NERC Guidance on Design of Safe Laboratories

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Introduction and background

This guidance is intended to provide information on the standards that may be expected in new, refurbished or updated laboratories that are installed in NERC facilities. It does not directly apply to ships, for which related guidance promoting similar standards is published incorporating factors to accommodate the particular issues involved in undertaking laboratory work at sea.

There is little official guidance issued to determine exactly how laboratories should be designed but much literature on the subject has been published, which often requires interpretation and adaptation. This guidance attempts to distil best laboratory design practice, legal requirements, official guidance, national/ international recommended standards and practical experience. The aim is to provide guidance which helps ensure new or updated facilities are fit for purpose, permit the best research, are flexible in use and allow for safe conduct of practical experimentation in a good working environment.

The guidance breaks the topic down into a number of areas:

- Write-up areas
- Finishes / Materials of construction
- Benching
- Seating / Space / Lighting
- Storage
- Specialist items of equipment
- Hygiene / Personal Protective Equipment (PPE):
- Waste
- Drains
- Ventilation
- Hazardous chemicals
- Fume Cupboards
- Compressed gases
- Cryogenics and dry ice
- Ionising radiation
- Signage
- Security
- Electricity
- Biohazard Laboratories
- Emergencies

Write up areas

Traditional laboratories incorporated write up areas into the general laboratory area, often at the end of bench-runs next to windows. This meant the write up area was part of the laboratory and the writing up activity should be subject to the same requirements for personal protective equipment etc. as practical laboratory work. In addition, the office materials and paperwork, books etc are liable to contamination in such a lay-out. It also means that drinks and food cannot be consumed in the write-up and that the means of escape requires travel from a safe area (the write up) through a higher risk space (the laboratory).

Nowadays it is best practice to segregate write-up/data entry or 'office' activities from laboratory ones and locate them in a segregated area next to a corridor or dedicated escape route so travel through the laboratory in case of an emergency is not required. There are safety benefits to locating write-up and laboratory associated office space close to the laboratory where people undertake practical work and best practice is to co-locate the two activities but segregate the two activities by full height partitions containing vision panels or composed of full height glazing. This also has the benefit of allowing the office space to have less stringent environmental and air change requirements so saving energy.

Where the write-up is contiguous with the laboratory, e.g. in a large 'flexible' laboratory arrangement, it should be segregated by partitions of 1.8 metre height (preferably at least half-glazed to allow for clear fields of vision) to clearly segregate the two areas, with the write up next to the exit.

Finishes / Materials of construction

The laboratory should be designed and constructed to prevent persistent contamination through impermeability, chemical resistance and ease of cleaning. Surfaces, walls and floors should, as far as is possible, be smooth, crevice–free and made of materials that do not absorb the agents being handled and are resistant to attack by chemicals and disinfectants. Any crevices, cracks or joints should be sealed with silicone or other resistant / flexible sealant.

The following should be provided:

- Floors to be non-slip, impervious and resistant to chemicals e.g. covered with safety vinyl sheet material (e.g. Altro safety flooring) with the minimum of joints, but, where joints are unavoidable, these being welded or have an epoxy resin coat, impregnated with anti-slip granules. Edges and corners to walls, openings and built-in cupboards should be coved to eliminate traps but have internal former/support to prevent damage.
- Walls should be coated with impervious and water resistant finishes, sealed at connection with permanently fixed benching.
- Worktops must be impervious and resistant to common laboratory solvents, reagents (e.g. acids and bases) and disinfectants, ideally being 'Trespa' (solid grade laminate with two grades TopLab Base or, for even better chemical resistance, TopLab Plus) or stainless steel. Cast epoxy or 'Corian' may also be appropriate. The worktop may need to incorporate lips to provide a degree of

'bunding' that helps contain spilt liquids via secondary containment. Free-standing or mobile benching can be useful to give flexibility and allow for easy re-arrangement of layout but in such applications it may be considered important that 'dished' or contained benches with lips around all sides are used where there is a chance of spillage of liquids.

- Sinks used for chemicals must to be resistant to the reagents used and of unitary one piece or welded construction e.g. stainless steel, polythene/PVC or cast epoxy resin. The joint to surrounding benching is often a weak point in terms of sealing and trapping contaminants.
- If drains are likely to carry chemicals they must be of resistant material e.g. vulcathene (glass drains can present problems).
- Furniture should be designed to resist corrosion from chemicals and constructed to allow ease of decontamination. Cupboards beneath worktop level should either be hung from frame with clear space beneath to allow the floor to be cleaned or built-in with coved flooring running up their plinth to prevent spills creeping under cabinets. An alternative is mobile furniture on lockable castors so they can be moved to aid cleaning/decontamination.
- Wooden frames to furniture should be avoided as should chipboard or other absorbent materials.
- If liquid nitrogen is used, flooring materials that are resistant to extreme cold from cryogenics and their vapours should be used in vicinity of dewars / dispensing points, e.g. polished sealed concrete, chequer plate steel but NOT vinyl.
- Ceilings should be able to be cleaned or easily replaced. Any ceiling tiles should be smooth and wipe-down or easy-clean.

Benching

Benching must be of suitable dimensions and strength to take all foreseeable apparatus.

Much modern laboratory equipment has a depth of greater than 750mm so double width benching without surface protrusions may be needed.

The means of providing services to benches will require careful consideration. Overhead supply, e.g. by pendants, has attractions but can be difficult to access for connecting and disconnecting/isolating equipment. Overhead 'wings' or aerofoils are attractive but again may present problems with access and can be difficult to keep clean, especially on their upper surfaces. Electrical outlets located on bench fronts where they may be subject to impact or spilt materials can be an issue. Dado supply on the wall at the rear of benches just above bench height is normal with the alternative of pods located in the centre of larger benches, provided this does not spoil open bench space and prevent use of larger equipment. Drip cups for waste water may be incorporated in benches but unless regularly used, their tarps dry out and allow passage of noxious vapours into the laboratory.

Equipment may be very heavy e.g. scintillation counters containing lead shielding so benching will need to be strong enough to carry foreseeable loads. For certain heavy or large items of laboratory equipment it may be necessary to have specially designed and dedicated benches or trolleys constructed for that item.

An adequate clearance height above equipment located on benches must be ensured as access for servicing or topping up with process material may be required.

Benches with a lower than standard height may be required to mount tall or stacked apparatus so it can be operated and accessed without use of steps, ladders or 'kickstools' by smaller staff.

Adjustable height benches can also be useful. It is particularly valuable for activities requiring extended periods of repetitive bench work by staff of varying height in allowing good ergonomic practice. Although this may be expensive initially, it is much more flexible in use.

Seating / Layout / Space / Lighting

Laboratory seating must be stable and finished in material that is easy to clean eg vinyl or hard plastic. Cloth faced seats are not appropriate in laboratories. General guidance on laboratory seating is given at Appendix 1.

Adequate space for each scientist to allow work to proceed safely must be provided, probably at least $5m^2$ per occupant unless they are engaged on the same work. A clear distance between a bench and a wall or any obstruction of at least 1m to allow for safe passage of staff / material behind the working scientist should be assured. Opposing benches should be no closer than 1.5m apart but ideally a clearance of 2m should be assured. Care is required in locating fume cupboards and they should be away from corners, doors, openable windows or draughts of air with a clear space of at least1m in front of fume cupboard through which personnel should not move when cupboard is in use (see fume cupboard advice for more details). Loose storage of laboratory consumables or other materials on the floor should be discouraged and adequate trolleys, racking, shelving or other storage arrangements provided (see storage section). Adequate circulation space for movement of persons, equipment, trolleys and room for safe handling, maintenance and operation of equipment must be ensured at all times.

