable during normal working hours that may not be acceptable during lone working.		
4.	Class E fires are electrical fires.		
5.	Fire extinguishers are different colours according to their type of extinguishers.		

Check your answers on the separate answer sheet.