Flow Chart Scheme

Waste Type		Equipment		Disposal
Food Waste	→	One-way Mascerator	→	Discharge Overboard
Food Contaminated Waste	→	Refrigerated Sack Compactor	→	Sack Volume 95 ltrs
Deck Waste (outdoor)	→	Outdoor Compactor	→	Big Bag 1.5m3
Dry General Waste	→	Multi Chamber Compactor	→	Sack 160 litres
Soft Plastic / Plastic Film	→	Multi Chamber Compactor	→	Bale 160 litres
Metal Tins & Cans	→	Multi Chamber Compactor	→	Wheelie Bin
Cardboard	→	Baling Press	→	Bale 160 litres
Glass	→	Glass Crusher	→	Wheelie Bin 80 litres
Aluminium Cans & Plastic Bottles	→	Mini-Shredder	→	Wheelie Bin
Oily Solid Waste	→	Lockable Bins	→	On shore
Medical Waste	→	Lockable Bins	→	On shore

EXEMPLAR: USON MARINE EQUIPMENT

OWMS 60 Uson Food Waste System 6,0 + 6,0m3	
Key Features:	Wet vacuum, DN50 for flexible fitting Double action pump
Application:	Indoor
Foot Print:	1667 x 1472 mm
Compliance:	IMO Marpol 73/78 Annex V
IP Class:	IP54
Voltage:	3x380-480, 50/60 Hz
Material:	Stainless Steel AISI 316
Including:	1x LMU local macerator units 1x double action pump 2x food waste holding tanks (6,0 m3) 1x three-way pneumatic actuated valve DN50 Piping between tanks and pump unit is yard supply. Uson standard painting Piping instructions of piping connected to the units*
Optional:	Colour of all non stainless steel equipment
Not Included:	Electric cables between the control panels Piping between the local macerators and holding tank (incl. additional service valves)
*) Provided that the piping is installed according to our (Uson Marine) instructions, we (Uson Marine) take full responsibility for the system.	

UMS-Food Uson Marine Shredder for Food (including local macerator)	
Key Features:	Shred all types of food waste; big bones, fish skins, etc Macerate any kind of food waste into < 25mm in size
Application:	Indoor
Foot Print:	910 x 840 mm
Compliance:	IMO Marpol 73/78 Annex V
IP Class:	IP54
Voltage:	3x380-480, 50/60 Hz
Material:	Stainless Steel AISI 316

UKP-6060 Uson Refrigerated Sack Compactor	
Key Features:	Food contaminated waste stored at 4°C Compaction in durable plastic sacks
Application:	Indoor
Press Source:	Electromechanical, 4 ton
Foot Print:	448 x 516 mm
IP Class:	IP54
Voltage:	3x400/440, 50/60 Hz
Material:	Stainless Steel AISI 316
Including:	10 pcs of extra thick plastic sacks

UGS M1-SS Uson Grease Separator M1 - Stainless Steel	
Key Features:	Unique separation efficiency at sea No heating or steaming
Application:	Indoor
Foot Print:	1160 x 1116 mm
Capacity:	Peakflow 1 l/s (60 l/min)
IP Class:	IP54
Voltage:	3x380-480, 50/60 Hz
Material:	Stainless Steel AISI 316

UMCC-3 STEEL Uson Multi Chamber Compactor - Three chambers	
Key Features:	Single machine for press operation Multiple, flexible chambers for waste separation
Application:	Indoor
Press Source:	Electromechanical, 5 ton
Foot Print:	1860 x 660 mm
IP Class:	IP54
Voltage:	3x400/440, 50/60 Hz
Material:	Mild Steel
Including:	2x chambers for baling 1x chamber with plastic sack for general waste 1x Sack holder 1x Bale ejection tool 1x Extractor hook 5x Plastic sacks 4x Rolls of baling bands 1x Tube of spindle grease

UBP-80 Uson Baling Press	
Key Features:	Baling of voluminous recyclable waste Semi-automatic bale ejection
Application:	Indoor
Press Source:	Electromechanical, 17 ton
Foot Print:	1450 x 800 mm
IP Class:	IP54
Voltage:	3x400/440, 50/60 Hz
Material:	Mild Steel
Including:	2 rolls of baling bands 1 tube of Spindle grease 1 Extractor hook for baling band

U-80 Uson Glass Crusher	
Key Features:	No glass dust, Automatic start & stop
Application:	Indoor
Foot Print:	535 x 620 mm
IP Class:	IP54
Voltage:	3x400/440, 50/60 Hz
Material:	Mild Steel
Including:	1 x 80L Plastic Wheelie bin

UMS-2530 Uson Mini Shredder	
Key Features:	Automatic shredder protection Hardox steel shredder Low Noise level
Application:	Indoor
Foot Print:	490 x 605 mm
IP Class:	IP54
Voltage:	3x400/440, 50/60 Hz
Material:	Mild Steel
Including:	1x Plastic bin incl. Base with wheel

Dry Solid Waste
Dry and shipboard solid waste comprise of different units such as marine compactors, baling presses, glass crushers and s hedders. The complete system shall assist the crew in:

a) Collecting

b) Sorting

c) Treating

d) Storing the waste onboard

and help to comply with regulations worldwide. The treated waste is transported ashore for recycling.

All equipment to be Type Approved by Class.

The Contractor shall provide in a number of locations around the vessel “triple bins” for the collection of waste for recycling. This shall include all public rooms, the wheelhouse, changing rooms, coffee shop and accommodation alleyways.

Waste Discharge Control
A system shall be installed to monitor the position of the ship as defined by the GPS system and i dentified the location in respect of environmental restrictions, both for discharge overboard into the sea or emissions from exhaust or incinerator equipment. The system shall also have an automatic control function that shall ensure that retention capacity is available prior to entering restricted areas.

The system shall also monitor and record discharges and retain the data for a minimum of two years in compliance with the requirements for the Garbage Record Book. Food waste discharge records shall include date, time, volume discharges and GPS position.

EXEMPLAR: USON MARINE GPS Discharge Control & USON Clean Pilot

6.1.70 Garbage Store

R6.70 An insulated and chilled garbage store shall be provided of at least 50m^2

It shall be chilled to +5ºC.

Corrals shall be arranged to stow and safely retain garbage containers.

6.1.71 Boat Store / Workshop (Garage)

R6.71 A Boat Store / Workshop shall be located within a steel enclosure, outfitted to support the small boats carried onboard. This store shall be located with direct access to the boats. Provision shall be made for the storage and maintenance of outboard motors workboats and RIBs.

Workshop to be arranged with direct access from the working deck via a double leaf weathertight door arranged with minimum sill height and 3m clear opening,

Workshop to be outfitted with steel workbench complete with 2 nos. 150mm vices, pillar drill, grinder, tool shadow boards, material storage racks, An area of workshop to be designated as a store and to be segregated with a mesh security bulkhead, complete with lockable door.

Store shall be outfitted with shelving and racking for the storage of small gear.

Workshop shall be provided with natural supply and mechanical exhaust ventilation.

Deck shall be bare steel painted anti-slip.

Fresh water (faucet) taps with screwed ends shall be arranged in each space for washing down purposes.

The Boat Store / Workshop shall be well scuppered to allow for washing down.

The deck head and all structure of the Boat Store Workshop shall be insulated and lined. The lining shall be suitable for a wet environment and shall allow for it to be washed down. The finish shall be to the approval of the Owner's Representative.

The Boat Store / Workshop shall be fitted with 4 nos. each 110V / 230V outlet sockets

All equipment fitted within the Boat Store / Workshop shall be suitable for the hazardous environment of the space.

6.1.72 SOPEP Store

R6.72 A SOPEP store shall be provided for storing equipment and consumables to be used in the event of pollution incident in accordance with the requirements of MARPOL requirements for Shipboard Oil Pollution Emergency Plan and shall be located on the Main Deck Aft in the vicinity of the Bunker Station. Store shall be outfitted with shelving and racking for the storage of equipment and consumables.

Store shall be provided with natural supply and mechanical exhaust ventilation.

Deck shall be bare steel painted anti-slip.

6.1.73 Hatchways

R6.73 Deck hatches and hatchway trunks shall be provided giving crane and lift access to the cargo hold and scientific stores, main engine room levels and the provision rooms and stores. The following hatches shall be required:

Cargo Hold Hatches

Flush Cargo Hold hatches shall be arranged with clear working aperture to allow 20ft ISO cargo containers, vehicles and break bulk cargo to be loaded through to be stowed in the cargo holds, using the ship's cargo crane. The cargo hold hatch shall have clear opening of approximately 10m in length by 6.5m in width.

Weather tight flush electro hydraulic folding hatch covers shall be fitted to close the hatches. Hydraulically powered locking dogs including remote open/closed status indication shall be provided. The hatch covers shall also be required to be A Class fire rated in accordance with Regulations.

Suitable interlocks shall be provided to ensure the hatch does not operate when the hatch is cleated closed.

Provision to connect a hand pump supply to the mechanical locking system supply ports shall be provided in the event of hydraulic supply failure.

Heating is required to ensure that the hydraulics operate and the hatch can be opened and closed at the Polar Service Temperature.

These flush cargo hatches are not intended to be open whilst at sea. However the drainage arrangement around the hatch shall still need to clear deck surface water. The flush hatch is therefore to be fitted with a deep wide channel and suitable drains to prevent deck surface water from entering the hatch when open. Drains to be trace heated to ensure no freezing down to the Polar Service Temperature.

The closing arrangements and the drainage of the flush channel shall be to the approval of the Classification Society the Flag Authority and the agreement of the Owner's Representative.

The hatch cover shall be arranged with recessed, flush cargo container sockets for 20ft ISO cargo containers as well as flush general cargo lashing fittings to secure loads of up to 35t. The hatch covers shall be designed to withstand the deck loading as per the main deck of 5 tonnes/m^2. The containers on the hatch cover shall be stacked two high with a stack weight of 40 tonnes.

Hinged access panels shall be provided in the deck to allow access to the cylinders and locking dogs/cleats

Sockets to be provided in the deck to mount a temporary personnel safety barrier around the flush hatches

The hatch covers shall be timber sheathed as per the rest of the deck.

Controls for hatch shall be arranged on the deck in way of the hatch.

Cargo Hold Tween Deck Hatches
Flush Cargo hatches shall be arranged with clear working aperture to allow 20ft ISO cargo containers, vehicles and break bulk cargo to be loaded through the tween deck to be stowed on the tank top in the cargo holds, using the ship's cargo crane. The hatch cover shall be arranged with recessed, flush cargo container sockets for 20ft ISO cargo containers as well as flush general cargo lashing fittings to secure loads of up to 35t.The cargo hold hatch shall have clear opening of at least 10m in length by 6.5m in width.

Flush electro hydraulic folding hatch covers shall be fitted to close the hatches.

Hydraulically powered locking dogs including remote open/closed status indication shall be provided. These shall not be required to be weather or watertight, however an A Class fire rating is required in accordance with regulations.

Suitable interlocks shall be provided to ensure the hatch does not operate when the hatch is cleated closed.

Provision to connect a hand pump supply to the mechanical locking system supply ports shall be provided in the event of hydraulic supply failure.

Heating shall be required to ensure that the hydraulics operate and the hatch can be opened and closed at the Polar Service Temperature.

The hatch covers shall be designed to withstand the deck loading as per the tween deck in the cargo hold at 2.5 tonnes/m2.

Hinged access panels shall be provided in the deck to allow access to the cylinders and locking dogs/cleats

Sockets to be provided in the deck to mount a temporary personnel safety barrier around the flush hatches

The Tween Deck Hatch covers shall be suitable to be left either open or closed at sea.

Controls for hatch shall be arranged on the deck in way of the hatch.

Portable stanchions and safety chains shall be provided for use in way of Tween Deck flush hatch.

A simple skidding system may be installed for moving containers transversely below deck.

Controls for hatch shall be arranged on the deck in way of the hatch.

6.1.74 Scientific Hold Hatch

R6.74 The Scientific Hold Hatch shall be located on the main deck within the hangar clear of primary working areas, wire routes, door openings and container stowage with a clear opening of no less than 2m x 3m

If it shall be of flush type with a hydraulic means of opening/closing and be equipped with a hydraulically operated dogging arrangement with manual back-up.

To be fitted with a bolting matrix system to match the surrounding deck

It shall be fitted with a portable guard rail system around its periphery when open.

It shall be equipped with a 2 Tonne SWL powered pallet lifting platform operating from a position flush with the lower scientific stores level to a position flush with the Hangar deck thus allowing pallet trucks to be used to transfer equipment.

Suitable interlocks shall be provided to ensure the hatch does not clash with the lift.

Controls for hatch shall be arranged on the deck in way of the hatch.

6.1.75 Engine Room Hatches

R6.75 The engine room hatches shall be located within the hangar space and shall be served by the hangar cranes allowing items up to 5 tonnes in weight to be lifted directly from the engine room and transferred to the main deck.

The engine room hatch access arrangement shall have a clear opening of at least 2m x 1.8m. If the main entry hatch is on a working deck it shall be of flush type with a hydraulic means of opening/closing and be equipped with a hydraulically operated dogging arrangement with manual back-up.

If the access routing to the engine room requires intermediate hatch arrangements through lower decks these too shall be hydraulically opened or closed and have hydraulic dogging arrangements with manual back-up. Each shall be fitted with a portable guard rail system around its periphery when open

Mechanical safety holdbacks shall be provided on each hatch when in the open position.

6.1.76 Provisions Hatch

R.6.76 A provisions hatch shall be provided for loading provisions and stores into the respective handling areas.

It shall be located on an open deck within the working radius of a ship's crane such that 2 tonne pallets of stores can be handled directly from vehicles on the quayside at 6m beyond the beam of the vessel into the ship and down to the handling areas.

The provisions and stores hatch shall have a clear opening of at least 2m x 1.8m. It shall be hydraulically operated with robust hand operated dogs. Accesses and temporary hatch trunk decks shall be arranged at each level being served.

It is envisaged that this hatch shall operate in conjunction with a pallet lift.

6.1.77 Starboard Side Lower Boarding Access Hatch

R6.77 The access stairway down from the Main Deck to the starboard side lower level boarding access shall be closed by a hydraulically operated side hinged flush water tight hatch in the Main Deck. The deck loading for this hatch shall be equivalent to the adjacent area of the Main Deck. The hatch shall be latched secure in its closed position and positively latched open.

6.1.78 Safety in Way of Flush Hatches

R6.78 Portable stanchions and safety chains shall be provided for use in way of all flush hatches. Sockets to be provided around the hatches so that the stanchions can be readily mounted.

Flush hatches shall be tight fitting around its edges to prevent tripping i.e. < 40mm gaps, and shall be flush with the surrounding deck with no more than a 10mm misalignment,

They shall incorporate timber decking to match the surrounding deck (if fitted),

Large drains shall be fitted to hatch recesses in way of all flush hatches. Drains to be trace heated to prevent freezing at the Polar service temperature.

6.1.79 Paint Locker

R6.79 A lockable paint store shall be provided for the secure stowage of paint for ships maintenance. This shall be a totally enclosed steel enclosure of about 5m^2 outfitted with galvanised steel racks with storm rails to contain paint drums, tins and painting tools and equipment. It shall be fitted with a fire detector connected into the ship's fire detection system and shall be fitted with a locally valved connection to the ship's fire main whereby in case of fire the space can be deluged with water. The door shall be steel, watertight and lockable. The store shall be mechanically ventilated, with natural supply and mechanical exhaust using fan suitable for atmosphere with paint fumes. Space shall be lockable. Deck shall be bare steel and painted with anti-slip.