Lighting needs to provide adequate illumination for the tasks undertaken. Much equipment uses DSE screens so general lighting should be DSE compliant (light fittings should be covered by reflectors to limit angle of illumination and prevent glare). Ideally fittings should have covers or transparent wipe clean shields to protect against ingress of material and allow for ease of cleaning. Detailed examination may be necessary in some work so average illumination at bench surface should be at least 300 lux and possibly higher but does not need to exceed 500 lux. Localised 'task' lighting may be necessary for detailed examination of specimens.

Storage

NERC guidance on the safe storage of laboratory chemicals provides information on the physical requirements for storage and should be referred to for laboratory design: http://www.nerc.ac.uk/about/policy/safety/procedures/guidance_chemical_storage.pdf. Other storage matters to consider include:

General Reagents: dedicated cupboards for storage of general reagents should be provided and made of resistant materials, ideally with bunded shelves.

Toxic Chemicals: a dedicated lockable cupboard is required for toxic or other high risk reagents

Highly flammable liquids (with a flash point of 32º C or below): an approved solvent cupboard with storage capacity for a maximum of 50 litres or 20 winchesters (i.e. a two door under bench cupboard with a single shelf) but the volume stored should be kept as small as possible so only a smaller single door cupboard. This must be of 30 minute fire resisting construction having a:

- sealed carcass (with bonded or otherwise fire stopped joints)
- high melting point hinges and fittings
- HFL sign (yellow/black triangle with a flame symbol and suitable wording)
- no vents (or, where there are vents, protected against passage of flame with a fire damper or flame arrester)
- bunded storage (eg shelves with lips turned upwards or trays)
- rebated doors or lid (preferably with seals)
- lockable door / lid fastening which will not allow warping in the event of a fire.

Corrosives: the storage cupboard must be made of material resistant to corrosion and with bunded shelves or trays. Corrosives should be kept separate from other chemicals but acids and bases should be kept segregated from each other so two corrosive cupboards may be required. The use of 'safepaks' or other unbreakable outer container may provide suitable segregation if the provision of separate corrosive cupboards is impossible.

Gases / gas generators: Gas cylinders should ideally be located in safe positions in the open air and piped in to their point of use in the laboratory. If a safe place in the open air is not practicable, then one or more dedicated, gas cylinder storerooms with forced high and low level extract ventilation and suitable segregation of fuel, oxidising and toxic gases should be used from where gases are piped to their point of use may be used. Such storerooms may require gas sensing for flammable atmospheres and/or low oxygen. Provision for storage of small gas cylinders may be required, which is often on racks with the cylinders horizontal or slightly inclined upwards. Suitably designed fire resisting gas cylinder cupboards with forced ventilated located in the laboratory close to the point of use are another alternative. Gas generators are worthy of consideration as they eliminate the need for cylinders, provided they are reliable enough or there are back-ups in case of failure. Hydrogen and nitrogen generators are available. Flammable gas cylinders must be fitted with flash back arresters. NERC guidance on storage and installation of gas cylinders is given at:
http://www.nerc.ac.uk/about/policy/safety/procedures/guidance_gas_cylinders.pdf

Fridges: fridges in laboratories should ideally be of a spark-free design free design unless there is no possible chance of flammable solvents ever entering the fridge. Such spark-free fridges will have their temperature control mechanism outside the storage compartment with only a temperature sensor inside the fridge and no interior light or light switch in the door. Laboratory fridges should be labelled with signs to indicate: ‘No storage of food or drink for human consumption’ and, if they are not spark-free, ‘No storage of flammable solvents’. If temperature control is critical, medical fridges may need to be specified. Storage of small bottles of chemicals in door compartments or shelves is to be discouraged unless the shelf is of a completely enclosed pocket design so the small bottles cannot fall out when the door is opened sharply. If fridges are used for storing radioactive materials, the fridge will need to be lockable and labelled to indicate this usage.

<u>Disposable consumables</u>: many laboratories will require storage of large amounts of disposable laboratory materials such as plasticware. Suitable storage facilities on shelves will be required but as plasticware is usually light so storage on shelves above bench height may be possible. Storage of such materials on floors or in positions where they restrict safe working is to be discouraged. If necessary, a store elsewhere on board is required from which smaller amounts of stock are regularly transferred as they are consumed.

<u>Glassware</u>: Special care is required in storage of glassware to help prevent its breakage. Dedicated storage cupboards or drawers with holders, foam rubber inserts or corrugated plastic lining (e.g. cut-down acrylic roofing sheet) can be used to prevent items of glassware moving or coming into contact with each other.

<u>Laboratory waste</u>: Wastes that contain incompatible materials must be kept segregated from each other and hazardous waste requiring special treatment or disposal must be safely stored and segregated from ‘domestic’ or harmless waste. Types of waste requiring consideration are:

- Sharps (special containers that comply with BS EN ISO 23907:2012 can be obtained with different colour coded/labelled versions available for biological, radiological and chemical contaminated sharps)
- Broken Glass – possibly for both contaminated and uncontaminated waste
- Biologically contaminated waste awaiting treatment (eg by autoclaving or incineration)
- Chemical waste (with segregation of incompatibles) - bottles should be packed in secondary containers (e.g. safepaks) with absorbent packing; drums should be stored in a manner which contains any leaks of material e.g. on a bunded pallet or in a bunded store
- Radioactive waste
- Flammable liquid waste (solvent)
- Contaminated consumables including tissues and gloves
- Materials placed in disinfectant e.g. discard pots

Specialist items of equipment

The laboratory may be required to accommodate specialist items of equipment such as compressors, vacuum pumps or sterilisers. Compressed air may be plumbed in as a standard service supply but if the supply is from a compressor located in the laboratory, matters such as noise and heat must be taken into account. Selection of the correct item of equipment, e.g. a noise suppressed or inherently quiet design should be chosen. However, it may be necessary to place such equipment in a dedicated cupboard with local ventilation, in order to dissipate heat or fumes or suppress noise. Local vacuum pumps will have similar problems of noise and heat are also possible issues but may also release oil mists, vapours and fumes should their exhausts discharge into the laboratory. This means local extraction for vacuum pumps is even more important. They can also be arranged to discharge to a safe place outside the building or have suitable exhaust filters e.g. to remove oil mist or cold traps to condense vapours.

Steam autoclaves to sterilise glassware, research materials and equipment or render infectious (or potentially infectious) waste safe before disposal may be installed. Autoclaves will also produce heat, steam and possibly noxious smells so should be located in areas with excellent general ventilation (possibly in their own alcove, ante-room or lobby) or have a dedicated extract hood.

For local treatment of waste, it is considered that only high temperature steam treatment via an autoclave will give true sterilisation. Alternative methods of local treatment, such as microwaving, will not give the same level of assurance but disinfection may be acceptable as an alternative to sterilisation where justified by risk assessment.

Hygiene / Personal Protective Equipment (PPE):

Handwash – it is best practice to provide a dedicated clean sink for hand washing which is not used for any disposal of chemical or biological agents. This should have hot and cold taps (or a mixer tap) which does not require the use of hands to operate, soap/detergent and a means of drying hands in every laboratory (or in an ante-room to a suite). The handwash basin, which is essential in a biosafety containment laboratory, should be located close to the exit.

