TOPIC

6

LABORATORY DESIGN FOR HEALTH AND SAFETY

This is a new Topic but it incorporates elements of Chapter 10 'Chemical storage', from the previous edition. It draws on information from several publications including DfEE Building Bulletin 80[1].

1 Introduction

This Topic is not intended to provide a blueprint for laboratory design. Some sources of further detailed information on laboratory design are listed at the end of this Topic. The purpose of this Topic is to highlight some key health and safety issues facing the head of science and to provide a briefing paper that the head of science can use in discussions with senior managers when dealing with safety issues involving the design of science facilities. Few heads of science are faced with the task of designing a brand-new department from scratch but many more are charged with advising on the updating of existing facilities. This Topic aims to be helpful in both cases and also should be of use to heads of science managing existing facilities and trying to keep the health and safety provision as up-to-date as possible.

2 Strategic design for health and safety

A high proportion of accidents in school science are traffic accidents, which fall into two broad categories. The first arises from technicians transporting materials or equipment over long distances or on difficult journeys which might involve a change of level or movement from one floor to another. The second involves collision between technician and students using the same thoroughfares. The ideal solutions to these hazards involve careful initial design. The department needs to be compact, aiming for a radial rather than linear structure, and the prep room and storerooms need to be well centralised so that distances between them and the laboratories they serve are minimised. Ideally technicians and students should use separate traffic routes. One possibility is to place the prep room at the hub of radiating laboratories although this clearly causes lighting problems in most situations and may also result in problems connected with ensuring adequate escape routes for technicians.

Modern buildings will meet current fire regulations. The laboratories and prep rooms must have two exits 'if a single exit door would be in a hazardous position'. The DfEE's position is one of delicate ambiguity but many fire officers would insist on a second exit; this may be into another laboratory provided the laboratories are properly separated. Stairwells should be isolated from the corridors by fire doors. These are minimum requirements and thought should also be given to escape routes used in emergencies and factors such as the effect of door and corridor width on the speed and ease of a full evacuation. Older buildings may have laboratories which share a ceiling or roof void. Fire can spread with great speed across such voids and any upgrade should include consideration of the possibility of installing firebreaks.

There is much to be said for science departments occupying a single floor (ideally the ground floor) but this is clearly impractical for larger departments and indeed in many schools. Departments occupying two or more floors should ideally have a prep room for each floor and/or an excellent lift system designed to accommodate trolleys and technicians. In this case the head of science will need to devise methods for dealing with the loss of flexibility caused by the restrictions in movement. Where apparatus, chemicals and equipment are moved using trolleys, movement should be minimised and if possible there should be designated trolley parks. One solution involves the storage of trolleys at both ends of their journey and the provision for this should be considered at the design stage of laboratories and prep rooms. The provision for deliveries should be considered in the overall design of the department. When delivering hazardous materials or delicate equipment suppliers should be able to transfer materials as directly as possible to safe storage.

Security is an important aspect of design. The designer needs to consider the protection of the building from outside intrusion in terms both of the quality of doors, windows and locks and of eliminating blind spots where illegal entry may be unseen. Careful siting of vulnerable rooms such as stores and prep rooms may also reduce the possibility of casual theft or vandalism. Unauthorised access needs to be difficult and supervision easy. It must be borne in mind that good

[1] DfEE (revised 1999) *Science accommodation in secondary schools, a Design Guide,* Building Bulletin 80. Stationery Office. ISBN 0 11271039 5.

design alone will not protect a building and appropriate management of the facilities is also essential.