6.1.80 Safety Equipment Locker

R6.80 Two dedicated safety equipment lockers shall be provided one within each of the accommodation fire zones, one with direct or easy access from the open deck.. This shall be large enough to allow for the stowage and maintenance of safety equipment and spares including but not limited to SCBA and Fireman's Outfits. Galvanised Steel Racks, cabinets shall be provided as required. .Space shall be provided with emergency communications.

Deck shall be steel, painted with anti slip.

6.1.81 Service Trunks

R6.81 Large vertical / horizontal service trunks shall be provided throughout the length of the vessel, accessible at each deck so that service piping, electrical wiring and vents can be accommodated and accessed for maintenance.

These shall be designed to allow the addition of systems through the vessel's life. The spatial allowance for Electrical Cable and Piping throughout shall be at least 100% greater than that demanded by the initially installed systems.

The design must allow ease of personnel access for inspections, repair and maintenance and for installation of additional systems without the need for staging, etc. Basic lighting shall be incorporated.

Structural fire protection and d amage stability integrity shall be maintained as appropriate throughout in the design and construction.

This requirement applies equally to scientific and ship systems.

6.1.82 Master Key System

R6.82 All internal accommodation spaces shall be equipped with a standardised door locking system complete with 10 master keys as well as 3 individual keys.

All laboratory and working spaces shall be equipped with a standardised door locking system complete with 10 master keys as well as 3 individual keys.

All external hull openings (doors, hatches, etc.) which might provide access by unauthorised persons shall be equipped with locking mechanisms and locks and wherever possible these shall be internally located to prevent tampering.

All external doors and hatches shall be configured to enable them to be securely locked against unauthorised entry but may still be opened from the inside to allow escape without the use of a key.

All hardware exposed to the weather shall be of brass or other approved material. Weather door locks shall be of high quality brass with cast brass casings of the heavy duty type.

The lock implementation shall satisfy ISPS requirements and allow easy exit in the event of an emergency.

Keyboard to be in ship's office

Sample door furniture and hardware shall be submitted to the NERC for approval.

Keyboard to be in ship's office

6.1.83 Internal Doors

R6.83 Doors shall be in accordance with the structural fire protection requirements.

Doors shall be lockable and shall be included on the master lock system.

Door sills shall be of minimum height and wherever possible flush with the floor coverings.

All internal doors throughout the accommodation to be constructed of incombustible material, with both sides lined with hard plastic faced veneer adapted to coincide with the chosen panel system, arranged in steel door frames, with stainless steel sill.

All cabin doors are to have at least 700mm clear opening with a 20mm air gap arranged at the bottom. Kick-out panels to be fitted as appropriate in way of MCA approved escape routes.

- All cabin doors are to be fitted with a Yale type lock (see 6.1.79), hold-back, ajar hook and door stop.
- Doors to all tiled spaces (Washrooms, galleys and other wet rooms) are to have 150mm sill with stainless steel trim.

Fire doors shall be fitted throughout the accommodation and ladderways in accordance with statutory requirements to maintain the fire integrity of the vessel. Fire doors shall be arranged with automatic door closers and magnetic hold backs centrally controlled from the fire control station on the bridge as appropriate to statutory requirements.

Hose ports shall be fitted in all fire doors in stairways, public spaces and main vertical zone bulkheads in escape routes.

Access doors to public toilet spaces shall be complete with indicator bolt and automatic door closer.

Access doors to toilet, shower cubicles shall be complete with indicator bolt and hold back.

Access door to bridge toilet shall be interlinked with toilet internal light.

6.1.84 Windows

R6.84 All windows shall comply with the following:

1. Windows and sidelights in accordance with ISO standards to be fitted throughout the vessel, generally as indicated on the arrangement drawing.
2. Windows and sidelights are to have welded in type frames of steel graded in accordance with Class requirements.
3. Glasses (except wheelhouse and winch control room) shall be double glazed toughened glass of thickness according to ISO with special consideration given to thickness of wheelhouse and all forward facing windows. All windows and sidelight glasses to be treated with water repellent at time of manufacture / installation.
4. Glass retaining frames to be brass construction.
5. Window dimensions given in this specification relate to clear glass size. Window sizes to be standardised as far as possible.
6. Defrosting system (hot air nozzle) and water spray nozzles shall be arranged for all of Wheelhouse, Crow's Nest, Observation Lounge and UIC Room windows, system to be self-draining and clearing for operation in cold climates.
7. Window and sidelight boxes of incombustible material to be fitted to windows / sidelights throughout accommodation spaces (but not wheelhouse or winch control room).
8. All windows except on the wheelhouse and winch control room and sidelights shall be fitted with internal secondary glazed hinged windows integrated into the window box. These secondary windows shall be configured to reduce heat loss.

9. All cabin windows and s idelights shall be f itted with blackout curtains/ blinds.

10. All cabins shall be provided with natural daylight. Skylights may be used to light to a limited number (Max 6 nos.) internal Scientist cabins.

11. All windows and sidelights are to be fixed type unless specified otherwise and subject to Flag/MCA approval.

12. Fixed hinged steel deadlights are to be provided to sidelights in accordance with Loadline requirements.

13. Spares of glass and gaskets are to be provided. Portable aluminium storm shutters to be pr ovided to be pr ovided for the windows as per loadline requirements

14. Windows bounding / adjacent to Evacuation Stations, Escape Routes and Life Saving Appliances and Heli-deck shall offer structural fire protection in accordance with the Regulations for a P assenger Vessel and the requirements of the Flag State Authority.

15. Wheelhouse, Crow's Nest windows and UIC room windows to be equipped with electric element heating.

16. Wheelhouse windows shall be sized to allow maximum visibility be sloped outwards to provide shading and rain protection. Smaller windows shall be fitted above and below the main windows giving visibility of both helicopter and deck operations.

17. Wheelhouse and UIC room windows fitted with full cover parallel action wipers are to incorporate electric heating complete with time controlled switches and an all-round fresh water window wash system with arrangement to prevent freezing. All window wash components must have appropriate safe and effective access

18. Windows are to be fitted in the deck of the bridge wings to allow a view of the waterline directly below the bridge wing. These viewing ports shall be fitted with protective flooring sections for use under normal operations. These shall be close fitting to prevent glare from the over-side floodlighting interfering with night vision of wheelhouse personnel.

19. All wheelhouse and winch operation room shall be fitted with anti-glare roller blinds (e.g. clear Mylar material with reflective outer coating).

6.1.85 Watertight Bulkhead Doors

R6.85 All access openings through watertight bulkheads shall be protected by horizontally sliding watertight doors of fabricated steel construction.

Doors shall be arranged with a minimum clear opening of 800mm x 2000mm. with exception of doors in stores routes where the openings shall be 1200mm x 2000mm or compatible with width of pallet and pallet trucks.

Doors shall be fitted with hinged automatically folding sill plate of similar material to adjacent floor plates.

Doors shall be hydraulically or electrically operated with self-contained power pack fitted adjacent to door.

Doors to be arranged for remote operation from wheelhouse, and Safety Control Room above the bulkhead deck and locally from either side of door each complete with audible and visual alarms arranged both sides of each door.

Door status indication with visual and audible alarms shall be arranged in wheelhouse emergency console.

Laser Safety Stripes in way of watertight sliding doors shall be provided. Along with additionally remote closing safety override (emergency mode) to be provided.

6.1.86 Weathertight Doors

R6.86 All accommodation weathertight doors, either to exposed weather deck or enclosed hangar area in way of moonpool, or covered mooring deck forward shall be of lightweight weatherproof construction, epoxy coated, complete with stainless steel dogs.

Doors shall be fitted with hydraulic door closers, hold-back hooks and 250mm dia. bullseye. All accommodation weather-tight doors are to be fitted in conjunction with internal accommodation door to generate an airlock.

Coamings shall be in accordance with Loadline requirements, except doors to the science labs in way of the moonpool to be with reduced sill 150mm.

Doors leading from the moonpool area along the stores corridor shall be fitted with double weathertight or semi-watertight doors to allow an unobstructed clear opening of 2000mm. Doors along this corridor are to be flush to allow palletised cargo to be transferred forward. This shall be achieved by recessing a water trap into the deck to give a sill on the door.

Wheelhouse door are to be of the hinged type with clear opening of 1000mm and fitted with glass pane in the upper half.

Portable galvanised steel gratings secured by bolts to be fitted outside all weather doors with perforated rubber mats installed in recesses (complete with scuppers) in the deck covering fitted immediately inside. Steel gratings to be fitted 12mm above deck.

Heating shall be fitted as identified by Winterisation considerations.

All accommodation weathertight shall be fitted with an airlock..

6.1.87 Lifeboat, Rescue Boat & Work Boat Bay Curtain Coverings

R6.87 Lifeboat, Rescue Boat & Work Boat Bay Curtain Coverings shall be made up of two parts, securely attached to top & bottom track. They shall be operated manually by the crew. The material of the curtain shall be of a strength that allows the lifeboat, rescue boat and liferaft davit to breakthrough in the event of a failure to open the curtain.

The material shall be weather and UV resistant

A tie back shall be provided to hold the curtain in the open position and a fastening to maintain the curtain closed.

Colour to match hull paint scheme

6.1.88 Load Sensors on Hull

R6.88 An ice load monitoring system shall be installed to:

- Provide to the bridge near real-time information of the measured local stresses in the icebelt structure while transiting in ice.

- Warn the vessel's personnel that the stresses are approaching permissible levels so that corrective actions can be taken.

It shall comprise of locally mounted strain gauges in accordance with LR requirements, a computer for processing the data and the ability to download remotely via the ships monitoring system.

6.1.89 Escape and Evacuation Routes

R6.89 Each fire zone shall be arranged with A Class fire protected muster station and stairway for escape in accordance with SOLAS requirements and to meet the requirements of the Flag authority and the class society. Escapes from machinery spaces, science and cargo spaces to be in accordance with SOLAS and Flag state requirements, but additionally they shall be arranged bearing in mind the cause and effects of fire and other determining events.

Exposed Deck plating in way of escape routes from the muster station to the lifeboat/liferaft embarkation shall be heated. See Section 5.1.14

Permanent, tested and marked lifting points shall be fitted for the transfer of injured personnel.

In addition to emergency lighting, Low Location lighting to be provided marking escape routes in accordance with SOLAS requirements within the accommodation and science areas. In machinery spaces, cargo areas and stores escape route guidance system utilising long persistence photoluminescence to be provided in accordance with Rule requirements.

Escape & Safety signage shall be provided to meet the requirements of the Flag Authority and the Classification Society.

At least three emergency accesses / escape ladders to the heli-deck to be provided.

Ladders in escape ways shall be equipped with handgrip and safety hoop according to requirements.

All emergency escape hatches and escape routes to be clearly marked "Escape Hatch – Do Not Obstruct".

Exit and Emergency Exit labels shall be luminous type attached by stainless steel screws.

Access escape trunk shall be provided to allow access/egress from the pipe tunnel, spaces from above the bulkhead deck.

6.1.90 Yokohama Fenders and Storage

R6.90 Six Yokohama type fenders shall be provided, each 1m diameter x 1.5m long, light weight to enable man handling. Secure stowage shall be provided.

6.1.91 Accommodation Ladders, Gangways and Pilot Ladders

R6.91 An Approved type loose aluminium gangway shall be provided and stowed in an accessible position for deployment in designated positions, port and starboard. Its length shall be sufficient to reach down to 1m above the light waterline, with Yokohama fenders between the ship and the quay and to land on adjacent ice at least 12m from the ship's side. The gangway shall be of light construction, fitted with hooks end rollers. Fittings shall be provided in way to allow safety nets to be slung under and outside the footprint of the gangway.

When not in use the gangway shall be stowed in a suitable position, easily and safely reached by personnel to stow and deploy it.

The gangway must be safe to use throughout a tidal range of 12m.

The deployment position shall be covered by the CCTV system for security purposes.

The gangway may be deployed using one of the ship's cranes.

An Approved rope pilot ladder shall be provided at each side of the vessel in an Approved arrangement, meeting International Guidelines.

6.1.92 Miscellaneous Outfitting Items

R6.92 The following items of miscellaneous outfitting shall be supplied:

a. Napery

96 Tea Towels 100% Cotton 26 inch x 26 inch
96 Glass Cloths 30 inch x 20 inch
96 Oven Cloths 100 % unbleached cotton 36 inch x 20 inch
12 Spare Shower Curtains (PLUS 12 sets spare shower hooks & eyes for shower rails)

b. Linen – calculated on 90 persons onboard

Master/Ch. Eng/PSO/Ch. Officer/2nd Engineer – Cabins with Day Rooms & Bedrooms

1 Mattress
1 Number Duvet - Tog rating 7.5
4 Pillows each cabin
8 Pillow Protector - white quilted (4 as spare each cabin)
2 Mattress Protector - white quilted (1 as spare each cabin)

3 sets linen for each cabin:

1 Duvet Cover - 50% Cotton Easy Care 50% Polyester
1 Fitted Sheet - white 100 % cotton
4 Pillow Cases- 50% Cotton Easy Care 50% Polyester
1 Bath Towel - white 100 % cotton
1 Hand Towel - white 100 % cotton

All other Cabins - (Presuming all beds are the same size mattress)

1 Mattress
1 Number Duvet each cabin - Tog rating 7.5
2 Pillows each cabin
4 Pillow Protector - white quilted (2 as spare each cabin)
2 Mattress Protector - white quilted (1 as spare each cabin)

3 sets linen for each cabin:

1 Duvet Cover - 50% Cotton Easy Care 50% Polyester
1 Fitted Sheet - white 100 % cotton
2 Pillow Cases - 50% Cotton Easy Care 50% Polyester
1 Bath Towel - white 100 % cotton
1 Hand Towel - white 100 % cotton

EXEMPLAR: HØIE NORDIC FLH DYNE Art.nr: 16001720 Flame retardant

A different colour duvet cover shall be provided for officers / ratings / scientists

12 number spare pillows

c. Crockery

Crockery – Churchill Plain Whiteware - 3 sets per crew member = 270 number of each

Coffee Mugs - Churchill Windsor Mug 10 fl oz
Soup Bowls - (JC Currently has Churchill 210 mm 8 ¼")
Ensure that any supplied fit electric soup plate warmer
Side Plates - 8 ¼ inch / 210mm
Side Plates- 6 ¾ inch / 170mm
Dinner Plates - 10 ½ inch / 270mm
Cereal Bowls- 6 ½ inch / 165mm

150 number only - White Tea Cups – Churchill Nova Tea Cup 7.5 fl oz
150 number only - White Saucers – Churchill Nova Sandringham
Saucer for above – 5 ½ inch /140mm
60 number – Ramekins 3 ½ inch / 90mm
60 Number – Ramekins 2 ¾ inch / 70mm
90 Number - eared oval Dishes – 195 x 110mm
90 Number -Crescent Salad Plates – 8 inch / 203mm
90 Number - Squared Bowl – 7 inch / 175mm

d. Cutlery

Cutlery – Stainless Steel - 3 sets per crewmember
Suggest Olympia Monaco 18/10 Mirror Polished = 270 number of each
Knives
Forks
Soup Spoons
Tea Spoons
Dessert Spoons
Steak Knives – Wooden Handle 144 only

e. Galley & Servery Utensils

2 sets each except where indicated

Knives:
Cooks Knife 10 Inch
Cooks Knife 6 Inch
Cooks Knife 4 Inch
Fillet Knife 6 inch
Boning Knife 6 inch
Palette Knife 8 inch
Bread Knife 8 inch
Serrated Slicer 12 inch
Zester 5 ½ inch
Steak Knife 10 inch
Steel 10 inch
6 nos.Paring Knife 3 inch
Steel 12 Inch
Cleaver 6 inch
Cleaver 9 Inch
Cheese Knife 14 cm
Roasting Fork 6 inch
Carving Fork 8 inch
6 nos. Peeler – double sided
Magnetic Knife Rack Bulkhead mounted