PPE - coat hooks should be provided for hanging laboratory coats or other dedicated protective clothing. Additional separate storage will be required if personal or external clothing is also required to be stored close to the laboratory. Provision should be made for storing / dispensing items such as safety spectacles, disposable gloves (in various sizes) and, where necessary and specified in risk assessments, disposable RPE etc. Lockers are best for storing personal clothing / items but these must be kept separate from in-use PPE.

Cleaning/decontamination – provision to allow storage/availability of equipment to allow cleaning/decontamination of the laboratory should be made.

Drains

Infrequently used drain outlets will dry out and allow passage of noxious vapours into the laboratory through open traps. The number of drainage points should therefore be kept to the lowest number practicable for the work likely to be undertaken.

Special requirements apply to drains used for disposal of radioactive material (see ionising radiation section).

Floor drains in laboratories should be avoided as they present a problem should a major spill of a hazardous chemical occur. However, they may be justified in certain circumstances where contamination is heavy but non-hazardous and regular wet floor cleaning and wash down is needed e.g. in a soils laboratory.

Ventilation

Laboratories are normally provided with mechanically ventilation. Naturally ventilated laboratories are possible, provided a high air exchange rate (i.e. 5x or more air changes an hour) can be maintained by open windows or ventilation grilles. However, achieving ventilation by natural means may be difficult in basements or where there is no or restricted window provision and no external walls. Where there are high air supply requirements due to the amount of local extract ventilation (LEV) in place or where strict control of conditions is required e.g. for cleanliness or temperature control, mechanical ventilation of laboratories is necessary.

Where forced mechanical is provided it should be left running continuously. A night set-back with reduced air exchange and / or widened temperature ranges during hours when the laboratory is unoccupied is possible, and even desirable, provided it is carefully managed and can be over-ridden when laboratory work is undertaken out of normal hours. If make-up air is provided, a net inflow of air into the room should be maintained to give a negative room pressure relative to surrounding non-scientific areas. Operation of equipment over evenings and weekends or other controlled condition requirements may necessitate continuous operation of ventilation and cooling.

There is no official guidance on ventilation rates for research laboratories. The only strict limit is for Home Office licensed rooms where a minimum number of air changes of 15x an hour may be specified depending on the species.

CIBSE Heating, ventilating, air conditioning and refrigeration Guide B refers to laboratories. This indicates air change rates in laboratories should be between 6 and 15 changes per hour.

The Home Office requirement for 15 air changes per hour is a very strict one which is difficult to justify for normal laboratories unless dictated by other factors such as the number size of fume cupboard(s) relative to the room size.

If mechanical ventilation is provided, the air change rate in the laboratory should not be below 6 air changes per hour, except during out of hours when 3 or 4 air changes per hour should be sufficient. A design standard of about 10x air changes an hour during normal operation is excellent and the maximum that should be aimed for unless dictated by other factors. However, air change rate is a relatively crude measure which does not take into account the size of the room, the occupancy or the activities being undertaken. In large open plan ‘flexible’ laboratories with considerable room volume to dilute fumes and mixed use, including write up and break out areas, lower air change rates are probably acceptable due to the greater dilution. Often ventilation rates can be calculated on volume per person or volume per rate of contaminant generation sufficient to give adequate dilution / dispersion. In addition, if all the hazardous work is undertaken in ventilated enclosures like fume cupboards, the amounts of contaminants escaping into the general laboratory atmosphere will be much lower than if work with volatile materials is done on the open bench.

Use of liquid nitrogen in laboratory can require high air change rates which may need to be supplemented by emergency extra extract e.g. in NMR laboratories when a quench of the magnet occurs (se section on cryogenics).

Air that has been re-circulated should not be included when calculating air change rates. It should be based on the volume of fresh make-up air unless that air has been artificially purified, e.g. by passing through a charcoal (for vapours/fumes) or HEPA (for particulate contaminants) filter, but even then this cannot take account of asphyxiant gases that reduce oxygen concentration (e.g. nitrogen from liquid nitrogen) which will not be removed by filtration. Laboratories should ideally have 100% dump of exhausted air to external atmosphere and full fresh air make-up. If cooling using fan-coil units is provided higher air change may not be needed.

The air discharged from the ventilation system should exhaust to external atmosphere, venting to a safe position in the open air where it cannot re-enter an occupied area or ventilation intake.

Fume Cupboards

Guidance on fume cupboards is given at Appendix 2.

Compressed gases

Laboratory designs which provide location of gas cylinders within laboratories should be avoided if at all possible. Ideally gas cylinders should be located outside buildings in safe places in the open air with the gas supply piped in to the point of use. Cylinders located outside buildings should be provided with secure storage cages that provide some protection against the elements. A satisfactory alternative is to locate gas cylinders in specially designed, dedicated and well-ventilated gas cylinder storage/manifold room e.g. having two opposing walls that are 50% open to air. Attention should be given to having adequate separation between cylinders of incompatible gases e.g. between flammable and oxidising gases. If it is essential to keep gas cylinders inside laboratories, consideration should be given to installing ventilated, fire protected gas cylinder cabinets in which they may be located with a short pipeline to the point of gas usage. An even more preferred approach is to dispense with gas cylinders altogether and use gas generators.

Guidance on storage and installation of gas cylinders is given at:
http://www.nerc.ac.uk/about/policy/safety/procedures/guidance-gas-cylinders/

Cryogenics and dry ice

Guidance on use of cryogenics and dry ice is given at
http://www.nerc.ac.uk/about/policy/safety/procedures/guidance_cryogenics.pdf.

A low oxygen alarm may need to be installed if large quantities of liquid nitrogen are stored or present. The sensor should be located between 1 and 1.5m from the floor, give a local audible and visual alarm inside and outside the laboratory with the nature of the alarms clearly identified and a sign posted: ‘low oxygen alarm: do not enter if illuminated’ by the external visual alarm. A low oxygen alarm should be set at 19% and regularly (at least twice yearly) calibrated. Dry ice must not be stored in freezers.

Ionising radiation

The former Environment Agency Guidance to Inspectors on Laboratory design is given at Appendix 3. This has now been withdrawn but still provides the best guide and indicator currently available.

All new designs of radioactive laboratories should be discussed with the appointed Radiation Protection Advisor

Items that will need particular consideration include:

- Finishes to allow for removal of contamination
- Facilities for storage of radiochemicals and labelled samples (including security)
- Radioactive waste management
- Facilities to handle radioactive materials including fume cupboards (filters may be required for some activities such as radio-iodine) and dedicated PPE
- Containment of spills (e.g. no floor drains in radiochemical laboratories or, if present, means of sealing for duration of radiochemical work)
- Exclusion of unauthorised personnel
- Signage

Signage

Suitable signage should be displayed outside the laboratory making it clear what PPE must be worn and any prime hazards within. There is a danger of ‘sign blindness’ so the number of signs displayed should be kept low, preferably no more than four safety signs being on any door. Size is also important with A5 or larger being desirable and A6 or smaller sizes liable to be ignored. The signs may need to able to be changed according to use and in such circumstances they can kept in a holder so they may be replaced / turned around to indicate the hazards of the work being undertaken or other restrictions at that time. Storage cupboards or fridges should be labelled with wording and symbols (e.g. yellow/black warning triangle with words beneath, although the GHS system may now require certain red and white diamond signs and wording to be used) to indicate if they are used to store hazardous materials such as toxic, highly flammable, biohazardous, radioactive, corrosive, oxidising.