3 Laboratories and prep rooms

One of the main considerations in the design of laboratories and prep rooms is the extent to which they are to be specialist facilities or will cater for all sciences and all age groups. Laboratories used for chemistry experiments require the greatest additional investment for health and safety (laboratory ventilation, fume cupboards and heat-resistant benches) and services (gas and water). The counsel of perfection is to design for maximum flexibility but the decision will depend on both philosophy and finance. The size of the laboratory will depend on the numbers in the largest groups to use it. The ideal may well be practical class sizes limited to twenty students (as in Scotland) but in practice it would seem realistic to expect a maximum class size of thirty (or possibly thirty-two) in England and Wales. The DfEE recommendation is for such a laboratory to have a floor area of 79–91 m^2. If the laboratory is too small, overcrowding will result, but, if the laboratory is too large, supervision may become difficult. Floor area is only one guide; the proportions of the space are significant and a laboratory also needs to be furnished. For the most efficient general supervision of practical work the laboratory should approximate to a square (DfEE recommend a 10:8 ratio).

Laboratories and prep rooms need good ventilation and it is desirable to have 5–6 air changes an hour, but this is often difficult to achieve in a prep room. Opening windows will provide basic ventilation and, in addition, laboratories used for chemistry should be fitted with extractor fans for which air inlets will also be necessary. Air inlets need to be placed to provide a proper flow of air through the laboratory. Fume cupboards ideally need to be sited away from corners and doors where turbulence might affect their performance. If residual current devices are fitted, the fume cupboards and extractor fans should be on a separate circuit to minimise the possibility of nuisance tripping. Remember that different ventilation systems affect each other and also the response of a room to fire. Furthermore, extraction systems generate noise which affects ease of class control.

Laboratory and prep room lighting is difficult. It goes without saying that teaching areas need to be well lit and that natural lighting has obvious benefits. However, thought needs to be given to the negative effects of bright sunlight. These include rendering Bunsen burner flames invisible, dazzling students and making rooms uncomfortably hot. Fitting solar film to the glass can significantly reduce these effects but this of course reduces the light levels in the room, a particular problem if plants are grown on window sills. There is frequently a need to dim a laboratory which can be achieved using curtains, or fabric, plastic or metal blinds. Curtains are significantly less safe than the other options.

All laboratories and prep rooms need gas, water and electricity and each room should have separate isolation valves or switches for each of the services. The electricity supplies should ideally be fitted with a residual current device which can double as an isolation switch. Some consideration needs to be given to the positioning of these isolation devices. One possibility is to site them just inside the main exit door to the room but there is also much to be said for placing them by the teacher's bench. Gas regulations require a gas shut-off where the supply enters the room but this may not be ideally placed for use by the teacher in an emergency. Use of a solenoid valve allows the switch to be located anywhere convenient. Washing and eye-wash facilities are essential for all laboratories (see Topic 5).

If smoke alarms are fitted it is important that they are automatically switched off when laboratories are in use, as they will be triggered by many class activities involving heating.

The choice between fixed benching and flexible units has been extensively discussed and debated. There are two possible safety aspects. The first involves those systems which utilise service pods hanging from the ceiling. These offer great versatility but the pods themselves may interrupt the sight lines of teachers and may be easily damaged. The second arises when the flexibility is used to create a configuration which affects the emergency escape routes within a room or access to emergency equipment such as eye-wash facilities or fire extinguishers. The conventional fixed system needs, of course, to have an optimum configuration for supervision and escape which needs to be established at the design stage. Long runs of benches that split the room and awkward corners without easy local escape routes should be avoided. The position of the board is an important decision. This is frequently on a short wall although the longer wall brings the class closer on average to the teacher and should improve supervision.

The design of the laboratory or the provision of its furniture should allow for the neat storage of bags. Clearly these should not obstruct gangways or escape routes directly or, indeed, indirectly by preventing stools being stowed under benches. Possible solutions will include additional under-bench storage or shelving; an alcove is a useful design feature. Here and elsewhere good management of the laboratories is as important as good design and such storage must not become a receptacle for waste. Additional planned storage for goggles and for laboratory coats (if used) is also desirable.

There is a wide range of materials suitable for floor coverings and benches. Floors need to be hard-wearing, non-slip, chemical resistant and easily cleaned or disinfected. From the safety angle there is perhaps little to choose between the various alternative materials for floors or benches.