Sharpening Stone
Kitchen Scales – Platform – 5 Kg
Thermometer – Foodcheck 1 -30 to +300 degrees C
Tubs probe wipes (blue) for above
Colour coded chopping boards 24inch x 18 inch x ¾ inches thick
4 nos. Food Grain Wooden Chopping Boards 18inch x 24 inch
1 Bonzer Easi Clean Can Opener–Super Model–Bench-for cans of up to 560mm complete with 2 sets spare blades and wheel for above
6 nos. Waiters Friend Cork Screw
1 No Large Panini Grill – Ribbed Plate – top and bottom plate
Cling Film Dispensers 18 inch wide with bulkhead mounting brackets
6 nos. refill packs for above
1 No. Robot Coupe Food Processor R301
Spatula – High Heat
Ice Cream Dipper – Stainless Steel
Stainless Steel Portioner – Spring Loaded 30 portion per litre 1.20 Fl Oz
Flan Server – Stainless Steel
Griddle Scraper Stainless Steel – 127mm Blade
Pizza Wheel – Stainless Steel Circular Wheel
Turner – Stainless Steel Blade – Plastic Handle – 254mm blade
Slotted Turner – Stainless Steel Blade – Plastic Handle
Hamburger Turner – Stainless Steel Rigid Blade
Food Tongs Stainless Steel
Spaghetti Tongs Stainless Steel
Steak Tongs – Stainless Steel – 508mm
6 nos. Plain Serving Spoons Stainless Steel 11 inch.
6 nos. Plain Serving Spoons Stainless Steel 13 inch
6 nos.Plain Spoon with hook – Stainless Steel – 12 inch
6 nos.Perforated Serving Spoon 11 inch Stainless Steel
6 nos.Perforated Serving Spoon 13 inch Stainless Steel
Fish/Egg Slice Stainless Steel – hook handle – Large 4.5 Inch x 5 inch
Fish/Egg Slice Stainless Steel – hook handle – Small 3.5 Inch x 4.5 inch
Plain Ladle Stainless Steel – Hook Handle – 65 ml
Plain Ladle Stainless Steel – Hook Handle – 122 ml
Plain Ladle Stainless Steel – Hook Handle – 250 ml
Perforated Ladle – 65 ml – Stainless Steel
Perforated Ladle – 196 ml – Stainless Steel
Serving Tongs Stainless Steel 70 x 60mm
Skimmer – Stainless Steel 110 mm dia.
Slotted Turner – Stainless Steel – 406 mm
Whisk – Light – Stainless Steel – 12 Light Piano Wire – 250mm
Whisk – Light – Stainless Steel – 12 Light Piano Wire – 300mm
Whisk – Light – Stainless Steel – 12 Light Piano Wire – 350mm
Whisk – Heavy – Stainless Steel – 8 heavy wires – 250mm
Whisk – Heavy – Stainless Steel – 8 heavy wires – 300mm
Whisk – Heavy – Stainless Steel – 8 heavy wires – 350mm
Balloon Whisk – Stainless Steel 430mm
Garlic Press 160 mm Stainless Steel
Fish Scissors – Stainless Steel
Kitchen Scissors – 8 inch
Zester – Stainless Steel
Paris Scoop – double 28mm

Scoop – 153 mm – Stainless Steel
Scoop – 197 mm – Stainless Steel
Scoop – 229 mm Stainless Steel
Lifter – Stainless Steel Spider 140mm dia.
Vegetable Ladle – Long Handle Stainless Steel – 220mm dia
Spaghetti Basket – 150mm dia. Stainless Steel
Conical Strainer – 121mm Stainless Steel
Conical Strainer – 178mm Stainless Steel
Conical Strainer – 229mm Stainless Steel
Chinois – Stainless Steel ring and mesh 200mm
Strainer – 300 mm Heavy Duty Double Mesh Stainless Steel
Strainer – 350 mm Heavy Duty Double Mesh Stainless Steel
Sieve – 100 mm Stainless Steel
Potato Ricer - Heavy Duty 102mm hopper
Potato masher Stainless Steel
Grater – 7 inch Stainless Steel
Graduated Measuring Jug – 1 pint – Aluminium
Graduated Measuring Jug – 2 Pint – Aluminium
Graduated Measuring Jug – 4 Pint Aluminium
Polycarbonate Measuring Jug 2.2 Litres
Mandolin
Juice extractor – 95mm dia.
Plastic Funnel 75mm
Plastic Funnel 95mm
Quick Fit Torch Head for 8 oz butane gas cylinder
Butane Gas cylinder for above 8 oz
6 nos. Cake Cooling Trays Heavy Duty – 25 inch x 16 inch
Pastry Brush – 19mm round
Pastry Brush – 51mm Flat
Wooden Rolling Pin 457mm
Flexible Scraper 84 x 135mm
Bun Sheet 12 Cup
Muffin Tray – 12 cup non stick 27mm deep
Fluted Flan Ring 25 mm deep
Piping Bag – Nylon 305mm
Piping Bag – Nylon – 407 mm
Piping Nozzles – set
Round Bottom whipping Bowl – Stainless Steel – 250 mm dia
Round Bottom whipping bowl – Stainless Steel – 300 mm dia
General Purpose Stainless Steel Bowls – 1 litre
General Purpose Stainless Steel Bowls – 1.5 litre
Colander – Heavy Duty Aluminium – 350mm dia
12 nos. Stainless Steel Serving Flats
Sauté Pan Aluminium 200mm dia x 46mm depth
Sauce Pan Aluminium 120mm dia x 61mm depth + lid
Sauce Pan Aluminium 140mm dia x 66mm depth + lid
Sauce Pan Aluminium 160mm dia x 81mm depth + lid
Sauce Pan Aluminium 180mm dia x 86mm depth + lid
Sauce Pan Aluminium 200mm dia x 101mm depth + lid
Deep Boiling Pot Aluminium 254mm dia x 231mm depth
Stock Pot Aluminium 300 mm dia x 276mm depth
Fry Pan 200mm dia Non Stick

Fry Pan 360mm dia Non Stick
Fry Pan 400mm dia Non Stick
Egg Poacher – Aluminium 12 eggs 350mm dia
Fish Kettle 457mm
Gastronorm Baking Sheet 1/1 Aluminium Non Stick
Bakewell Pan – Aluminium 470mm x 355mm x 40mm deep
Roasting Dish – Aluminium 470mm x 355mm x 70mm deep
Deep Roasting Pan – Aluminium – 470mm x 355mm x 100mm deep
Pudding Mould – Aluminium with metal clasp – 380mm
Pizza Pans – 11 inch dia x 3/10 inch deep

f. Food Storage

Seal Fresh Containers
Cereal dispenser – 230h x 100w x 230d mm - 6.5 litre
Meat and Poultry Storer – 140h x 210w x 300d mm - 7.5 litre
Popular – 80h x 170w x 235d mm - 2.25 litre
Rubber Maid Space Saver Containers
222 x 211 x 222mm – 7.5 litre
290 x 265 x 305mm - 18 litre
290 x 265 x 365mm - 22 Litre
12 nos. Food Container – Polypropylene 510 x 400 x 150mm – 23 litre
12 nos. Stacking Food Trays – 762 x 457 x 123mm – 32 Litre.
Shallow food storage trays – Polypropylene – 80h x 485w x 335d mm
38 litre storage bin - plastic

g. Tableware

18 No. Glass Jug – Bistro 1 Litre/1.8pt
2 nos. Cheeseboard – marble with Perspex roller top
6 bos. Wooden Pepper Mills 120 mm
24 nos. Stainless Steel Sugar Bowls 10 Fl Oz
24 nos. San Jamar H3001 Full Fold Napkin Dispenser
8 nos. Wicker Baskets: Shallow Counter Display Baskets 51 x 279 x 457mm
8 nos. Wicker Baskets: Shallow Square Table Baskets 76 x 254 x 254mm
2 nos. Wicker Baskets: Shallow Bread Display Baskets 203 x 406 x 508mm
112 nos. Non Slip Clear Table Place Mats (Admiral Harding Brothers UK)

h. Glassware

96 nos. only - Pint Glasses – Tulip – 20 oz/570 ml
96 nos. only - Pint Glasses – Nonic – 20 oz/570 ml
96 nos. only - Hi Ball Glasses – 10 oz/280 ml
96 nos. only - Red Wine Glasses – Imperial Plus Brand – Toughened 11oz
96 nos. only - White Wine Glasses– Imperial Plus Brand – Toughened 11oz
96 nos. only – Champagne Flutes
156 nos.- Plastic Hi Ball Glasses – 10 oz

i. Other

6 nos. Wall/Bulkhead Mounted **Outdoor** stainless steel ashtrays
4 nos. San Jamar Bulkhead Mounted Polystyrene Cup Dispenser
8 nos. Plastic Cutlery Tray – 4 compartments – for dishwasher
2 nos. Plastic cutlery baskets– for dishwasher
4 nos. Dishwasher Rack – Open Cup
8 nos. Dishwasher Rack – Plate Peg Rack
2 nos. Dishwasher Rack – Cutlery Rack

2 nos. Milan Chafing Set Gastronorm 1/1 9 litre capacity
24 nos.Sterno Chaffing gel fuel 200 gm tin
12 nos Lotus Professional Centre Feed Towel Dispensers
2 rolls Non Slip Matting – non porous and non absorbent x 10m per roll
3 nos. Coffee Percolators – Bridge/Pursers Office/Engineers Office

j. Janitorial

2 nos. foot operated stainless steel frame waste sack holders (for galley)
6 nos. Sani Bins – 20 Litre Capacity
6 nos. 70 Litre Dustbins
720 nos.Plastic Coat Hangers – 8 per person
50 nos. Janitorial Carry Caddy's (for cabin cleaning materials)
12 nos. Safety Floor Signs – wet floor – free standing
6 nos. Henry Style Vacuum Cleaners 1200 watt
1 nos. Rotowash Carpet Cleaner with trolley system
1 no. Multi Deck Rotary Scrubber/Polisher 230v with 5 pack pads
24 nos. Washable Entrance Barrier Mats 0.9 Mtr x 1.5 Mtr

k. Towing & Mooring Ropes

i. Mooring Ropes – 2 sets each comprising: 4 pieces, length 220m spliced eye at each end, breaking strength to meet Classification Society requirement.
EXEMPLAR: Cosalt Nuflex 8

ii. Towing Line – 1 piece: length 200m, breaking strength to meet Classification Society requirement.

iii. Four off heaving lines each 60 metres in length 12mm diam. nylon rope.

l. Bosun's Tools

Swaging Machines

1 no. Cabco-Talurit press model no. H17/21 Capacity 15000kn, up to 21mm wire dia).

1 no. Cabco-Talurit press model no. H6/8 which is a 250Kn press for 6mm and 8mm wire.

2 sets standard dies to match above machines (mm) 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18. NB. Not thin walled dies.

Other

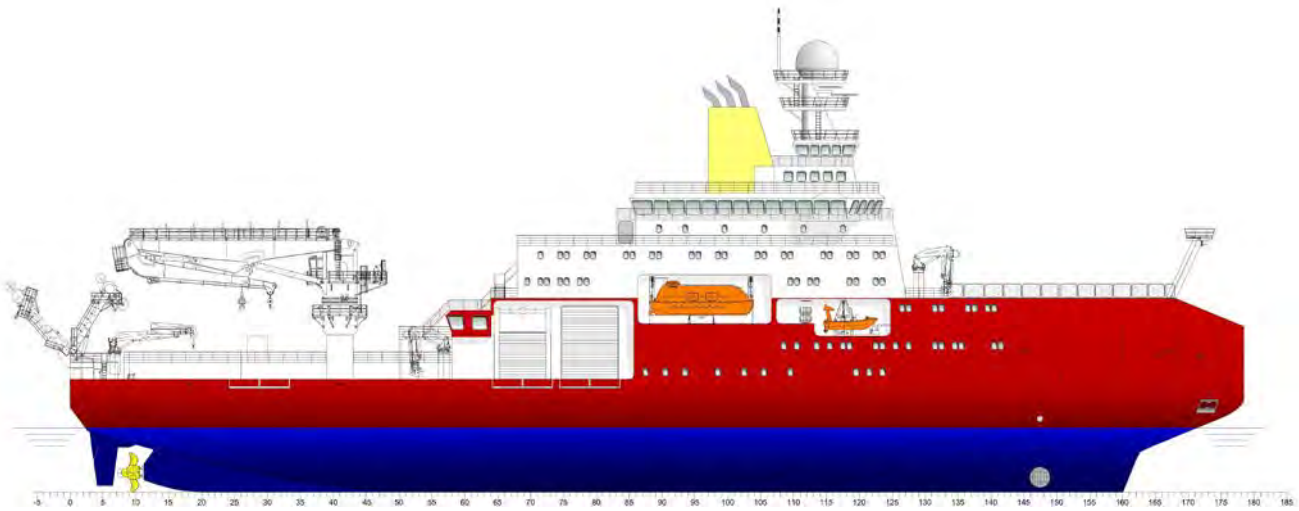
2 no. Marline spikes for Wire Dia.: Ø16mm
2 no. Marlin spikes, stainless steel plate (30 mm)
2 no. Hand splice tool (max dia 14 mm)

m. Domestic Spare Parts

Lighting fittings – 5% of overall supply boxed and labelled.
Carpeting – 5% of overall supply boxed and labelled.
Deckhead Panelling – 5% of overall supply boxed and labelled.
Door hardware and fittings – 5% of overall supply boxed and labelled.

SoR – New Polar Research Vessel (NPRV)

STATEMENT of REQUIREMENTS (SoR) for the DESIGN and BUILD of the NEW POLAR RESEARCH VESSEL (NPRV)



Volume 2 of 2

Sections 6.2 to 8

6.2.1 Science Hangar

R6.93 The Science Hangar shall be located centrally and arranged with the following features.

- Location for the Science Moonpool.
- Science equipment handling systems for deployment through the moonpool and over the starboard side (two positions).
- Handling and preparation areas for science equipment, including CTD and seabed drill.
- Enclosed working environment.
- Direct access to the aft Working Deck.
- Direct access to the starboard overboard deployment area.
- Direct access to permanent laboratories with the capability of two being capable of abutting up to the Wet Laboratory providing direct access therein.
- Location for portable laboratories.
- Services (electrical, communications, fluids & gases) to support science equipment and portable laboratories.
- Access to the Science Hold.

For a description of the science equipment handling systems refer to Section 6.3 Open Deck1, Section 6.10 Overside Handling Equipment and Section 6.11 for Cranes.

The enclosed area of the Science Hangar shall have a working deck area not less than 275m^2. The wood sheathed deck shall be flush with external working deck, allowing transfer of rolling loads. Clear working height shall be not less than 7.0m (below handling devices) in a transverse area above the Science Moonpool and forward starboard side overboard deployment position. Elsewhere the clear height shall be 4m (below the crane hook). It shall be fully enclosed by a steel structure and provided with large access openings to the aft and side decks protected from wind, wave and weather by suitable folding / removable coamings and substantial doors of a design appropriate to the location on the ship. The doors for equipment deployment shall have clear openings as follows:

- Aft door to Aft Working Deck 6m wide x 4.5m high
- Forward side door 4m wide x 8.8m high
- Aft side door 4m wide x 5.8m high

The deck shall be sheathed with timber complete with peripheral gutterways. A bolting down matrix system shall be fitted throughout at 500mm spacing. The specification of the deck and bolting down matrix shall be the same as for the aft Working Deck, see Section 6.3 Open Decks.R6.137

Flush twistlock container fittings shall be fitted in the deck in positions to suit the portable laboratories also where the lab containers butt up to the wet laboratory and science equipment as indicated on the Concept General Arrangement Drawing. See Section 6.3 Open Decks.R6.140 and 141.