Security

Unauthorised access to the laboratory should be ensured. The door should be lockable and a prohibition sign stating ‘no unauthorised access’ displayed. Cupboards used to store restricted, radioactive, very toxic, poisons (e.g. mercuric chloride) or mutagenic / teratogenic / carcinogenic materials should be lockable. High containment laboratories must have an access control system in place so that only authorised persons may enter. High containment laboratories may also need vision panels, mirrors or closed circuit TV systems to allow checks on occupants from outside the laboratory.

Electricity

There should be sufficient switchable socket outlets to allow for each item of equipment to be plugged in separately – the use of extension leads with multi-socket outlets should not be necessary except by design on purpose built apparatus. The sockets should be mounted above bench level at the rear of the worktop but still allowing ease of access to sockets around large items of equipment. Pendant fittings may also be possible. Mounting sockets on the cupboard framework below the front of worktops allows for ease of access / isolation but also leads to looping / trailing leads and the sockets may get exposed to spilt liquids so is best avoided. Metal framework for benches used with live electrical apparatus must be earthed and cross-bonded.

Ideally the electrical supply should be provided with a residual current device (RCD) located and easily accessible within the laboratory, set to trip after 30 milliseconds at 30 mA earth leakage, with its safe operation regularly tested

Socket outlets located wet conditions or in positions where they may get splashed should be to at least IP54 rating. However, having all sockets within the laboratory fitted with a hinged, spring loaded covers may be undesirable and can introduce other hazards e.g. making use of plug-in transformers only possible with extension leads.

Consideration should be given to a central, isolation point close to the door (which may exclude certain sockets circuits such as those supplying permanently running equipment such as fridges, freezers etc). This isolation point may also be provided with an emergency isolation button e.g. mushroom headed. If provided, it is best the emergency isolation button is 'shrouded' to help prevent inadvertent operation by brushing or leaning against them *(note: a key operated type is not warranted in this application)*.

The use of 110V centre tapped earth supplies may be advisable in high risk wet conditions. Earth free areas and electrical supply via an isolating transformer may be required where testing of apparatus with exposed conductors at mains voltage or above occurs.

Biohazard Laboratories: There are strict containment requirements laid down by COSHH and GMO Regulations for laboratories where exposure to hazardous biological material may occur. For such work a minimum biosafety containment level 2 (CL2) should be aimed at, even if it is not always necessary. The minimum requirements for a CL2 laboratory are:

- Easy to clean surfaces
- Bench surfaces must be impervious to water and resistant to acids, alkalis, solvents and disinfectants.
- Adequate space in the laboratory for each worker.
- Dedicated handwash basin located near the laboratory exit.
- Handwash taps able to be operated without being touched by hand.
- Pegs in the laboratory for laboratory coats.
- If mechanically ventilated, an air pressure negative to atmosphere.
- A microbiological safety cabinet for operations where aerosols may be generated
- Safe storage of biological material. Security of storage should be achieved by control of access to areas where biological agents are held and appropriate measures to prevent spills or breakage of containers.
- Computer keyboards / equipment controls should be protected.
- Personal protective equipment such as disposable gloves and safety spectacles.
- A Biohazard sign at access point indicating the level of work undertaken.

More information on the design requirements for laboratories handling pathogens or materials containing potentially pathogenic organisms is given in the HSE guide entitled: 'The management, design and operation of microbiological containment laboratories'.

Emergencies:

Eye wash: Eye wash bottles within the laboratory will be acceptable for most laboratory activities provided only relatively small quantities of corrosive material are being handled. However, for large sites it is often desirable that at least one plumbed-in eye wash is located somewhere on site so that an extended period of irrigation of fifteen minutes or more may be possible.

Emergency showers: An emergency shower may be required if larger quantities of more than 2.5l of corrosive material are handled.

First Aid: provision for storage / availability of first aid equipment must be made.

Fire Extinguishing Equipment: Fire blankets should be provided in any laboratory where flammable or pyrophoric reagents are handled. Provision of extinguishers of the correct type, size and design will be determined by risk assessment but provision of fire points at strategic locations in corridors rather than widespread distribution of extinguishers across each laboratory is now best practice. An exception might be if there is provision of a specialist fire extinguisher for a specific hazard, e.g. a metal powder fire extinguisher, is required close to a unique hazard. In some circumstances fixed fire fighting provisions may be necessary e.g. for fume cupboards handling large quantities of flammable solvent.

Spill Kits: Provision for storage of spill kits within laboratories is best practice.

References:

1. BS EN ISO 23907:2012: **'**Sharps injury protection. Requirements and test methods. Sharps containers'

2. HSE Guidance on Regulations, L64: 'Safety Signs and Signals. The Health and Safety (Safety Signs and Signals) Regulations 1996'; HSE, 2015 (3rd Edition), ISBN 978 0 7176 6598 3, http://www.hse.gov.uk/pubns/books/l64.htm

3. Globally Harmonised System:
   - http://www.hse.gov.uk/chemical-classification/legal/clp-regulation.htm#ghs-hazard-pictograms
   - http://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=7634&furtherPubs=yes
   - http://www.hse.gov.uk/chemical-classification/legal/background-directives-ghs.htm

   (Note: The European Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures came into force on 20 January 2009 in all EU Member States, including the UK. It is known by its abbreviated form, 'the CLP Regulation' or just plain 'CLP'. The CLP Regulation adopts the United Nations' Globally Harmonised System on the classification and labelling of chemicals (GHS) across all European Union countries, including the UK).

4. CIBSE Guide B 'Heating, ventilating, air conditioning and refrigeration', 2004, Chartered Institute of Building Services Engineers, 222 Balham High Road, London, SW12 9BS, UK.

5. Index of Protection: ANSI/IEC 60529-2004: 'Degrees of Protection Provided by Enclosures' (IP Code), 2004. http://www.nema.org/Standards/ComplimentaryDocuments/ANSI-IEC-60529.pdf

6. HSE Publication L5 (6th Edition) 'Control of Substances Hazardous to Health Regulations 2002 (as amended): Approved Code of Practice and guidance', 2013, ISBN 978 0 7176 6582 2

7. HSE Guidance on Genetic Modification: 'The SACGM Compendium of Guidance from the Scientific Advisory Committee on Genetic Modification', Part 3: 'Containment and control of activities involving genetically modified micro-organisms'. http://www.hse.gov.uk/biosafety/gmo/acgm/acgmcomp/part3.pdf

8. HSE Guidance: 'The management, design and operation of microbiological containment laboratories', 2001, ISBN 9780717620340. http://www.hse.gov.uk/pubns/books/microbio-cont.htm

APPENDIX 1 – LABORATORY SEATING

The Health and Safety Executive guidance booklet on seating (HSG 57) does not address specific laboratory seating issues.

Issues with laboratory seating can be broken down as follows:

1. Height of worktop. If it is standard lab benching this requires a taller than normal seat which is normally catered for by a 'stool'. In addition, there needs to be 'knee holes' provided at the working positions so the scientist can get closer to the worktop to obtain a good ergonomic working position. Much lab work is now DSE related so lower height 'desks' and office-style chairs are required (see 9 on finishes and 11 on castors). Such desks should not be of an inferior office quality as these are not robust enough and tops may become damaged, chipped etc in use. Lab desks should be of the same quality and finish as the lab benches. Variable height benches are available.