4 Storage

To a large extent storage will depend on the layout of the school. Modern designs have a central store and an adjacent prep room area but in existing buildings compromise is inevitable. Any store needs to be readily accessible to technicians (and possibly other staff) and inaccessible to students and unauthorised personnel. There should be additional, possibly separate, secure storage for expensive equipment. Outside stores should be avoided if possible, as such stores are susceptible to vandalism, labels rapidly become unreadable and they often lead to the creation of unofficial internal stores, to avoid journeys outside in bad weather.

Lighting should be excellent to reduce the possibility of error. Storage on deep shelves should be avoided, as should placing heavy equipment or bottles above eye level. Some stores may need provision for securing gas cylinders either on or off their trolleys.

If at all possible, there should be a separate chemical store, preferably opening off the prep room area. It needs good security and it is desirable though not essential that doors should open outwards. Ventilation can be achieved using air-bricks at a high and low level if there is an outside wall; otherwise, extractor fans on a time switch will be necessary. Ideally, the floor should slope away from the door and be made of concrete or quarry tiles. The chemical store should have a spillage kit. Running water may be helpful in emergencies unless the store is adjacent to the prep room but it should not have a gas supply.

Highly flammable liquids can be stored within the building in flammables cabinets, with a maximum of 50 litres in any one room. Other chemicals can be arranged on shelves in the locked chemical store but, if local conditions suggest that extra security is required, they can be locked in ordinary wooden cupboards.

Chemicals can be separated into:

- corrosives chemicals;
- oxidising agents;
- toxic and other inorganic chemicals;
- toxic and other organic chemicals;
- flammable solids;
- large bottles of made-up solutions.

Incompatible chemicals (e.g. acids and alkalis or oxidising agents and most organic chemicals) should be stored as far apart as practicable, e.g. in different cupboards, or on shelves on different walls of the store room. Large bottles should be low down but off the floor, or protected from kicking. This can be achieved by standing them in a container such as a plastic trough or on a plinth. In the latter case further protection can be achieved by using a barge board to retain an absorbent material such as sand. Chemicals that are hydrolysed by water in the atmosphere should be kept in containers with soda lime. Radioactive substances should not be kept within the chemical store, but must not be within 2–3 m of any area occupied by the same person on a regular basis.

After use, bottle necks and drips should be wiped to avoid any further evaporation within the store. Ensure caps are firmly screwed on.

Spark-proof electrical fittings (e.g. fans and lighting) are not essential unless highly flammable liquids will be dispensed there. Even then, spark-proof fittings may not be necessary if there is good ventilation and dispensing takes place some distance (e.g. 2 m) from any electrical fittings. However, with new buildings and refurbishment it is usually easy to locate switches outside the store and this is worthwhile.

Unfortunately, the design of the school may dictate that chemicals have to be stored in the prep room. In this case all but the most innocuous should be locked away to prevent the possibility of theft if students enter the room. As chemicals will be dispensed, access to a fume cupboard will be necessary, either in the prep room or in an adjacent laboratory. In addition, forced ventilation (with an extractor fan) is almost certain to be necessary.

A biology store may well need a refrigerator for micro-biological materials but higly flammable liquids must not be stored in or adjacent to it.

Effective storage requires good management of resources with equipment and materials organised in a simple but effective way that allows for rapid stock checks and easy removal of out-of-date chemicals or other materials. A possible organisation of a chemical store is illustrated in Appendix 1. Appendix 2 summarises the main options for the storage of chemicals.

Further information

ASE (1989) *Building for science, a laboratory design guide*. ISBN 0 86357 119 0.

ASE (1996) *Safeguards in the school laboratory*. ISBN 0 86357 250 2.

CLEAPSS School Science Service Guide (March 2000) L14 *Designing and planning laboratories*.

DfEE (revised 1999) *Science accommodation in secondary schools, a Design Guide,* Building Bulletin 80. Stationery Office. ISBN 0 11271039 5.

DfEE (1996) *Safety in science education*. Stationery Office. ISBN 0 11 270915 X.

Appendix 1 Possible organisation of a chemical store