This shall be a wet space and shall be self-draining over the port side and shall be fitted with large clearing ports to prevent retention of water on deck

The Science Hangar shall be arranged central to, and with direct flush deck access at the same level to the Working Decks, Rough Workshop, Wet Laboratory, ship's stores, Clean Laboratory and Deck Workshop. Where flush deck access is specified doors to each of these spaces are to be split to allow coaming sections to be in place, with the main section of the doors open.

Water Sampling
CTDs shall be stored, prepared and deployed from the Science Hangar.

Deployment shall be through the Science Moonpool or over the starboard side in either of two positions.

The sampling equipment, up to 3m diameter, 2m high and weighing up to 2 tonnes, shall be deployed and retrieved with the minimum of manual handling.

One over the side deployment position shall be equipped for use with the metal free wire, that which is not aligned with the Scientific Moonpool.

The following table identifies access requirements to other spaces and areas of the vessel from the Science Hangar.

Main Deck	**Door type / features**
Deck Workshop	Double width, clear opening 1500mm Flush to deck
Rough Workshop	Double width, clear opening 1500mm Flush to deck
Wet Laboratory	Double width, clear opening 1500mm Flush to deck
Deck Laboratory	Double width, clear opening 1500mm Flush to deck
Controlled Temperature Laboratory	Single Width via air lock from Deck Lab
Core and Sample Cold Store	Single Width via air lock from Deck Lab
Clean Laboratory	Single Width via air lock
Main Laboratory	Double width, clear opening 1500mm in close proximity to hangar. Flush to deck
Science Lab/ Stores	Double width, clear opening 1500mm Flush to deck
Access alleyway (port)	Single width, Fixed coaming
Stores alleyway (starboard	Double width, clear opening 1500mm Flush to deck
Personnel access to Aft Working Deck	Single width, Fixed coaming
Deck 1	Access via elevated walkway, with stairs from Main Deck.
Data Suite	Access from Walkway and close proximity to UIC Room
Accommodation Alleyway (Port & starboard)	Single width
Deck 2	Via Stairs up from internal walkway
Underway Instrumentation Control Room & Winch Control Room	Single width
Winch Room	Single width, common with the UIC Room

A flush hatch with clear opening 2.0m x 3.0m shall provide access to the scientific storage hold which shall be provided with a 2 tonne SWL powered pallet lifting platform from the lower level (flush with the deck in the Science Hold) to a position flush with the Science Hangar deck allowing wheel access at each level.

The hatch opening at the Main Deck shall be fitted with guard rails and a gate for access to the pallet lift for access of a pallet trolley and gate to be interlocked with the lift.

Adequate guards shall be fitted at the lower level in the Science Hold.

The various electrical power supplies in the Science Hangar area required to service equipment and containers on the aft deck are to be grouped together as far as is practicable at a location aft in the hangar close to the main entry door.

Goose necks with closing flaps are to be provided in the aft bulkhead of the hangar so that cables and their connectors can be led outside to the equipment and containers. These cable leads shall not obstruct or interfere with means of access of personnel when they are in place.

A clear bulkhead length of at least 4m, extending from the Main Deck to mezzanine height, is required for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Ventilation of the Science Hangar shall be specially considered to avoid adverse effects of condensation.

A pressure relief system shall be provided that prevents rapid and frequent change of air pressure within the space, which would be likely to cause discomfort among personnel working in the space and difficulty in opening or closing doors. Air inlet and exhaust shall be at opposite side of the space to induce an air flow across the Science Hangar.

6.2.2 Scientific Moonpool

R6.94 The moonpool will be used to increase the operating conditions in which over the side work can take place safely. The moonpool shall be an integral part of a complex comprising hangar, transfer, storage/equipment preparation for deployment of over the side devices and the subsequent laboratory processing and sample storage.

The moonpool shall be located aft of sensitive sensors that may be subject to interference arising from the aperture/bottom shell hatch.

The Scientific Moonpool shall have clear opening of 4m x 4m. Motion damping structure shall be external to this clear opening.

The CTD may be deployed through the moonpool. Other equipment may be deployed through the moonpool, including the following.

- Landers.
- Box corers.
- Small ROVs.
- HIBIS.

- AUVs
- Acoustic sensors
- Seabed drilling
- Other devices on a wire.

The moonpool should be designed to further still the wave action by the inclusion of a double shell, incorporating large free flow openings. A bottom door is required to minimise resistance when free running and avoid ice accumulation. Means shall be provided of avoiding ice accumulation within the moonpool.

Measures will be required to avoid wires snagging obstructions or the bottom doors, for example by means of a cursor arrangement.

The moon pool should be served by the same overhead transfer/hoist systems as the hangar space and Over the Side handling systems, as far as practical.

The moonpool shall be closed by watertight doors which fit flush with the bottom shell of the vessel. The bottom shell doors shall have suitable strength for their location in the bottom of the ship, with the moonpool pumped dry. Means shall be provided for pumping out the content of the moonpool for transit or when the moonpool is not in use. Means shall be provided to keep the water in the moonpool clean and prevent freezing. Internal access for cleaning shall be provided.

Flush fitting doors shall be installed at the working deck of the Science Hangar. These closing panels shall have similar strength to the surrounding deck. A moveable cover panel with aperture to allow the passing of the equipment wire to pass through it is to be provided in the moonpool cover. Safety railing shall be fitted to surround the moonpool when the top doors are opened.

Positive guidance shall be provided for all equipment deployed through the moonpool. This is expected to comprise a cursor system which has positive latching to all equipment to be deployed. The cursor shall be rail mounted through the depth of the moonpool. During the deployment the cursor shall remain in position at the base line of the vessel and provide a fair lead for the deployment wire / cable, avoiding contact with the ship's hull.

Integrated control of the moonpool doors and handling system shall be provided in the UIC (at the Winch control station) with a view of the Science Hangar. Back-up local control shall be provided. Manual emergency activation shall be provided for the moonpool doors.

The cursor, deployment system, top and bottom doors controls shall be integrated to prevent clashes.

The moonpool and its cursor system will be used for the deployment of science sonar sensors, up to 2m below the base line of the vessel. In this mode the vessel speed may be limited. In this mode the sensor must be held captive in a precise orientation to hull reference points.

The cursor shall be designed to mate with a variety of bespoke scientific equipment, using different arrangements.

Winterisation Features

Winterisation features shall include, but not be confined to the following.

- Prevention of freezing within the moonpool and surrounding wave damping spaces.

- Hydraulic systems for top and bottom doors
- Material selection for moonpool doors and handling systems.

6.2.3 Wet Laboratory

R6.95 This shall be a 'wet and dirty' area i.e. water and mud from samples shall be carried into and released in the space

It shall be a steel enclosure and arranged with direct access from and to; the Hangar, Deck Laboratory and integrated Science Containers

The general design of the space and its fittings must promote proper cleaning and containment/discharge of spilled water.

An area of at least 40m^2 is required.

A clear deck to deckhead height of at least 2.3m shall be provided.

The space shall accommodate at least 4 scientific work stations and 2 deep sinks complete with laboratory style taps, in the fixed benches.

A removable central stainless table at least 2m x 2m shall be supplied with raised edges to allow containment of the 'junk' material and sediment generated during sectioning and splitting of sediment cores.

Two sinks to be HDPE and two to be stainless steel incorporating drainer sections with side and back splash protection for the bulkheads and benches. All sinks are to be arranged to discharge overboard on the port side of the vessel and are to be arranged to drain directly overboard. Each overboard drain shall be of 75mm internal diameter incorporating a removable strainer at the sink outlet. The drain pipes are to be hot dipped galvanised and are to be led by the most direct route with smooth large radius bends to below the main deck level where they are to discharge just above the waterline. A screw-down non-return storm valve shall be fitted at the shell penetration in a position accessible for maintenance and ease of operation.

Fresh (hot and cold) and sea water shall be supplied to both these sinks.

Access into the laboratory shall be removable coaming shall be installed to reduce water ingress,

Lifting Eyes shall be fitted to deckhead for lifting purposes

At least 3m of work benching shall be provided in the space including two stainless steel (SS316L) and two HDPE sinks each length front to back 600mm x width 600mm x depth 500mm deep complete with hot and cold tap supplies, clean seawater to double tap and a large sediment trap in the drain.

Stauff rail systems are to be fitted on the bulkheads.

Fixed bench tops (inclusive of the workstations) shall be provided aggregating at least 8m in length, plus 6 nos. 1.5m long by 1m wide portable units, shall be provided which are designed to be bolted down to the deck matrix.

Bench tops shall be laminate faced and fitted with Stauff rails.

Sacrificial tops are to be supplied and fitted.

Bench height to be 900mm.

A common earth rail shall be provided full length along the port side bulkhead.

Lighting shall be switchable in groups of no more than 4 units spaced throughout.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

A stainless steel table of at least 2m by 3m dimension, designed to be bolted down to the deck matrix. This shall have a lip and drains with the table draining into scuppers or a suitable drain (this shall be waste water, mud, zoo plankton and ideally needs to drain over the side). Ideally it shall have fresh and sea water taps from the deckhead to deliver water to it to facilitate cleaning. It shall also have power sockets fitted overhead (in the deckhead) to deliver power to it.

A number of displays/repeaters shall be installed for navigation, winch and hydrographic information

At least one chemical locker shall be provided

Storage shall be provided with 8 .drawers, and probably 4 cupboards. Ideally all other storage shall be areas where zarges boxes will fit.

Stauff rails on the bulk heads

It needs a goose neck/cable gland from the hanger and through to the deck laboratory.

6.2.4 Deck Laboratory

R6.96 This laboratory shall be wet and dirty area for some disciplines. The general design of the space and its fittings must promote proper cleaning and containment / discharge of spilled water.

It shall be a steel enclosure and arranged with direct access from and to the Hangar, Wet Laboratory, Controlled Temperature Laboratory and Core and Sample Cold Store.

An area of at least 55m^2 is required. A clear deck to deckhead height of at least 2.3m is required.

The space shall accommodate 4 deep sinks complete with laboratory style taps, in the fixed benches.

Two sinks to be HDPE and two to be stainless steel incorporating drainer sections with side and back splash protection for the bulkheads and benches. All sinks are to be arranged to discharge overboard on the port side of the vessel and are to be arranged to drain directly overboard. Each overboard drain shall be of 75mm internal diameter incorporating a removable strainer at the sink outlet. The drain pipes are to be hot dipped galvanised and are to be led by the most direct route with smooth large radius bends to below the main deck level where they are to discharge just above the waterline. A screw-down non-return storm valve shall be fitted at the shell penetration in a position accessible for maintenance and ease of operation.

Fixed bench tops (inclusive of the workstations) are to be provided aggregating at least 18m in length, plus 6 nos. 1.5m long by 1m wide portable units, are to be provided which are designed to be bolted down to the deck matrix. Bench tops are to be laminate faced and fitted with Stauff rails. Sacrificial tops are to be supplied with no gaps between the sacrificial units, they shall fill all the bench tops completely hence making all benches useable for securing scientific equipment. Bench height to be 900mm.

Island benches to have electrical services provided at deck head height, over the benches, so as to operate equipment used on these island benches

A common earth rail shall be provided full length along the outside bulkhead.

Lighting shall be switchable in groups of no more than 4 units spaced throughout.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Bulkhead cable penetrations (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this laboratory to; the aft deck, hangar, clean chemistry and other laboratories and service spaces via installed ductwork.

Main door to hangar shall be fitted with a heavy duty plastic curtain for atmosphere control.

Access into the laboratory (i.e. removable coaming be installed to reduce water ingress, lifting eyes shall be fitted to deckhead for lifting purpose)

A clear bulkhead length, deck to deckhead, of 2m is required for electrical, scientific wiring and special junction boxes.

Stauff rail systems are to be fitted to the bench tops, bulkhead panels and deckhead.

2 nos.spark free type refrigerator to be fitted under the bench top.

1 no. -20ºC freezer to be fitted

Also Milli-Q at one sink.

2 nos. chemicals storage cabinets under bench fitted.

Fume cupboard to be fitted.

8 nos. laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material.

6.2.5 Controlled Environment Laboratory

R6.97 One Controlled Environment Laboratory shall be located on the Main Deck accessed from the Deck Laboratory through an air lock and suitably insulated doors to access Core & Sample Cold Store.

The space shall have suitably insulated floor.

This space shall allow experiments and samples to be maintained at a range of temperature and humidity for extended periods of time and to maintain reasonable habitability for personnel tending such experiments.

Temperatures are to be maintainable at values between 0ºC and 30ºC with a tolerance of ± 2ºC.

Relative humidity shall be maintainable at values between 35% and 60% with a tolerance of ± 5%. In addition, the humidity control accuracy to be +/- 5%RH.

The Laboratory shall be fitted with entrapment alarm with signal to Wheelhouse and Safety Control Room.

An external digital temperature gauge shall be fitted.

The environmental control equipment shall be located in an adjacent space.

The space shall be insulated accordingly and be fitted with an air lock entry complete with hanging space, with 1m wide doors, from deck laboratory, this entrance to be protected by an airlock or curtain to retain the atmospheric conditions. A secondary entrance shall be provided by way of a door to Core and Sample Cold Store.

An area of at least 24m^2 is required. A clear deck to deckhead height of at least 2.1m is required.

Bench tops shall be fitted with two. deep sinks able to handle large volumes and discharge over port side, aggregating at least 10m in length are to be provided.

Bench tops to be 900mm height, constructed from HDPE and mounted on powder coated stainless steel frameworks and shall be of dimensions suitable for deck matrix attachment. Sacrificial tops to be provided.

Under bench storage shall be av ailable for zarges of dimensions 600 by 400 by 300mm which is standard small box

A clear bulkhead length of 2m x 1m is required for electrical, scientific wiring and special junction boxes.

Stainless steel Stauff rail systems are to be fitted on bulkheads and bench tops.

Bulkhead cable penetrations (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this laboratory to; the Main Laboratory, Wet Laboratory, Core and Sample Cold Store and Deck Laboratory, all via installed ductwork.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Chemical locker shall be installed under the bench top.

6.2.6 Core & Sample Cold Store

R6.98 A Core and S ample Cold Store shall be arranged on the Main Deck with direct access from the Deck Laboratory through an air lock. The store shall be arranged similar to the Controlled Temperature Laboratory, suitably insulated and with an insulated door. A secondary entrance shall be provided by way of a door to Controlled Temperature Laboratory.

It shall be 24m^2 floor area and 2.1m clear head height.

It shall be outfitted with removable racking for storage of core samples and other samples.

It shall be capable of being held at temperatures from ambient down to minus 2^{o}C. An external digital temperature gauge shall be fitted and the temperature shall be incorporated into the same Bridge alarm system as the Provision Rooms.

Relative humidity shall be maintainable at values between 35% and 60% with a tolerance of ± 5%

The door shall be fitted with the same lock-in safety measures as a Provision Room.

The Sample Cold Store can be used as a second Controlled Environment Laboratory shall this be required during specific cruises and therefore shall be easily convertible with the necessary services installed as per SoR 6.2.5 however, the primary use shall be as a core and sediment cold store.