2. Standing or sitting. Much lab work is standing up but if it is repetitive and done in one location for extended periods of time then a seat is needed.

3. Fume cupboards. These present a problem since there may not be a kneehole beneath the worktop; indeed the presence of an opening beneath the worktop has on occasions been shown to affect containment performance. Fume cupboards are normally located with their worktop at the same height as the bench worktop and with a cupboard beneath. Use of a stool may be possible but will either require sitting a long way from the cupboard or at an angle/sideways, which are not ergonomically satisfactory although possibly acceptable if only observation is involved.

4. Safety cabinets. There is normally always an opening beneath a safety cabinet but there is a choice of heights. Many cabinet suppliers will automatically supply a cabinet with a lower stand that only allows them to be used when sitting. If this lack of choice is not desired, then the cabinet must be specified with a higher stand although variable height adjustable cabinets are available but expensive. Higher stands allow use either standing, for work of short duration, or sitting using a stool if the work is of long duration and/or involves repetitive actions. The stand should also have a foot rest which can be useful in providing extra comfort. Class II safety cabinets are a problem if persons are sitting and resting their arms on the edge so affecting flow of air into the front grille and hence the protection offered to both work and worker.

5. Backrests. If the work is for long periods with close manipulation then a backrest (preferably adjustable) is desirable and it is important if DSE work is being performed for periods of greater than an hour (i.e. for 'habitual users').

6. Height adjustability. For habitual DSE users this is essential and, given fixed height benching with variability in size of staff, is always desirable but such seats cost a lot more than a traditional lab stool.

7. Armrests. These are not essential and may even be undesirable for some situations but are likely to be a matter of personal preference. Armrests can cause the user to adopt an undesirable position with their elbows and wrists.

8. Footrests. If a tall seat (stool) is used then some form of footrest will probably be required. This can be a separate item, built into the bench or part of the chair and probably the latter is best with most lab seats having a 'ring' type footrest.

9. Ease of cleaning and decontamination. For lab work it is essential the materials of construction are impervious to liquids, resistant to corrosive materials or solvents and easy to clean/disinfect. Fabric seats should not be permitted in labs and vinyl covered / solid types are required.

10. Comfort. The question of whether or not to have padded seats is down to choice and budget. Padded ones will undoubtedly be more comfortable but not as hard wearing or long lasting and if damaged or ripped this exposes foam that can then get contaminated. It may depend on how long the person will be sitting at the seat and it may be possible to get compromises like a solid back and a padded seat. Swivelling may also allow more comfort.

11. Movement. Getting the seat to the correct working position is an important aid to comfort and good ergonomics. Seats which are not easy to move into the desired position are unsatisfactory as people then sit further away from the work-surface than they should or strain themselves getting into the right position. However, in labs with vinyl floors, chairs with totally freewheeling castors can fly everywhere and there are cases of the chair moving away when persons try to sit down, leading to them falling and landing on their coccyx. Tall lab chairs and stools are less stable than office style chairs (greater height/base ratio) and if they have totally freewheeling castors they can fall over when people try to ‘push off’ and move around whilst seated. However, the alternative of slides to castors is not necessarily the preferred option as they are awkward and difficult to move into the best position. A better solution is use different types of castor, of which there are many designs, to suit different situations. One design of castor has ‘soft’ wheels which have a built-in resistance to rotation. There are also braked castors, one type is known as 'brake loaded', which mean the castor locks when you sit on the chair, the other is 'brake unloaded' which mean the castor is locked when no-one is sitting on it.

    In labs with vinyl floors soft wheels should always be specified. For ‘braked’ castors the recommended solutions are:

    - Low lab chair: brake unloaded
    - High lab chair: brake loaded.

    There are also permanently ‘restrained’ castors which allow movement but also offer resistance and do not easily move around on hard floors. Soft wheels can give this effect.

APPENDIX 2 - GUIDANCE ON FUME CUPBOARDS

This document describes the design, installation and performance/test criteria for laboratory fume cupboards. It applies to all conventional fume cupboards which are ducted to discharge their contaminants to a safe place outside the building, whether by individual dedicated ductwork / fan set or by a shared ductwork system with common fans, which may or may not also take general extract air. It includes 'walk-in' and 'low threshold' designs.

1. Description

A fume cupboard is a form of partial containment LEV device with a working aperture, through which the operator's arms may be placed, and whose dimensions may be varied by means of an opening and closing sash. This sash may be of a vertically sliding 'rise and fall' design or have horizontally 'side to side' sliding elements with some sashes incorporating both types of variable opening within a single unit. Sashes which incorporate hinged elements or lift off panels to reduce the working opening should not be considered under this code. 'Walk-in' designs of fume cupboards, where the base of the fume cupboard is at a level with the floor of the lab to allow large items of equipment to be wheeled in, should have their individual sash elements operated independently of each other or some other means of allowing the operators arms to enter the fume cupboard whilst the operator is at a standing position without having the majority of the working aperture open. Designs with inter-linked vertical rise and fall elements where all elements have to be raised in order to gain access require special consideration and are outside the scope of this appendix.

Fume cupboards are designed to control exposure of the operator to gases and vapours. Technically a 'fume' is a condensed vapour (i.e. an aerosol) but in common usage the term is inaccurately used to describe all noxious vapours. Fume cupboards are not designed to control exposure to airborne particulates (dusts or aerosols), although they are often used for this purpose. If a fume cupboard is designed for activities which generate appreciable airborne quantities of powders or dusts as well as gases/vapours then its extract system should include a HEPA filter close to the cupboard to remove airborne particulates and prevent them being deposited in the extract duct or near the point of discharge. Gases and vapours will not be deposited within the extract system unless cooled below their dew-point during their residence within the extract duct and this must be avoided.

The level of containment afforded by a fume cupboard is dependent on a smooth, uniform inward airflow through its working aperture. This airflow must be at a velocity sufficient to overcome draughts or other adverse air movements external to the device. These adverse air movements may be created by room furniture, equipment lay-out, ventilation systems and the movement of personnel and machinery. The requirements for locating fume cupboards are designed to minimise the effects of adverse external air movements within the room. The effective scavenging and removal of contaminants generated by operations within the fume cupboard is determined by airflow patterns within the cupboard. This is greatly influenced by the extract slots provided within the rear baffle and is the reason it is essential these slots are unimpeded.

2. Location

The optimum performance of a fume cupboard will be obtained when it is positioned in an area away from major disturbances to airflow. Distances to help ensure fume cupboards are located in positions away from disturbed airflow where optimum performance will be achieved are given in BS7258:1994 Part 2 and must be complied with as far as practicable for all new installations. The new BS EN 14175 does not give recommended lay-outs.

The recommendations for clearances to avoid disturbance of airflow at the face of the fume cupboard may be summarised as:

- 1 metre clearance between the face of the fume cupboard and any traffic routes

- 1.5 metre clearance between the face of the fume cupboard and any opposing bench

- 2 metre clearance between the face of the fume cupboard and any opposing wall or obstruction above bench height

- 3 metre clearance between the face of any fume cupboard and any opposing fume cupboard (or microbiological safety cabinet, local extract ventilation etc.)

- No adjoining columns / furniture in front of the plane of the sash opening

- 0.3 metre clearance between the edge of the fume cupboard and any bench, column or wall that is in front of the plane of the sash

- 1.5 metre clearance from an opening door to a fume cupboard whose sash is at right angles to the plane of the door when closed.