6.2.7 Main Laboratory

R6.99 The Main Laboratory shall be located on the Main Deck.

This is essentially a dry working laboratory into which samples shall be processed using analytical instruments.

It shall have easy access to and from the working deck and the other laboratories and in particular proximity to Deck and Controlled Temperature Laboratory.

Stauff rail systems are to be fitted in bench tops, on bulkheads and deckheads.

Entry doors to be double width with clear openings of 1.5m

Island benches shall have all electrical services at deck head height, 230V and 110V outlets.

2 Spark free fridges required in here also under bench

The area shall be allocated into three primary sections:

- the general working benches and sinks
- the displays and control consoles
- the scientific control area

An area of at least 90m^2 is required. A clear deck to deckhead height of at least 2.1m is required.

It shall be a multi-role laboratory and be used for science analysing water samples, it shall have 2 s inks in the corners with all services, hot cold and non-toxic water supplies. Also Milli-Q at one sink. Lips to front of sink

A small office space shall be provided for the Laboratory Manager and scientific technicians. It shall be located within the Main Laboratory on the Main Deck.

It shall be fitted with chairs, a bench top 4m long with drawing storage (drawers) under.

At least 5 standard 4-drawer filing cabinets shall be provided.

6.2.8 Clean Laboratory

R6.100 A Clean Laboratory shall be located on the Main Deck. This requires close access to the Hangar area close to where the CTD water sampling system is operated and returns with samples. It needs to be positioned close to the hangar.

All surfaces must to be non metallic or suitably coated with no exposed metal at all.

This laboratory shall be used to deal with and analyse water and biological samples for ultra trace metal analysis. It will allow preparation of samples for transfer for other specialist analysis in other laboratories.

The laboratory shall be easily accessed from the Hangar via an air lock and have internal easy and safe access to the other main laboratories.

The laboratory shall be insulated and be capable of environment control.

Entry doors shall have at least an 800mm clear width opening.

A minimum area of 4.5m^2 for the outer lobby area is required (3m x 1.5m minimum). A clear deck to deckhead height of 2.1m is required. Inner laboratory to be minimum of 6m long and 2.8m wide), this is 16.8 m^2. Minimum dimensions must be maintained to fit all 24 CTD bottles in a clean environment.

There is a requirement for a specialist low pressure oil free laboratory air compressor to supply air to the Clean Laboratory a gland. Air compressor shall be fitted when required for trace metal work.
EXEMPLAR Oil-less Dental Compressor c/w Silencer Enclosure & Dryer Maker OED, Serial No: OAC1

Glands shall be provided to allow routing of plastic tubing for air supply into laboratory from air compressor in hanger area.

The space will house up to 5 nos. scientists at times of busy activity.

Bench tops (inclusive of the workstations) aggregating at least 5m in length are to be provided. Bench tops to be 900mm height, constructed from HDPE and mounted on hardwood timber frameworks set on high plinths (timber must not be exposed. All units shall be plastic material or equivalent). Sacrificial tops to be provided as inserted onto the HDPE work tops. There shall be no stauff rails. Sacrificial tops to be provided.

A clear bulkhead length, deck to deckhead, of 6m shall be fitted with non-metallic water sampling bottle racks from which samples can be drawn.

Areas of bulkhead in the outer section, aggregating 2m^2, are to be provided for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

The Space shall be divided into two sections;

- Air lock section with hanging space. This entry area to have door opening to hanger area with observation window. Bottles will enter this area and outer door closed, before door to inner main laboratory area is opened. Large observation window required to this door also. This is for safety and ease of operation. This shall be a Minimum size of 3m x 1.5m, and no smaller. Coamings/steps to be of minimum height for safe CTD bottle transporting.

- Main Clean Lab area. One side to include benching, vulcathene sink with front lip and clean water Milli-Q system fitted. Also hot, cold and Non-toxic supply to sink. Under bench shall have cupboards and drawer units as with other laboratories. 2 small chemical lockers (1 acids, 1 solvents), one spark free refrigerator and one freezer shall be fitted under the bench top.

- Bench to have fume cupboard (recirculation) and laminar flow cabinet fitted.

- Other side of laboratory to house bottle racks to hold 24 CTD bottles, all plastic fittings (Teflon) with water drip tray below the bottles.

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- All equipment, fittings etc are to be non-metallic.

- All linings, floors and deckheads are to be covered with heavy duty vinyl sheeting (***EXEMPLAR*** Armstrong Altro) with all joints welded to form a ‘capsule’.

- Light fittings to be non-metallic as far as possible with controls in the Outer section.
- All attachment fittings (screws etc.) to be sealed with a clear solvent free compound.
- The door between the inner and outer areas to have vision panel for safety.

The division between the inner and outer sections shall be formed using clear polycarbonate sheeting 6mm thick mounted in PVC framework sealed around the edges, the entry door shall be likewise constructed with a soft rubber seal. Air supply to the inner space shall be separate from the general space supply and fitted with a HEPA filter run at a slightly positive pressure.

6.2.9 Aerosol Laboratory

R6.101 Aerosol Laboratory space shall be located close to the on Bridge Top with easy access to and from the meteorological equipment and locations for personnel and data connections.

A minimum area of 11m^2 is required. A clear deck to deckhead height of at least 2.1m is required.

The space shall accommodate at least 2 scientific work stations.

A full height 19” instrument rack with resilient mounts shall be included to house instrumentation.

Bench tops (inclusive of the workstations) aggregating at least 5m in length are to be provided including a sink. Bench top height shall be 720mm. The top shall be laminate faced with inserted Stauff rails. Sacrificial tops to be provided.

A clear bulkhead length, deck to deckhead, of 1m is required for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Stauff rail systems are to be fitted to all bulkheads and deckheads.

Bulkhead cable penetrations (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this laboratory to; the Main Laboratory and mooring deck, all via installed ductwork.

A glanded duct shall be required to lead laboratory gases in pipes/tubes to this laboratory from nearby stowage.

Data cabling and small bore plastic piping, both permanent and temporary shall be led via trunking from the space through the covered mooring deck space to firstly a goose neck on the deck over next to the container stowage area and secondly up though the deck into the meteorological platform support structure and thence to a gooseneck on the platform itself. The trunking shall be typically of 125mm diameter with liberally placed access points or gaps to allow temporary cabling to be easily installed/ removed.

2 . laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

Glandular access shall be provided out up to the open 'monkey island' deck where the air filter systems shall be mounted on the forward rail above the bridge.

Electrical supplies, 230V / 110V need to be supplied in the dry out on the open deck to power the equipment. 8 nos. sockets shall be provided. Laboratory shall have a small Milli-Q clean water system with a single small sink with hot and cold.

Power and network points shall be provided

Floor-to-ceiling 19-inch racks (with movable shelves) shall be provided for installation of user kit during cruises – easy access power points to rear and l ots of network points (a 16 or 24 way network switch installed in each the rack would be useful)

Deck matrix shall be install for fixing at floor level for gas standards etc

Easy access to compressed gas cylinders (ideally with racks close by outside lab) shall be provided

6.2.10 Atmospheric Science Laboratory and Stores

R6.99 Laboratory space and Stores shall be located close to the foredeck with easy access to and from the meteorological platform and foredeck container locations for personnel power and data connections.

A minimum area of 25m^2 is required each. A clear deck to deckhead height of at least 2.1m is required.

The space shall accommodate at least 2 scientific work stations.

A full height 19" instrument rack with resilient mounts shall be included to house instrumentation such as the Wave Recorders items R7.42 & R7.45 and the pCO2 System R7.69.

An additional full height 19" instrument rack with resilient mounts shall be included to house user's own instrumentation.

Bench tops (inclusive of the workstations) aggregating at least 5m in length are to be provided including a sink. Bench top height shall be 720mm. The top shall be laminate faced with inserted Stauff rails. Sacrificial tops to be provided.

Sink shall include a s upply of pumped seawater from non-toxic inlet for underway sampling.

A clear bulkhead length, deck to deckhead, of 1m is required for electrical, scientific wiring and special junction boxes.

A clear bulkhead, deck to deckhead, of length 1.5m is required for temporary installation large items of instrumentation.

Easy transfer of compressed gas cylinders on/off ship, and easy replacement of in-use cylinders at lab during cruise

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Stauff rail systems are to be fitted to all bulkheads and deckheads.

A glanded duct shall be required to lead laboratory gases in pipes/tubes to this laboratory from stowage within the Mooring Deck or Heli Hangar.

Data cabling and small bore plastic piping, both permanent and temporary shall be led via trunking from the space through the covered mooring deck space to firstly a goose neck on the deck over next to the container stowage area and secondly up though the deck into the meteorological platform support structure and thence to a gooseneck on the platform itself. The trunking shall be typically of 125mm diameter with liberally placed access points or gaps to allow temporary cabling to be easily installed/ removed.

2 laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

Power and network points shall be provided

Floor-to-ceiling 19-inch racks (with movable shelves) shall be provided for installation of user kit during cruises – easy access power points to rear and lots of network points (a 16 or 24 way network switch installed in each the rack would be useful)

Deck matrix shall be installed for fixing at floor level for gas standards etc

Easy access to compressed gas cylinders (ideally with racks close by outside lab) shall be provided

6.2.11 Dark / Photo Room

R6.103 A small totally light sealable laboratory required for photographic work and bio-luminescence observations shall be located on the Main Deck.

The laboratory shall be totally enclosed within steel bulkheads which are fully welded and fitted with the necessary fully welded keyhole plates to ensure light tightness. The door would be best provided as a GRP weathertight type which can be dogged closed and made light tight. All bulkhead penetrations are to be sealed light tight.

Air conditioning and ventilation shall be provided from the central system and it must be light tight.

A minimum area of 8.5m^2 is required. A clear deck to deckhead height of at least 2.1m is required.

The space shall accommodate at least 2 scientific work stations.

Bench tops (inclusive of the workstations and a sink) aggregating at least 6m in length are to be provided. Bench tops height shall be 900mm, and they are to be laminate faced with inset Stauff rails. Sacrificial tops to be provided.

Stauff rails are to be fitted on the bulkheads and deckhead.

A clear bulkhead length of 1m^2 is required for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities shown in *R6.288 Schedule of Electric Sockets.*

An indicator light system shall be provided immediately outside the lab to show when the lab is in use.

Two laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.12 Salinometer Room

R6.104 This laboratory shall be located on the Main Deck close to the Clean, Controlled Environment and other laboratories.

The salinometer room shall be fitted with and correctly installed mounted on a worktop two salinometers (R.7.31) and samples to be tested shall be held in racks in order to stabilise to the room temperature.

The absolute value of the room temperature is not critical between certain limits, 15 - 25ºC, However, whatever the temperature, it shall not vary more than ±1ºC while sample stabilisation and testing is taking place. The room shall therefore have its own climate control air handling unit with suitable controls in order to achieve the desired result.

A minimum area of 13m^2 is required. A clear deck to deckhead height of at least 2.3m is required.

The space shall accommodate at least 2 scientific work stations.

The Salinometer room shall have at least 3 wired ethernet ports.

The salinometer room shall have a means of monitoring displaying and recording the laboratory air temperature shall be displayed in the lab and be able to be recorded in the ship data system.

Bench tops (inclusive of the workstations) aggregating at least 5m in length are to be provided including a s ink. Bench top height shall be 720mm. The tops are to be laminate faced with inset Stauff rails. Sacrificial tops are to be provided.

Shelving shall be provided to safely store sample crates, 12 nos. each sized 250mm x 200mm x 400mm.

A clear bulkhead of 1m^2 is required for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

A bulkhead cable penetration (Type defined by boundary requirements e.g. Roxtech) is required to allow temporary cables to be r un from this laboratory to the other laboratories,

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Stauff rails are to be fitted to bulkheads.

A matrix bolting system shall be fitted, 2.5m^2 at 500mm spacing.

Three laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.13 Uncontaminated Seawater Laboratory

R6.105 The Uncontaminated Seawater Laboratory shall be located on the Upper Tween Deck close to the uncontaminated sea water pump room so that distance to the pumps is minimised and with easy access to the wet / deck / clean laboratories. The main supply piping from the pumping station shall pass closely to or ideally through the space so that tappings can be taken directly from the lines for sampling purposes.

The room shall be accessible from the laboratory areas without passing through any machinery or ship service or accommodation spaces.

A minimum area of 10m^2 is required. A clear deck to deckhead height of at least 2.1m is required.

The room shall have similar temperature control specification to that of Controlled Temperature Laboratory.

Spark free refrigerator shall be fitted, see 7.37,

Chemical locker shall be fitted

Fume hood to be fitted.

The space shall accommodate at least 2 scientific work stations.

Bench tops (inclusive of the workstations) aggregating at least 5m in length shall be provided.

The bench top material shall be HDPE and the supporting framework shall be powder coated stainless steel. The sacrificial tops are to be marine ply inserted between the lips. Bench height shall be 720mm.

A stainless steel sink shall be provided with stainless steel splash-backs as necessary. Sink to be fitted with laboratory style taps.

Flooring shall be heavy duty vinyl.

Bulkhead cable penetrations (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this laboratory to; the clean seawater pump room and the other laboratories via installed ductwork.

A clear bulkhead length, deck to deckhead, of 1m is required for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Stauff rail systems are to be fitted to bench tops and bulkheads.

2 laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.14 Underway Instrumentation Control (UIC) Room for Scientific Control

R6.106 The UIC Room shall be located aft of the Science Hangar, with a clear view aft over the Working Deck, Side Deck and inside the Science Hangar including moonpool.

A minimum area of 55m² shall be provided

This section shall contain the Winch / CTD Operations and hydrographic suite Control Console (See R7.21 and R7.22), multi-functional data display monitor, cupboards and book shelving for manuals and reports.

Portable benches, 4 nos. 1.5m x 1m, are also to be provided for attachment to the bolting matrix. This will allow different configurations of benching dependent on the task requirements (e.g. a plotting table).

Scientific winch and over-side lifting equipment control shall be provided in the UIC Room

It shall have unimpeded views of the aft and side working decks including the full length of the starboard bulwarks and the deployment positions and outboard sheave blocks of all over-side lifting equipment. Ideally views of all wire and sheave runs to over-side lifting equipment shall be arranged including those on the hangar top.

It shall be spacious enough for at least 4 people to be accommodated for working and observing activities i.e. 4m^2 clear floor area excluding consoles.

It shall be equipped with all necessary controls and readouts for the effective and safe operation of the equipment with control appropriate consoles overlooking both aft and starboard deployment positions. Portable winch controls for self-contained winch packages shall be accommodated.

Ship's and Winch room CCTV monitor and a data slave link into the Wheelhouse IBS shall be provided.

It shall be fully air conditioned and equipped with communication arrangements and slave data and CCTV displays duplicating those provided in scientific laboratories. Echo sounder and Sonar repeaters shall be provided.

All windows shall be fitted with fresh water washing, full cover parallel action wipers and to be heated.

All window washing and wiping units, both inside and outside, shall be eas ily accessible for maintenance during seaway operations when no craneage or access platforms are available.

The window arrangement shall be orientated to maximise the clear viewing of the main work areas. Consoles shall be located and orientated towards the equipment being controlled.

Power supplies and Ethernet sockets shall be provided

The space shall be well lit with dimmable lighting.

All windows shall be fitted with anti-glare roller blinds (e.g. clear Mylar material with reflective outer coating).

The deck in the work station areas shall be fitted with a bolt down matrix, similar to that used in the laboratories. Stauff rails, similar to the laboratories, shall be fitted to bulkheads in the work station area.