- 1 metre clearance from an opening door to a fume cupboard whose sash is parallel to the plane of the door when closed.

3. Air Supply

Adequate supply / make-up air must be provided to all rooms where fume cupboards are located. The make-up air inlets must be located so as to ensure any air movement they create does not affect the containment of fume cupboards by creating excessive drafts or other adverse room air movement such as swirling. In rooms where there are high air-change rates due to the number of containment devices, or where room dimensions are restricted, the provision of a ventilated ceiling may be necessary in order to prevent drafts affecting fume cupboards. No supply air jet velocities in excess of 0.3 metres per second (mps) within 1 metre of the front of a fume cupboard are permitted.

4. Discharge to atmosphere

The discharge from any fume cupboard extract system must be to a safe position outside the building, where the contaminated air cannot re-enter the same or any neighbouring building or reach an occupied area before they have been adequately diluted. Fume cupboard discharges which are less than 3m above the highest point of the building or 125% the building height above ground (whichever is the greater) are unlikely to be satisfactory. Smoke tunnel or computer based modelling can give useful information on location and height of discharges. Effectiveness of the discharge position can be shown at commissioning by smoke testing the discharge, although weather conditions at the time of testing will have a major effect. Efflux velocity should be in the range 10 mps – 20 mps, with means to prevent the ingress of rainwater provided unless the system runs constantly with run and standby fans. Duct runs should be as straight and direct as possible. Temperature differentials along the duct route should be avoided.

Fume cupboards installed for use with volatile or vaporised highly corrosive materials such as hydrofluoric acid or perchloric acid (e.g. used in digestion experiments) should be fitted with specially designed wet scrubbing systems and water wash-down facilities to minimise escape and release of vapours to external atmosphere, to prevent corrosion and deterioration of the fume cupboard carcase / extract system and to allow thorough internal decontamination of the cupboard prior to maintenance etc.

5. Alarms

All fume cupboards must be fitted with means to indicate:

a) Safe airflow is being maintained; this should normally include both a light and a face velocity indicator.
b) Unsafe airflow conditions (less than 80% normal extract rate), including both audible (with a mute button, provided it is automatically reset after a time delay) and visual alarms.
c) Unsafe sash condition (‘sash high’ or excessive working opening). This should include audible (with a mute button, provided it is automatically reset after a time delay) and visual alarm. A manually over-rideable physical ‘stop’ set at the maximum safe working opening is also recommended for vertical rise and fall sashes to help prevent using the cupboard with the sash set too high.

6. Fire Detection and Fixed Fire-fighting Provision

Consideration should be given to fitting fire detection. This may either be a flame detector or a heat detector, depending on application. For fume cupboards used to handle large quantities of highly flammable liquids or pyrophoric materials or for conducting overnight experiments with flammable materials, the fitting of a fixed fire extinguishing system (e.g. Firetrace) filled with an appropriate medium (usually foam for most fume cupboard applications) is strongly recommended. The Firetrace system can provide both detection as well as fire extinguishing capability.

8. Performance Criteria and Testing

The following criteria should be applied to assess the performance of fume cupboards:

Face velocity

Average face velocity at maximum working opening (normally 500mm for rise and fall sashes), taken from at least 9 point tests and preferably 12 done across face (more required for >1.8m wide), individual point figures should not be outside a range more than + or – 20% the overall average.

Average face velocity = 0.5 metres per second (mps), unless justified by type / commissioning containment and robustness testing. Extreme care and attention to detail is required if considering using low flow fume cupboards and face velocities below 0.3 mps are not acceptable

For variable volume cupboards, the face velocity recovery time following rapid raising of the sash (≤5 secs recovery time) should be tested.

For safety purposes no fume cupboard should have an average face velocity of more than 1 mps and for environmental reasons this should be kept to a maximum of 0.6 mps wherever possible.

For type testing (to justify the face velocity chosen) and at commissioning containment testing should also be undertaken in addition to face velocity testing:

SF6 Containment testing (see BS7258:1994 Part 4 and BS EN 14175 Parts 3 & 4)

<u>Inner Plane</u>:

(a) Type test (i.e. under ideal test room conditions) = leakage to be no more than 0.005 ppm average / 0.01 ppm peak SF6;

(b) As installed / commissioning test (empty and in finished facility with furniture installed and a/c functioning) = leakage to be no more than 0.01 ppm average / 0.02 ppm peak SF6;

<u>Robustness test</u> (moving board):

Must be undertaken at type testing with 'outer plane' SF6 detection set-up and can justify the selection of the design face velocity and for further 'as installed / commissioning' testing. The peak leakage must not exceed 1 ppm and the average leakage over six passes (three in each direction) not exceed 0.2 ppm. In addition, the peak at each pass should return to close to zero within the 30 secs before the next pass of the moving board; continually rising peaks at each pass would indicate a fail.

Disturbance test (dynamic sash opening):

This is part of the outer plane test procedure and should be performed at commissioning to detect escape levels when the sash position is moved. This is especially important for variable volume systems when it will check the speed of response and stability of the extract volume sensor / damper system. The peak escape during opening should not exceed 0.04 ppm. It can also be used as a periodic test if it is suspected there are problems with the variable air volume system or when alterations or repairs to this system have been made

References

1. BS EN 14175 Fume Cupboards Parts 1 'Vocabulary' (2003), 2 'Safety and Performance Requirements' (2003), 3 'Type Test Methods' (2003), 4 'On site test methods' (2004), 6 'Variable air volume cupboards' (2006)

2. BS EN 14175, TS 5 Technical Standard (not yet issued): 'Recommendations for Installation and Maintenance'

3. BS 7258 Laboratory Fume Cupboards 1994 (withdrawn) Parts 1 'Specification for safety and performance', 2 'Recommendations for the exchange of information and recommendations for installation, 3 'Recommendations for selection, use and maintenance' and 4 'Method for determination of the containment value of a laboratory fume cupboard'

4. COSHH Regulations ACoP and Guidance (5th Edition), L5, 2005, HSE, HMSO, ISBN 07176-2981-3

5. HSG 258 'Controlling airborne contaminants at work: A guide to local exhaust ventilation (LEV)', 2nd Edition, 2011, HSE, HMSO, ISBN 978 0 7176 6415 3 (Replaces HSG54 'Maintenance, examination and testing of local exhaust ventilation' and HSG 37 'An introduction to Local Exhaust Ventilation')

6. 'A Literature Survey and Design Study of Fume Cupboards and Fume-Dispersal Systems' Occupational Hygiene Monograph No 4 (1980, reprinted 1987) D Hughes, Science Reviews Ltd in association with H&H Scientific Consultants Ltd ISSN 0141-7568

7. 'Fume Cupboards Revisited', HHSC Handbook No 2, J. D. Cook and D. Hughes (1986, Reprinted 1989) Published by H&H Scientific Consultants, Leeds, ISBN 0-948237-01-5

8. 'Discharging to Atmosphere from Laboratory-Scale Processes', HHSC Handbook No 4, D. Hughes (1989) Published by H&H Scientific Consultants, Leeds, ISBN 0-948237-03-1

APPENDIX 3 – GUIDANCE ON RADIOCHEMICAL LABORATORY DESIGN

Note: In 1997 the EA issued guidance to inspectors which was applicable to laboratories in teaching and research establishments but has now been withdrawn. There is very little official guidance on this subject so, although no longer in force, the old EA guidance is still a very useful source of information and is given below.

Guidance on standards for radiochemical laboratories in non-nuclear premises.

1. Introduction

1.1 This Note provides guidance to Inspectors on the key considerations, from the Agency's perspective, for laboratory facilities on premises where "open" radioactive sources are kept and used.

1.2 This Note focuses on radioactive waste management implications. It does not specifically cover radiation safety and the protection of workers on premises, which may give rise to additional requirements such as radiation shielding. However, nothing in this Note should conflict with occupational radiation safety considerations, e.g. those in the Ionising Radiations Regulations. As the matters dealt with in this note are of common interest to the Agency and HSE, Inspectors should consider liaising with colleagues in HSE on specific cases.

1.3 By its very nature, any use of open sources is dispersive to some extent, and there will inevitably be arisings of radioactive wastes that will need to be managed. There is a requirement to ensure that any radioactive waste that is generated is of such a type and quantity that it can be disposed of by an available route, and to prevent any disposal of radioactive waste by an unauthorised route. Additionally, in accordance with Government policy on waste minimisation, the Certificates of Registration issued by the Agency under the Radioactive Substances Act 1993 require that, so far as is reasonably practicable:

(a) the amounts of radioactive waste that do arise are minimised; and
(b) all relevant parts of the premises are constructed, maintained and used in such a manner that they do not readily become contaminated, and that any contamination which does occur can easily be removed.

1.4 The purpose of this Note is to expand on those requirements so as to provide guidance on the standards which users are expected to apply. This is neither prescriptive nor exclusive, and there may be other appropriate means of compliance in specific circumstances. Clearly this Note is not a detailed design guide, and users should be expected to consult relevant publications on laboratory design and to take advice before constructing a new radiochemical laboratory.

1.5 The benchmark for the standards given in this Note is a new radiochemical laboratory. Inspectors should always have regard to the criterion of reasonable practicability; therefore it may not be appropriate to impose these standards where any of the following are involved:

- existing facilities
- holdings only of the less-radiotoxic nuclides such as tritium or carbon-14
- or minor usage, such as a few radioimmunoassay kits;
- or "one-off" (as opposed to continuing) uses

1.6 Specific guidance has been produced by the National Radiological Protection Board on the categorisation and designation of radiochemical laboratories (Ref 1). It should be noted that the categories and associated facilities are based on occupational radiation exposures, rather than waste minimisation principles, and a proposal involving the facilities indicated by NRPB Categories IV and V may need particular scrutiny from the Agency's perspective. Nevertheless they are a useful indication of what may be expected at various levels of work.

The Association of the British Pharmaceutical Industry has also published specific guidelines for that industry (Ref 2).

1.7 In the following sections, extensive use has been made of points contributed by user organisations (Refs 3, 4) which are acknowledged with thanks.

2. Floors

2.1 The floor should be covered with an impervious surface such as a **continuous** sheet of PVC or linoleum at least 2.5 mm thick. The covering should be coved to the walls to a height of about 15 cm contiguous with the floor surface. All edges at the walls should be sealed or welded to prevent seepage of spilled materials.

2.2 Joints between sheets are not recommended, but may be permitted if the joints are welded and inspected to ensure the absence of a seepage path for contamination.

2.3 Any non-slip sealant material used to facilitate cleaning may be applied provided that spilled materials can be easily removed during the decontamination procedure. Generally, epoxy resin coatings are easily decontaminated.

2.4 As an alternative to a sheet material covering (such as PVC), an epoxy resin coating may provide an acceptable finish on smooth concrete.

3. Walls and Ceilings

3.1 The walls and ceilings should generally be smooth and painted with a hard gloss or high quality waterproof vinyl emulsion to facilitate cleaning. (BS 4247 Part 2). The use of stippled surfaces or a paint finish applied to unplastered concrete blocks, may be undesirable.

3.2 A note of caution: many paints undergo chemical or physical reactions with certain radionuclides. A more important criterion may therefore be the ease with which the paint can be stripped off again rather than its cleaning properties. A known problem occurs with chloride ions, which may bind irremovably with painted surfaces.

3.3 Suspended ceilings may potentially cause problems due to penetration of contamination.

3.4 Joints should be sealed or filled with silicone type materials to facilitate cleaning (or removal in the event that decontamination cannot be achieved). Service penetrations in walls and ceilings should be sealed and coved.

4. Doors and Windows

4.1 Wooden surfaces should be covered with plastic laminate material or painted with a good quality polyurethane gloss paint or varnish. See 3.1 and 3.2 above.

4.2 Security of keeping radioactive materials is essential and therefore doors should usually be lockable to ensure safekeeping or to restrict access in the event of major spillage of the materials. Doors leading off public places and which are frequently opened may additionally be secured by use of a keypad lock. For some sites, for example in the pharmaceutical industry, the user may provide a high level of security for a building and/or an entire site, rather than for an individual laboratory within a building.

4.3 Where opening windows are fitted, care should be taken that no persons will be affected by any release of radioactivity immediately outside. Open windows should not be used as intentional discharge routes.

5. Benches

5.1 Working surfaces should be smooth, hard and non-absorbent and have necessary heat and chemical resistant properties. All gaps and joints should be sealed with a silicone type material. Depending on the type and quantity or radioactive materials used, account may need to be taken of the problems involved in decontaminating certain materials used for bench surfaces.

For example:

- "Corian" apparently locks onto iodine (e.g. I- 125) in several chemical forms;
- Melamine fixes sodium ions (e.g.Na-22) under some conditions;
- Stainless steels may bind phosphate (e.g.P-32) or chromium (e.g. Cr-51) firmly and may be very difficult to decontaminate (Ref 4).

5.2 The benchtops should be coved (upstand) at the rear against walls. Gaps should be sealed with a silicone type material. Benchtops may also have rounded front edges (lipped) so as to give fewer entry points for contamination - although some users feel this increases the likelihood of spills on to the floor, as the operator may misjudge where the flat surface of the bench finishes. Some bench top designs have a raised front lip, which can help prevent a spillage running off the bench on to the floor.

5.3 Exposed wood, including under benches and under bench cupboards, should be painted with a good quality hard gloss paint or polyurethane varnish or laminated. The use of wood surfaces should be avoided on all new laboratory designs.

5.4 Users should carry out inspections to ensure that cracked surfaces are repaired or painted as appropriate.

5.5 Dedicated areas of bench should be set aside for radioactive work and be clearly delineated. It is good working practice to work in plastic or metal trays on bench tops - and, especially, in dispensing / preparation cabinets where larger quantities of activity are involved - to minimise spills and spread of contamination. Disposable absorbent coverings such as "Benchkote" may similarly be useful - but as a supplement to, rather than instead of, proper bench surfaces: these coverings may therefore best be used inside trays.

6. Waste Disposal Sinks and Drainage Pipes

6.1 Sinks for the disposal of radioactively contaminated aqueous liquid waste should be constructed of suitable material: for most applications, stainless steel is preferred. Where possible, combined sinks and draining boards should be used, with rounded front edges and coved (upstand) at the rear against walls. Ideally an easily decontaminatable rear splash plate should extend a reasonable distance up the wall behind the sink. Side splashguards may also be useful.