6.2.15 Data Suite

R6.107 A Data Suite with an area of at least 55m^2 shall be provided. Windows shall be provided in the external bulkhead, in addition to providing a view to the Science Hangar and aft to the Working Deck.

The space is to accommodate at least 6 scientific work stations

Bench tops with laminate facing inset with stauff rails are to be provided at 720mm height. A total length of about 16m is required (including workstations). Sacrificial plywood panels are to be fitted to the Stauff rails.

Storage drawers and cupboards shall be arranged.

A data display system shall be installed utilising one of the internal walls.

Space must also be allowed for free standing equipment (e.g. A0 plotters)

Space must be allowed for a scanner and A3/A4 printer with appropriate storage for a local number of spares (paper and replacement cartridges)

A chart table 2m x 2m (with light) with chart draws underneath is required (large enough for a full size hydrographic office navigation chart), preferably as an island bench (or with only one side against a bulkhead).

A deck matrix at 500mm spacing shall be provided over maximum allowable area to allow equipment tie downs.

A clear bulkhead length, deck to deckhead, of 1m is required for electrical, scientific wiring and special junction boxes.

Various electrical power socket outlets with approximate quantities are shown in *R6.288 Schedule of Electric Sockets.*

Network solution required, gland to hanger and deck lab/main lab

Lighting shall be diffused to prevent screen reflections and to be split into two switchable levels.

Bulkhead cable penetrations (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this room to; the UIC, deck Laboratory and the server room along with open cable trays (2 to each room).

Office style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.16 Gravity Meter Room

R6.105 The room shall have a space of minimum area 7m^2 shall be provided as close as possible to midship and the normal load waterline. The location shall be free from noise and vibration as far as is possible.

The entry door shall be at least 1m wide.

The deck shall be fitted with a bolting matrix and a fabricated wooden plinth 1200mm x 1500mm x 150mm thick attached to the bolting matrix to carry the Gravity Meter unit (NERC supply) and other items such as the Motion Reference Unit (MRU) (See Item R7.43). Clean supply 50-60Hz 110V – 140V

The space shall be fully air conditioned

6.2.17 Science Electronics Workshop and IT Workshop

R6.109 These shall be a clean dry spaces.

This shall be located close to the Date Suite such that equipment can be readily repaired, modified, re-built, tested and calibrated.

It shall have an area of at least 11m^2 and 8m^2 respectively with a deck to deckhead height of at least 2.2m.

It shall have at least three work stations.

Racks shall be provided to stow aluminium boxes each 400 x 400 x 600mm.

Bench tops (inclusive of the workstations) of height 720mm and aggregating at least 6m in length with rubber mat working surfaces are to be provided. Lockable drawers are to be provided under the work bench. Two 4 inch engineers' vices are to be provided.

Two large lock able tool cupboards are to be provided.

Heavy wooden boards are to be provided on the compartment walls for mounting plastic storage bins and tool racks.

At least 4 heavy duty metal 230V (2 nos. 32A, 2 nos. 16A) power sockets are to be provided in addition to 18 - 230V domestics outlets and 10 – 110V, 60Hz outlets. 2 power tools outlets to be provided.

An extractor fan and a hood shall be provided for removing fumes generated by soldering work over one work station position.

A common earth rail shall be provided over the bench tops.

Suitable lighting shall be provided for both general illumination and close up detailed work at the work stations.

Bulkhead cable penetrations (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this workshop to other laboratories all via installed ductwork.

3 laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.18 Gas Bottle Store

R6.110 The scientific processes employed on board will require the supply of a wide range of gases.

The space shall be a ventilated steel enclosure with access to the open deck through which bottle exchanges can take place.

A simple transfer system shall allow ease of gas bottle movement into and out of the space and its racks.

Space and clamping arrangements shall be provided for at least 50 ‘ J’ sized bottles.plus up to 10 small ‘X’ sized cylinders (NOTE: different letter designations for different gases depending on the gas ‘X’ is Oxygen free nitrogen for example)

A gas leak alarm system (Bridge alarm) is required, see item R7.36. An insulation and ventilation system shall be required to prevent overheating or overcooling of the gases.

Gas tight ductwork out into the alleyways so as to run temporary gas lines form the gas store to the laboratories shall be required from the store into each of the laboratories such that temporary piping systems can be easily and safely installed on a cruise by cruise basis. This ductwork shall be included in the monitoring and alarm system.

The gas store to be provided with a suitable gland, or glands to allow piping of user supplied plastic or metal gas piping for specialist very high purity gases, and standard gas mixtures, that shall be required to be run from the central gas store to any of the scientific laboratories. These shall be fitted when required on a cruise to cruise basis.

One of more glands may be required to run these lines to the various labs. Corridor tray runs to be fitted so as to easily run user provided gas lines along and then to have suitable glands to pipe into the laboratory spaces.

Corridor trays to be provided to easily route the gas lines out from the gas store along corridors and then ducts/vents to route the gas lines into the individual labs.

6.2.19 Scientific Laboratory Structural and Outfitting Standards

R6.108 The following standards Scientific Laboratory Structural and Outfitting shall be followed:

General

NERC will consider alternatives which, through the use of modern materials and production techniques, offer improvement with regard to robustness, durability, and cost effectiveness.

In the unlikely event that any of these standards create a c onflict with the requirements of the Classification and Surveying Authorities then the requirements of the latter will generally apply. In such event however it shall be brought to the immediate attention of NERC who will discuss the issues with the Classification and Surveying Authorities directly.

Scientific laboratories shall be designated as 'wet' or 'dry' spaces.

A 'wet' space shall be designated as such when it has direct access to an open deck and/or when the scientific activities will have the potential to introduce water to the space under normal operations.

A 'dry' space shall be all other spaces.

A 'Controlled Atmosphere' space shall be designated as such where special arrangements are made to control the temperature and/or humidity of the space independently of the main air conditioning system. It shall be a 'wet' or 'dry' space.

Boundary Design & Preparation

Unless otherwise required by Rule all scientific laboratory boundaries shall be steel equivalent to at least Shipbuilding Standards A0. This is to ensure the principle of sealed boundaries to prevent cross contamination between specialist laboratories.

Cable penetrations shall be sealed or unsealed considered on a case-by-case basis to the requirements of NERC.

The boundaries shall be suitably stiffened and supported to prevent noise and vibration.

Boundaries which are Subject to External Ambient Atmospheric Conditions on One Side:

- Shall be of Classification Society approved and inspected ship building steel shot blasted to SA 2.5 and coated with shop two-pot epoxy primer prior to construction.
- Shall be of steel plate thickness as defined by the Classification Society Rules for Construction but nevertheless subject to a NERC minimum of 4.5mm SHALL NOT to be stiffened by swedge type stiffening
- Shall be fitted with stiffeners, girders, brackets, stringers and all welded attachments fully welded on all sides and returned at the ends at all the joints with the plating.
- Where structural requirements do not demand full welding a seal weld, to prevent long term corrosion in the joint, shall be applied in any event.
- Shall be stripe coated with a two-pot epoxy shop primer at all welds after fabrication

- Shall be coated internally & externally.

- Shall be insulated suitably for the requirements of the external ambient conditions combined with the requirements for internal atmospheric control and efficient, cost effective operation of the air conditioning system
- Insulation is to be:

  - A NERC minimum thickness of equivalence to 50mm mineral wool bats.

  - Substantially attached, suitably for a 25 year life, and be properly and completely vapour sealed to prevent internal condensation occurring on the steelwork exposed to external conditions. Vapour seal to be continuous over entire boundary with all edges and joints fully taped. Insulation and vapour seal to be continued inboard at least 300mm at all intersections with internal boundaries. Insulation on external bulkheads to be stopped a maximum of 50mm above steel deck and vapour seal edge to be taped to external boundary. In any event adequate drainage of the steel-to-lining void, utilising continuous steel gutter bars, shall be provided at each deck level down to the bilge.

  - Subject to thickness/density adjustment where timber sheathed decking might be applied on top of the deckhead plating, due account being taken of its insulating properties.

  - Properly sealed and finished around any penetrations of the underlying bulkhead. Any modifications affecting the integrity of the insulation carried out after primary completion shall be made good in accordance with the above.

  - Integrated with and be made compatible with the requirements of the Structural Fire Protection requirements as they might apply.

Boundaries Internal to the Vessel Superstructure of Hull:

- Shall be of Classification Society approved and inspected ship building steel shot blasted to SA 2.5 and coated with two-pot epoxy shop primer prior to construction.

- Shall be of steel plate thickness as defined by the Classification Society Rules for Construction but subject to an NERC minimum of 4.5mm

- Shall be stiffened by swedge type stiffening

- Shall be fitted with stiffeners, girders, brackets, stringers intermittently welded on all sides providing they do not form a boundary to a designated 'wet' space on the stiffener side. Where structural requirements do not demand full welding in a 'wet' space a seal weld shall be applied.

- Shall be stripe coated with a two-pot epoxy shop primer at all welds after fabrication

- Shall be left only shop primed at 'Dry' space boundary bulkheads.

- Shall be coated with 2 coats of top-coat at 'Wet' space boundary bulkheads and at 'Controlled Atmosphere' space boundary bulkheads

- Shall be insulated in 'Controlled Atmosphere' laboratories for the requirements of the external ambient conditions combined with the requirements for internal atmospheric control and efficient and cost effective operation of the air conditioning system.

- Insulation is to be:
  - A NERC minimum thickness of equivalence to 50mm mineral wool bats
  - Substantially attached, suitably for a 25 year life, and be properly and completely vapour sealed to prevent internal condensation occurring on the steelwork exposed to external conditions. Vapour seal to be continuous over entire boundary with all edges and joints fully taped. Insulation and vapour seal to be continued at least 300mm past all intersections with boundaries. Insulation on bulkheads to be stopped a maximum of 50mm above steel deck and vapour seal edge to be taped to boundary. In any event adequate drainage of the steel-to-lining void shall be provided at deck level.
  - Subject to thickness/density adjustment where timber sheathed decking might be applied on top of the deckhead plating due account being taken of its insulating properties.
  - Properly sealed and finished around any penetrations of the underlying bulkhead. Any modifications affecting the integrity of the insulation carried out after primary completion shall be made good in accordance with the above.
  - Integrated with and be made compatible with the requirements of the Structural Fire Protection requirements as they might apply.

Outfitting
Deck coverings
All necessary fittings and fixtures to be welded to the deck plating shall be in place before applying the deck coverings. NO penetrations shall be made of the steel deck with screws, bolts or other such fittings for the attachment of outfitting items and equipment.

Immediately before applying deck coverings the deck plating shall be thoroughly cleaned, degreased and any weld scabs or scars ground flush.

After cleaning one coat of compliant primer to be applied all over

Wet Spaces
In designated 'Wet' spaces, excepting the Water Sampling Room (See below), the deck shall be levelled using a rubberised compound, e.g. Durastic or equivalent, of minimum laid thickness at any point 10mm. The compound shall be coved up at the floor boundary in a 50mm radius.

The final covering in 'Wet' spaces shall be 3mm thick heavy duty vinyl sheet flooring with a non-slip finish, exemplar would be Armstrong Altro. All seams shall be fully welded.

At the floor boundaries the vinyl sheet flooring shall be coved up the boundary with a 50mm root radius and an extension up the boundary of 150mm above the deck.
At penetrations (e.g. furniture plinths) the vinyl shall be tightly fitted, coved up, welded at corners, glued in place, and sealed with silicon rubber compound.

Flooring adhesives shall be approved for type and chemical content by NERC. Long term leaching of solvents can compromise the results of scientific analyses.

The top edge of the coved vinyl sheeting shall be sealed to the boundary linings by a stainless steel profile bedded in clear silicon rubber compound and screwed to the boundary using stainless steel screws.

At doorway coamings the vinyl shall be coved as described above.

At doorway thresholds the vinyl shall be tightly fitted and bedded/sealed with silicon rubber compound.

Dry Spaces
Shall be as above but would be acceptable without the coving at the boundaries in which case the Vinyl sheeting to boundary joint to be finished with a 100mm high timber skirting board bedded in silicon rubber to seal against wash down water. Patent skirting systems shall be considered but screwed and polyurethane varnished tight grain hardwood has been found to be the most durable.

Hangar
The deck of the Science Hangar shall be timber sheathed and prepared flush with the starboard side deck.

The deck shall be thoroughly cleaned and degreased and shot blasted. It is then to be hot metal sprayed with a suitable anti-corrosive material. The whole area shall be protected from wind and rain during the process and the atmosphere temperature controlled where necessary.

The timber shall be a minimum of 65 mm thick and shall be of properly prepared close grained hardwood, equivalent or better, well-seasoned, free from sap, shakes, warps and other defects and shall be reasonably free from knots. All wood shall be impregnated with anti-pest and anti-rot composition.

It shall be attached using recessed deck studs, washers and nuts and the recesses filled with wood plugs glued in place.

The whole deck shall be sanded smooth on completion of the fitting and before caulking.

The timber shall be laid on a resilient waterproof sealing compound and shall be caulked and sealed with a modern resilient caulking compound (e.g. Sykaflex). The timber shall be laid under totally dry conditions. The timber itself shall be maintained in a totally dry condition before laying.

The deck area and any cut-outs around deck attachments shall be fitted with steel coaming bars welded to the deck and filled with Sykaflex. Drainage gutterways shall be provided as necessary at the space boundaries.

Laboratory Deck Matrix
Certain laboratories and UIC Room shall be equipped with areas of bolt-down matrix for the securing of equipment.

A matrix will have bolting sockets pitched at 500mm x 500mm. The socket units shall be steel round bar, 75mm long, 30mm outside diameter with a blind tapped hole 25mm deep to take an M12 bolt. Each socket shall be supplied with a bronze M12 grub screw with a screwdriver slot or hexagonal socket (Allan key). The grub screws shall be fitted using a suitable anti-seize compound. e.g. Copperslip.

The primary loading of the bolting matrix is shear parallel to the deck. ‘Pull out’ or compression loading shall be taken as 2 tonnes.

The sockets shall be fully welded into the deck plating with the requisite extension above the deck to be flush with the final deck covering position.

All sockets shall be tested to the requisite pull-out loading and a certificate supplied.

Linings
Bulkhead lining panels shall be fitted to substantial galvanised or stainless steel grounds welded to the structure. The system shall be based upon a sandwich of vinyl coated steel sheeting, minimum thickness 1mm (excluding coating), enclosing a core of mineral wool. An equivalent to mineral wool would be considered but must be approved by NERC.

Typical sound attenuation of 30dB for a panel thickness of 50mm is required or as necessary to achieve the noise requirements. The system shall be of an approved type by the Surveying authorities. Panel widths shall not exceed 600mm. Panel joints to provide substantial stiffness and a tight seal.

Deck Head Linings
The type and configuration of the deck head lining material will depend upon the chosen air conditioning arrangements and the structural fire protection arrangements.

It shall be durable, easily cleaned, easy to remove and replace without damage.

The deck head must be flush throughout. It is to incorporate a Stauff rail attachment system (where required) throughout pitched at 500mm. All lighting systems, detectors etc. must be recessed flush.

Stauff Rail Systems
Stauff Rails are proprietary equipment and piping support system which NERC has fitted as standard throughout the fleet onto which scientific equipment can be mounted in laboratories and working spaces.

They shall be of Stainless Steel 316L material throughout.

The rails shall be installed throughout the particular laboratories on all clear vertical surfaces of the linings including above bench tops

The rails shall be bolted through the lining material into steel angle, which is drilled and tapped, mounted vertically behind the lining and welded to the structure. The steel angle pitch shall be a maximum of 1m and the vertical pitch of the rails shall be 600mm starting at 300mm above the deck covering.