6.2 As noted in 5.1 above, phosphate ions may bind strongly on to stainless steel, and this may cause problems in laboratories where P-32 is used in quantity. (Similar problems may arise where old-fashioned sinks have been sealed with putty or in hard water areas where a calcium phosphate layer may be precipitated in the sink). Borosilicate glass sanitary ware may be appropriate in some circumstances.

6.3 Small diameter U-shaped or bottle traps should be used, instead of large traps or catch pots, so as to avoid accumulations of radioactive sediments.

6.4 The drain should be connected as directly as possible to the main foul water sewer leaving the premises. Holding tanks are generally undesirable in terms of sedimentation, but may be used by some industries for other reasons - such as confirming compliance with chemical discharge consent conditions. The discharge route should be mapped and recorded for future reference in case of maintenance on the system. Drainage system materials should take into account the possible build up of contamination on surfaces.
NB All drainpipe materials may retain specific radionuclides. The most generally useful type - "vulcathene" fixes iodine very strongly - which may be significant where the radioiodines have to be disposed of through drains of this material.

6.5 Drainage pipes for radioactive effluent should be labelled with the ionising radiation symbol up to a point at which their contents are diluted substantially with frequently - flowing, non-radioactive effluents. This is to alert maintenance staff and thus prevent unauthorised disposal of any contaminated pipes removed during maintenance work. Pipes should be well-supported along a suspended run, should be down-sloped to prevent accumulations of radioactivity, and, where reasonably practicable, should be made accessible - for example by the use of demountable panels - and subject to periodic inspection so as to assure their integrity.

7. Ventilation and Containment

7.1 Dispensing or preparation of radioactive materials that may cause airborne contamination should be carried out under conditions to prevent dispersal of the substances. In particular, volatile radioactive materials should never be used in the open laboratory, only in appropriate containment such as a fume cupboard. Recirculating ventilation systems may be inappropriate for volatile radioactive materials.

7.2 General dilution ventilation (air circulation) should be provided in all radioactive laboratories. Where small quantities of radioactive materials are used, this may be provided using an extractor fan mounted in a window or a wall.

7.3 Where larger quantities of radioactive materials are used, a guiding principle for effective control of contamination is that air movement should be maintained from less-contaminated areas to more-contaminated areas. This may be achieved for example by extracting from a general laboratory area through a fume cupboard to a discharge stack.

7.4 Inspectors should note that the balancing of an extract ventilation system having a number of ducts, dampers and inlet points, so as to achieve design airflow rates, requires considerable skill and expertise. Alterations to damper settings by unskilled operators are therefore generally to be deprecated.

7.5 A contained workstation (Class I - III microbiological safety cabinet or fume cupboard) should be used for dispensing or manipulation of large quantities of radioactive materials. Adequate ventilation by continuous movement of air into the workstation should be checked regularly, preferably by measurement with an anemometer. Airflow criteria for fume cupboards are specified in BS 7258.

7.6 Internal and external surfaces should be smooth, hard and non-absorbent and have the necessary heat and chemical resistant properties.

8. Radioactive Storage Facilities (Including Waste)

8.1 Adequate storage space should be available to keep essential equipment in order to minimise the cluttering of equipment near working areas, and reduce the risk of spreading contamination. It may be desirable to have an area set aside for the storage of equipment awaiting decontamination.

8.2 All refrigerators / freezers, and radioactive materials within them, should be easily identified (labelled) and should be lockable and should be kept locked unless they are under surveillance, especially in large general laboratories. Refrigerators / freezers should be regularly defrosted. It should be noted that volatile radionuclides, in particular tritium, might accumulate in the ice: it is good practice for the user to check this periodically.

8.3 Waste disposal bins in the laboratory (used for storing solid waste awaiting disposal) should be constructed of a material that is robust, and preferably should be foot-operated. The lid should be closed when not in use and the contents in the bag sealed or secured before removing them from the bin. All sharps, bottles, tubes, etc should be placed in sharps containers to ensure safe handling of the, materials. Bins located outside the control of the user must be secure to prevent misuse of the contents.

8.4 Adequate storage space (e.g. a bunker or storeroom) should be available for radioactive waste either inside or outside the laboratory. The storage space must be kept locked and may need to be under surveillance.

9. Other Facilities

9.1 Adequate **decontamination facilities,** including decontamination solutions, should be available. "Decon" (and "Radiacwash", "Countoff' etc.) is principally useful where heavy metal contamination is present, as its special properties are in solubilising poorly soluble metals. In other circumstances, its performance may be similar to other phosphate free detergents. For most labs only the ordinary detergent used for washing up and liquid soap for hand washing should be needed, although certain other more specialist cleaning agents may be used for special purposes. It is important that some of the old-fashioned laboratory cleaning agents such as chromic acid and permanganic acid are never used in radioactive areas (risks of fire, explosion and volatilisation of radioactive materials). More aggressive decontamination agents should normally be held centrally, as they require specialised knowledge to use them properly and safely.

9.2 A **contamination monitor** should be available and it must be appropriate for the type of radionuclides used in the laboratory. Indirect monitoring (by liquid scintillation counting of swabs taken from surfaces) may be needed for soft beta emitters such as carbon- 14 and (almost always) tritium. Records demonstrating that instruments are checked before use and are calibrated are required. A logbook should be available to show that the laboratory is regularly monitored (benches, sinks, floors, drainage traps and equipment), that the results are recorded, and that any necessary decontamination is carried out.

9.3 **Tacky mats** may usefully be installed in laboratory doorways, to prevent the spread of contamination. Monitoring of these mats may give early warning of a contamination problem.

9.4 A designated **hand wash basin** should be provided: it must never be used for the disposal of radioactive substances (other than traces from the washing of hands).

9.5 **Warning signs**, clearly and legibly marked with the word "Radioactive", with the Ionising Radiation symbol conforming with BS3510: 1968 or ISO 36 1, and any other information necessary (contact person, telephone number, etc), should be placed on doors, cupboards, equipment, refrigerators, working areas, drainage pipes, sinks, storage facilities, sewers, exhausts as appropriate. An indication of the maximum holdings in the laboratory may usefully be included on the sign placed on the door.

Warning signs should only be used when there is a real possibility of contamination: in particular, indiscriminate use of "radioactive" warning tape should be avoided. Generally, ancillary items such as pens and books should not be used where there is a possibility of contamination and therefore should not require warning signs.

9.6 Adequate **lighting** should be provided throughout the laboratory, particularly to enable operators to see spillages easily.

9.7 Particular considerations apply to users who handle **tritium in quantity.** Although this is a rather specialised field affecting relatively few users, nevertheless Inspectors may find it useful to be aware that tritium may be readily converted to tritiated water, which when allowed into the working environment moves with atmospheric water vapour. It is taken up by most common materials - wood, paper, clothing - and this can make them impossible to decontaminate. It is the usual practice for a facility handling large amounts of tritium to be separate from other buildings to prevent the spread of radioactivity beyond the controlled area and to allow any escape to be diluted by the outside atmosphere.

References

1. A P Hudson and J Shaw, 1993. Categorisation and Designation of Working Areas in which unsealed Radioactive Materials are Used. National Radiological Protection Board Memorandum NRPB - M443.
2. Association of the British Pharmaceutical Industry, 1996. Guidelines on the Control of Radioactive Substances in the Pharmaceutical Industry. Published by the ABPI, 12 Whitehall, London SW1A 2DY.
3. South Birmingham Area Health Authority, Personal Communication.
4. D Walland, University of Bristol, Personal Communication.