The rails shall be arranged with a suitable number of toggle bolt insertion notches and each rail shall be supplied with 2 toggle bolts per metre run.

The rails are also to be incorporated in all bench tops except where otherwise stated.

Work Stations and Bench Tops
General
In general all furnishings shall be of robust construction, waterproof, and high impact resistant finish to withstand the rigours of hard use over the life of 25 years.

All hardware shall be metal, no plastics shall be used. Brass, anodised seawater resistant aluminium or stainless steel would be acceptable. Draw handles shall be of smooth profile to prevent injury.

All glues and adhesives shall be waterproof marine grade but shall be chosen for fast curing abilities without continuous leaching of solvents over extended time which may interfere with scientific measurements.

All woodwork, inside or out, open to atmosphere shall be sealed with at least two coats of polyurethane varnish.

Chipboard and MDF materials are not acceptable and if found shall be rejected. In general all timber based materials shall be solid seasoned tight grained hardwood, veneer or laminate faced marine grade block board, or high grade multi-ply (5 ply minimum) marine plywood.

Facings shall be wood veneer (1mm minimum thickness) or Laminate (Perstorp or Formica) on doors and drawer fronts and bench/table tops shall be finished with Laminate (Perstorp or Formica) and finished with a close grained hardwood edging surround shall be fitted of at least 8mm thickness glued and screwed in place.
Colour schemes shall be defined by NERC.

Workstations
These shall be incorporated under continuous bench tops which shall be at the standard heights shown on attached SKETCHES 1 & 2.

A workstation will consist of a kneehole 600mm wide flanked on either side by 600mm wide pedestals containing storage rack on one side and a drawer with cupboard under on the other side. These are mounted on a recessed plinth 100mm high up which the flooring material is coved.

The pedestals, carcasses and drawer framing shall be constructed from tight-grained hard wood or marine grade plywood as described above. Panels shall be of marine grade plywood or marine grade block board. MDF and Chipboard are not acceptable.

The storage rack shall be fitted with lashing points for retention of boxes typically 600mm x 500mm x 400mm high.

If laminate facing is utilised a close grained hardwood edging surround shall be fitted of at least 8mm thickness glued and screwed in place.

Drawers shall be fitted with smooth handles, mortice locks and separate storm clips.

The kneehole shall be fitted with storm rails at the front and at 500mm from the front so that they can be utilised as storage as necessary.

Securing points shall be provided at each workstation to enable lab chairs to be temporarily fixed in position and still retain their use in rough weather. These securing points shall be generic and part of a ship wide securing system for fixing loose furniture in rough weather. A system utilising adjustable chains with hooks and fixed eyes or sockets in the deck (flush with deck covering) and on the furniture, would be acceptable.

Bench Tops
They shall be at a standard height above floor (see SKETCHES 1 & 2) and have a front to back width of at least 700mm and no more than 800mm except where otherwise stated by NERC.

Unless stated otherwise, these shall be constructed from marine grade plywood of thickness suitable to allow the recessing and attachment of Stauff rails. To achieve this two laminations of plywood shall be required

Stauff rails shall be flush with the top surface bedded and sealed flush with silicon rubber compound. The first rail shall be mounted 100mm from the front edge of the bench top and the second parallel to it at 600mm from the front edge. Toggle insert notches shall be provided at 1m spacing. Two toggle bolts per metre run of rail shall be supplied. At each end a 50mm length of rail top flanges shall be removed to facilitate cleaning.

The bench tops shall be faced on top with a heavy duty acid and solvent proof laminate at least 1.5mm thick. Tight grained hardwood edging, at least 8mm thick shall be fitted on open edges glued and screwed in place.

Where indicated by NERC, bench tops shall be constructed from an inert plastic such as High Density Polyethylene (HDPE), provided with a 15mm save-all lip around their extremities.

Where the bench top abuts linings or furnishings a 100mm depth finishing board of wood or inert plastic as appropriate shall be fitted.

Bench tops are to overhang the supporting furnishings by 25mm and all protruding corners shall be radiused or chamfered.

Temporary bench top plywood panels, 15mm thick, shall be provided in 1.4m length sections to cover all the bench tops and sinks. These shall be coated with two coats of polyurethane varnish. These shall be bolted to wooden bench tops using the Stauff rails and fitted tightly between the save-all lips for HDPE bench tops, such that equipment can be screwed to these without damage to the permanent bench tops.

Where indicated by NERC Workstations shall be equipped with a reduced bench top height in way of the kneeholes to accommodate microscope work. The height shall be 650mm above the deck from front to back. A section of standard height bench top folding backwards and clipped to the bulkhead shall be arranged to reveal the recess when required.

Cupboards and Storage Sections
Between and outside the allocated positions of workstations the space under the bench tops shall be divided into cupboards and stowage recesses.

The cupboards shall be of similar construction to the drawer pedestals with one or two doors equipped with mortice locks and bolts. Lower and one intermediate full depth shelves shall be fitted. Cupboards shall be a minimum of 500mm wide and a maximum of 1000mm wide.

Storage recesses shall be similar to knee holes and shall be fitted with removable storm rails across the front and two small lashing pad eyes towards the rear of each recess, allowing items to be safely stowed under the bench tops.

Under bench storage shall be available for zarges of dimensions of 600 x 400 x 300mm which is standard small box

All drawers shall be fitted with a robust and positive means of holding them closed in a seaway

Sinks
Various laboratories will contain sinks.

Sinks are to have the following standard dimensions: Length front to back 600mm, breadth 700 and depth 500mm.

Where indicated by NERC, sinks shall be stainless steel (SS316L). They shall be incorporated into a stainless steel sink top unit which will overlay the bench top structure. This is to provide draining sections to 1m either side of the sink or sinks, a raised square save-all lip along the front edge 20mm high, a splash back to 500mm above the bench and side splash boards at each end from front to back also to 500mm above the bench top. The side splash boards shall be properly supported and free from sharp edges.

All corners shall be generously rounded for personnel protection and all welds ground smooth.

A similar double sink with a 2m long draining section on one side and 1m long on the other shall be provided in the Deck Workshop.

Where otherwise indicated by NERC, sinks shall be fabricated or fabricated or moulded from an i nert material such as High Density Polyethylene (HDPE) and recessed into the bench top. An HDPE or equivalent splash back shall be fitted to the rear bulkhead to 500mm height and extending 250mm either side of the sink unit.

Temporary bench top plywood panels, 15mm thick, shall be provided to cover all the sinks. These shall be constructed to securely fit each sink and coated with two coats of polyurethane varnish.

Overflow and drains shall be fitted with removable sump type traps immediately below the sink to allow easy cleaning. In the Deck Laboratory, Constant Temperature Laboratory, Clean Chemistry Laboratory the sump type traps shall be of large capacity, at least 10 litres each, and shall be easily removable for cleaning.

Where indicated by NERC, HDPE sinks to have adjacent drainer of the same material as the sink, minimum length 1050mm, for mounting of Millipore unit(s) above.

Bulkhead area above drainer to full height shall be clear of all fixtures and electrical equipment. Two 230V 13A clean power outlets shall be provided at high level adjacent to the drainer area.

All sinks shall be fitted with metal hardware and rubber plugs. Fittings shall be internationally recognised standard type. No push fit systems shall be used

Port Light Boxes
The laboratories shall be fitted with fixed portlights of minimum 350mm glass diameter.

Port light boxes shall be arranged in the linings to allow proper dispersion of light. The boxes are to provide an insulation of the external steel as far as possible and a vapour barrier. They shall be waterproof and shaped to allow drainage of the inevitable condensation to an integral save-all.

Roller type blackout blinds shall be incorporated within the box. No curtains shall be fitted.

Doors
Doors shall be in accordance with the structural fire protection requirements. They shall be lockable and shall be included on the master lock system. Doors sills shall be of minimum height and wherever possible flush with the floor coverings (low height ramping would be acceptable).

Doors to science spaces shall in general have a fixed portlight of 300mm diameter.

Lighting
Lighting shall be provided throughout the space by recessed flush light fittings in the deckhead linings. These shall be of LED where practicable type and must be arranged and sized to provide a lux level on the bench tops of 500 lux with the port light blinds and doors closed. Undue shadowing shall be avoided.

The lighting shall be on multiple circuits so that individual light units can be switched off as desired.

Emergency maintained units shall be incorporated in the lighting arrangement.

Power Sockets
Double pole switched power sockets shall be provided for 3 types of supply:

- 230V, single phase, 50Hz, ship's domestic supply - 1 or 2 nos..if per space as necessary primarily utilised for cleaning machines.

- 230V, single phase, 50 Hz clean supply - 6 nos. in groups over work station benches and spaced at 1.5m intervals otherwise around the space.

- 110V, single phase, 60Hz, clean supply – 1 over work station benches and spaced at 1.5m intervals otherwise around the space.

Sockets shall be set at least 100mm above the bench tops.

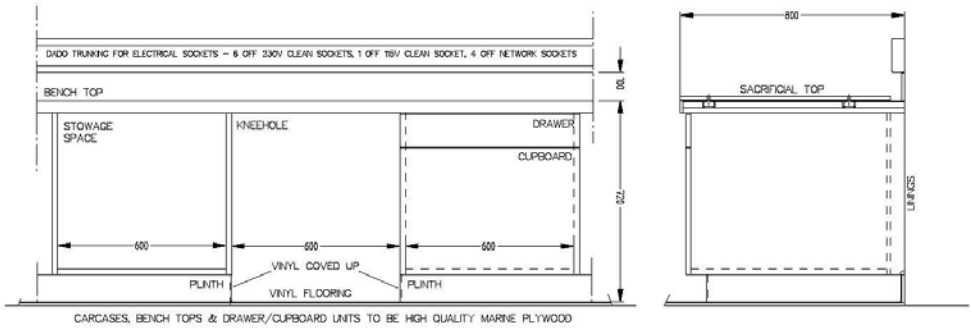
Continuous dado rail trunking shall be used for the sockets incorporating suitable circuit protections and allowing positional changes to be made as necessary later on.

Where bench tops are not adjacent to bulkheads the power sockets shall be mounted on brackets suspended below the deckhead lining above the centres of the bench tops, such that the height from the finished floor covering to each socket is no more than 1.7m.

230V, 50Hz sockets shall be type G (UK standard 3 pin, BS1363), colour coded for type of supply.

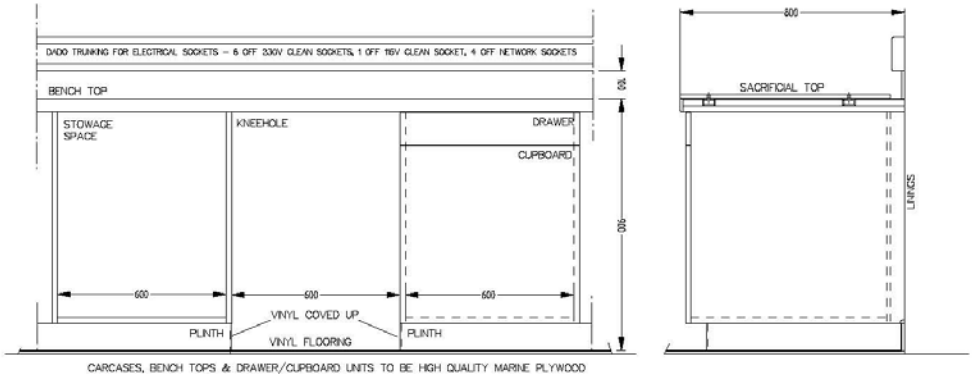
110V, 60Hz sockets shall be type B (USA 2 flat and one earth pin)

All sockets shall be double pole switchable locally.



CARCASES, BENCH TOPS & DRAWER/CUPBOARD UNITS TO BE HIGH QUALITY MARINE PLYWOOD

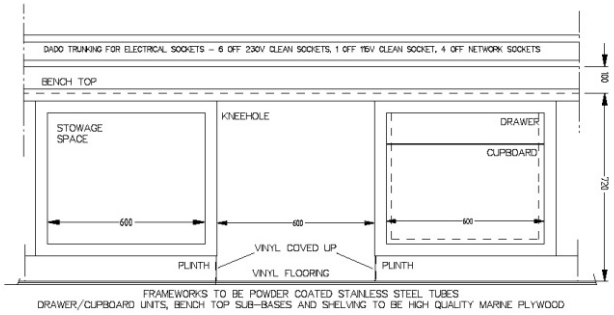
COMMON WORK STATION LAYOUT FOR;
MAIN LABORATORY
COMPUTER ROOM
SERVER ROOM
METEOROLOGICAL LABORATORY
SALINOMETER ROOM

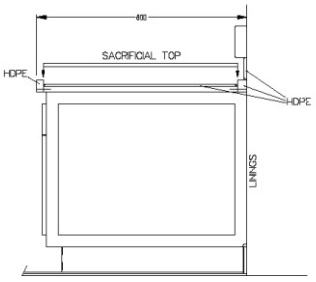


CARCASES, BENCH TOPS & DRAWER/CUPBOARD UNITS TO BE HIGH QUALITY MARINE PLYWOOD

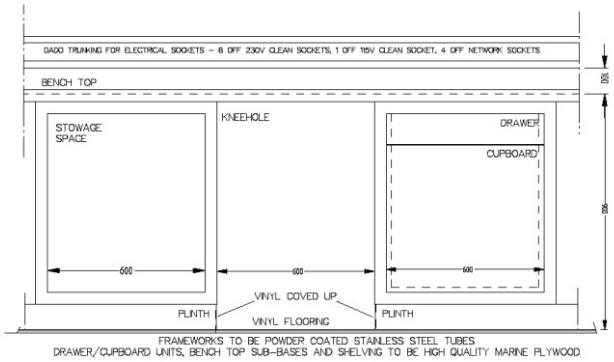
COMMON WORK STATION LAYOUT FOR;
DECK LABORATORY
ELECTRONICS WORKSHOP
GENERAL PURPOSE LABORATORY

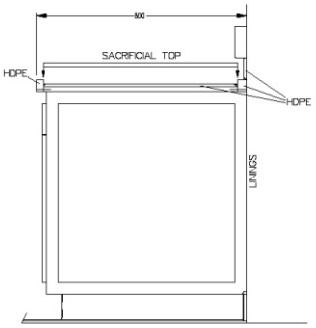
SKETCH 1





COMMON WORK STATION LAYOUT FOR;
CLEAN SEAWATER LABORATORY





COMMON WORK STATION LAYOUT FOR;
CLEAN CHEMISTRY LABORATORY
CONSTANT ENVIRONMENT LABORATORY

SKETCH 2

6.2.20 Displays and Control Consoles (See R7.21)

R6.112 Displays and controls (e.g. swath bathymetry, bottom mounted equipment, ADCPs, Biological Echo Sounders, Winch Controls & Monitoring and CTD) are to be gathered into two sets of racks so that instrument outputs can be easily seen by all persons in the laboratory and managed by specialists working at a console at the face of the racks.

Local deckhead lighting shall be separately controlled.

6.2.21 General Lighting and Bulkhead Penetrations

R6.113 Lighting shall be switchable in groups of no more than 4 units spaced throughout.

Various electrical power socket outlets with approximate quantities are shown in R6.288 *Schedule of Electric Sockets.*

Bulkhead penetrations for cables and temporary gas lines (Type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run between laboratories and to from the science hangar and working decks including, Wet Laboratory, Deck Laboratory, Controlled Environment Laboratory, Core & Sample Chill Store, Main Laboratory, Science Laboratory / Store, Uncontaminated Seawater Laboratory, Atmospheric Science Laboratory, Aerosol Laboratory, Clean Laboratory, Wheelhouse, Electronics Space, Sensor Space, Data Suite, UIC Room (2), Server Room (2) and Salinometer room all via installed ductwork.

6.2.22 Server Room

R6.114 The Server Room shall be suitably located to accommodate the main data acquisition, processing and storage systems.

This shall accommodate a processing system (NERC supply), acquisition system, archiving media and networking facilities

An area of at least 14m^2 is required of dimensions to suit server racking system + spare capacity.

At least 8 x '19 inch' computer/network racks are to be supplied into which the various systems are to be installed and wired into the distribution networks. The racks shall be full height and a depth to accommodate a server style enclosure with ventilation ducts to aid cooling. The racks shall have adjustable rear vertical rails to facilitate the installation of equipment slide rails and with access from front and back

A bench top and work station 1.75m long shall be fitted along with a two tier set of wall mounted book shelves 1.75m long complete with storm rails.

A matrix bolting system shall be provided 1.5m^2 over the whole deck area at 500mm spacing to which rack plinths can be attached.

A clear bulkhead length, deck to deckhead of 2m is required for electrical, scientific wiring and special junction boxes.

Bulkhead cable penetrations (2 type defined by boundary requirements e.g. Roxtech) are required to allow temporary cables to be run from this room to the Laboratories along with open cable trays.

Various electrical power socket outlets with approximate quantities are shown in R6.288 *Schedule of Electric Sockets.*

Air conditioning and ventilation shall be supplied from the main ship system but up-rated as necessary to take into account a 7kW trace heat input. Ductwork shall be provided from each rack in order to ensure proper circulation and heat removal.

The space shall be outfitted in a similar manner to dry laboratories including Stauff rails on the bulkheads.

One laboratory style chair of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.23 Uncontaminated Seawater System

R6.115 The Contractor shall design, supply, and fit clean sea water sampling systems for scientific analysis purposes.

A clean seawater sampling system shall be provided of total capacity at least 40 m³ / hour.

The system shall draw water from the forward end of the vessel via a retractable intake which will protrude 300mm out from the shell plating. The pumps and isolation/shipside valves shall be located close to the intake. A remote temperature sensor (R7.20) shall be installed at the inlet and connected to the closest Scientific Wiring Junction Box

The shipside valve shall be a hand-operated valve but fitted with an extended spindle to above the freeboard deck for emergency closure.

The selected position for the intake shall minimise the potential for drawing air into the pumps and hence shall be as deep as possible but not extending below the keel line.
The pumps (2) shall be Bornemann Twin Screw Non Toxic Pumps Model SLH80-40, including frequency converters to allow control of capacity. Two pumps are required to provide capacity and redundancy within the system.

The intake shall be of flanged and bolted sleeve type, the sleeve being of stainless steel 316L material.

The system shall need to include a filter (5mm mesh) or filters for krill. It shall be possible to isolate the filter for cleaning without draining down the system. The filter chamber shall be of a large size.

The rest of the piping and fitments shall be ABS with the pipework insulated with Armourflex rubber insulation and completely and properly vapour sealed throughout.

The insulation shall be designed and applied so as to maintain the outlet water temperature at the sinks and external valves to within 1°C of the shipside inlet temperature.

The system shall need an air bleed point in the vicinity of the pumps (important that the water is de-bubbled)

A means of flushing the system through shall be required employing a p ump and connection next to the ship side valve whereby fresh water treated with a cleansing agent can be injected and flushed through the whole system including all outlets.

Inspection and testing to the satisfaction of the Classification Society. Sea trials of operation and delivery volumes in accordance with the requirements shall be to NERC satisfaction.

6.2.24 Scientific Low Pressure Compressed Air System

R6.116 The Contractor shall design and fit a low pressure compressed air system for use by the scientific party.

Clean air supplies, at 7 Bar pressure, to all laboratories and containers must be supplied from a dedicated rotary vane air compressor with after cooler, oil eliminator, and duplex heatless dryer installed as close to the Clean Laboratory as practical. A back-up supply must be cross-connected from the ship's control and instrument system.

Air shall be drawn from the external atmosphere at a point where the potential for contamination by, for example, exhaust gases is minimal.

The system shall be distributed throughout the following areas:

• Hangar	2 positions
• All Workshops	2 positions in each
• All Laboratories	1 position in each
• Container Service Points	1 at each laboratory container (2 fwd + 6 elsewhere)
• Aft Working Deck	1 on each Pedestal
• Side Working Deck	2 positions
• Hangar Top (if open deck)	2 positions

Each position must be fitted with 2 bayonet type self-sealing quick connectors. The outlet shall be colour coded to identify it as scientific, not a general service air supply for use with tools.

6.2.25 Scientific Cooling Water Systems

R6.117 The Contractor shall design, supply, fit and test the system in total.

Deck mounted and containerised portable equipment will require cooling water services (See 6.4.20 R6.165).

The Scientific Hydraulic Power Distribution System will also require cooling as will the hydraulic power packs driving over-side lifting equipment and cranes.

The approximate typical cooling water volumes required by NERC provided portable equipment are:

• Deep CTD Winch Container	5 m³/hour
• Winch Container Slot	
• Hydro Winch Container	5 m³/hour
• Winch Container Slot	
• HP Air Compressor Container	30 m³/hour Aft Deck slots
• Mezzanine Deck	
• ROV Power System	5 m³/hour

- Deck Slots Hangar

There will of course be a diversity factor to be applied to these demands since they will not all be operating at once.

The maximum demand predicted would be the aggregate demand of the following equipment:

- HP Air Compressor Containers (4) 90 m³/hour
- Aft Crane power packs Contractor defined
- Temporary Deck Mounted equipment 30m³/hour allowance
- Hydraulic Power Distribution System Contractor defined

The fresh water ring main system shall be fitted with a header tank located well above the highest point in the system. This shall be located inside a structure, e.g. the funnel, to protect it from wind chill factors and freezing. The tank shall be fitted with a low level alarm, a valved filling connection to a local supply of ship's fresh water, a chemical dosing connection and an access/cleaning manhole. The tank shall be connected to the suction manifold side of the fresh water circulating pumps.

All connection standpipes or spur lines off the main ring shall be fitted with isolating valves and a drain valve so that, if not in use they can be isolated and drained down to prevent freezing.

All piping shall be Schedule 40 black steel and valves shall be gate or globe type.

This system shall be completely monitored by the VMS system.

The system shall be operable in the environmental conditions shown the SoR Section 4 earlier.

6.2.26 Scientific Hydraulic Systems

R6.118 A Hydraulic Power Distribution space shall be provided

Distribution Points shall be provided in the following locations:

Two positions on each side of the Aft Working Deck

Two positions at the aft end of the hangar to service HP air containers or machinery containers in the deck slots

One position in the forward part of the Hangar.

One position forward on the Starboard Side Working Deck

Crane power packs

6.2.27 Science Hold & Stores

R6.119 The Science Hold shall be located below the Science Hangar, shall accommodate all manner of shapes and sizes of scientific equipment and stores.

Demountable and flexible means by which scientific equipment can be segregated and stowed safely shall be provided (e.g. pound boarding).

The minimum stowage area of the scientific store (after allowing for ship's oil stores. ship & scientific chemical stores and freezer space) shall be 115m^2.

As stated elsewhere a separate general use loading hatch shall be provided complete with deck coaming and hydraulically operated cover and hand operated clips along with a pallet lifter for transfers up into the hangar.

Four separated storage areas are to be incorporated within the stores space:

- Used chemical Store 4.5m^2
- Segregated chemical store No.1 4.5m^2
- Segregated chemical store No.2 4.5m^2
- Scientific low temperature freezers. 12.5m^2

These are to be of cage constructed from heavy duty steel mesh with a steel coaming plate at least 300mm high all round in order to contain any spillages or leakages. They are to have a suitable sized lockable door.

Steel racking shall be provided in each chemical store.

The spaces are to be fitted with explosion proof light fittings and mechanical ventilation of the scientific store shall be arranged such that air flow through the storage areas will tend to draw any fumes out of the space.

The deck head of the scientific stores shall be thermally insulated with at least 100mm of mineral wool held in place by pins and wire mesh (25mm mesh size) and then sealed with metal sheeting to form protection and a vapour seal.

6.2.28 Scientific (Walk In) Freezer -20ºC

R6.120 A Scientific (Walk In) Freezer -20ºC of at least 8.5m² area shall be installed with similar specifications as other refrigerated spaces elsewhere in this SoR

6.2.29 Lifting Eyes

R6.121 1 Tonne SWL lifting eyes are to be provided at the deckhead spaced usefully on either sides of doorways and along routes:

- From the Hangar into the Deck Laboratory to the matrix of bolting down points.
- From the open deck into the Main Laboratory to the matrix of bolting down points.

The eyes are to be recessed flush to the ceiling lining with due clearance allowance for hand operated chain block units.

Each lifting eye shall be numbered, load tested and a test certificate provided.

6.2.30 Sensor Junction Box Room

R6.122 Most of the sensors are fitted with a signal cable tail which shall pass through a conduit pipe that leads the sounder cables to a convenient position above the waterline. These reduce the risk of flooding in case of a window failing and also act as air vents and filling pipes for the sea boxes.

6.2.31 Science Laboratory / Stores.

R6.123 The Science Laboratory / Stores shall be located on the Main Deck.

This is essentially a dry working laboratory into which samples shall be processed using analytical instruments. It will have versatile and mobile fixtures to enable the laboratory to be easily reconfigured as a science equipment storage area.

It shall have easy access to and from the working deck and the other laboratories and in particular proximity to Main Laboratory.

Stauff rail systems are to be fitted in bench tops, on bulkheads and deckheads.

Entry doors to be double width with clear openings of 1.5m

Island benches shall have all electrical services at deck head height, 230V and 110V outlets.

The area shall have the general working benches and sinks. Storage shall be provided with drawers and cupboards and areas where Zarges boxes (dimensions 600 x 400 x 300mm) will fit. Benches must allow space to be able to be converted with ease into to a storage area with racking to hold equipment.

An area of at least 50m^2 is required. A clear deck to deckhead height of at least 2.1m is required.

One RO system shall be fitted at one sink, R7.33.

One fumehood shall be fitted, R7.40.

Two . fridges and one -20^{0}C freezer shall be fitted under bench top, R7.36 and R7.37.

Four -86^{0}C freezer shall be fitted, R7.37.

One laminar flow cabinet shall be fitted, R7.39

It shall be a multi-role laboratory and be used for science analysing water samples, it shall have 2 sinks in the corners with all services, hot cold and non-toxic water supplies. Lips to front of sink

Laboratory style chairs of robust timber or metal construction with upholstered arms, seats, and backs and fitted with a means of tying down in heavy weather are to be provided. Covering materials are to be heavy duty breathable vinyl type or woven material. Height of chairs shall suit the heights of desks/benches.

6.2.32 Science Office and Research Room

R6.124 An office and research room for scientists shall provided for the scientists onboard the vessel with a minimum area of 22m² and 35m² approximately.

It shall be outfitted with 3 workstation desks, 3 computers, bench tops, cupboards and at least 6 standard 4 drawer filing cabinets, desk chair with arms for each desk, a minimum of 2000mm length full-height bookshelves, notice boards.

‘

A lockable file storage shall be provided in support of the ship’s office.

The room shall have fixed desks, chairs, filling cabinets, large bookshelves for manuals, etc. and at least two P.C. workstations with appropriate power sources and securing arrangements for the computers.

6.2.33 Other Store Rooms

R6.125 A other storage spaces shall be provided complete with racking and shelving. as follows:

Clothing Store - 11m²

Baggage Store - 15m²

Storm Clothing Sore - 5m²

Battery Store - 13m2

The spaces shall include at least 2 double heavy duty metal 230V power sockets.

6.2.34 Deck Workshop

R6.126 This shall be arranged leading directly off the Hangar, with direct access to the Starboard Working Deck

The area of the workshop shall be at least 50m^2.

It shall be comprehensively equipped as a mechanical fitting and welding space with material storage.

Access from the open deck shall be via a double weathertight door having a clear width opening of 1.5m. The lower edge of the door shall bear against suitable height coaming plate which can be un bolted and folded down to provide a smooth transition from and to the hangar using sack trucks, trolleys or pallet lifters. Overhead lifting rails are to be provided servicing each machine tool bench and the welding booth.

The following equipment shall be fitted into this workshop as a minimum requirement. Commonality of suppliers of machine tools with the engine room work shop would be advantageous. The proposed arrangement shall be submitted to the Owners representative for approval:

- Workbench(s) heavy duty steel 840mm high at least 10 m long with steel draws under and 6 inch engineers' vices (minimum 2).
- Centre lathe minimum 250mm swing 1.1m bed
- Turret/Vertical Milling machine with a 900mm bed.
- Pedestal drill deck mounted with variable speed control.
- Electric grinder deck mounted. Coarse and fine grit wheels.
- Mechanical hacksaw 300mm blade with coolant system and vice.
- Band saw 250mm cutting aperture. With coolant system vice and accessories.
- Off cut saw with 12inch abrasive disc deck mounted - with vice.
- 3 and 4 jaw chucks, face plates, steadies, machine vice, basic selection of cutting tools, collets and all safety guards and coolant systems for each of the above machines.
- Hydraulic press 10 tonne capacity
- Hydraulic swaging press for hydraulic hose ends and steel wire terminations. (Facility possibly part of the above press)
- Welding machine 20-250A for stick welding in a welding booth fitted with curtains and an extractor fan plus a steel bench. Standard masks, gloves, hammer, electrode holder plus 20m leads for use on deck. Storage bracket for leads.
- Oxy/acetylene cutting equipment on a cart with hoses, torch, heads and nozzles, igniters, masks, hose reel and provision for secure deck storage within the workshop.
- At least 4 electric safety stops strategically installed around the workshop to stop the machine tools in an emergency.

- At least 10 double heavy duty metal 230V power sockets around the workshop over benches and in user friendly positions.
- Provision for storage of plate material on its side in racks and bar material horizontally on racks.
- Heavy wooden boards for installing tool racks and a plastic bin storage system for consumable items shall be provided in way of work benches
- 6 heavy duty lockable tool cabinets
- Hand wash sink and eye wash.
- Compressed Air Connection

Consideration to be given when arranging the above machine tools to the possible length of work pieces to feed the machines and the provision of roller supports. i.e. a long length of pipe being cut on the band saw will need enough space and roller supports.

A clear bulkhead length, deck to deckhead, of at least 1.5m is required for electrical, scientific wiring and special junction boxes. Large armoured glass or polycarbonate windows are to be provided on external (not ship side) bulkheads. Ship side bulkheads shall be fitted with 400mm portholes with deadlights to provide a good standard of natural light.

A very good standard of lighting (500 Lux at deck level) is required to support detailed working.

Various electrical power socket outlets are to be fitted in accordance with *R6.288 Schedule of Electric Sockets.*

Electric fan heaters are to be provided to maintain the space at 20ºC (with all doors closed) in an ambient temperature of -10ºC.

The deck shall be painted and coated with a non-slip compound. Duck boards shall be provided in way of machine tools.

The open deck area shall be fitted with 8 matrix sockets and screw plugs into which can be screwed eye bolts to be used for lashing equipment being worked upon.

The deckhead shall be fitted with 8 welded eye plates suitable distributed above the working deck area for moving equipment around. The eye plates shall have their SWL defined and if they are to be included in the Lifting Register.

Hydraulic Hose Storage Space

A storage space is required to store readymade hydraulic hoses and fittings for all of the hydraulic machinery on board.

It shall be fitted out with a metal storage cupboard with individual drawers for fittings and seals.

There shall be racking in the form of different size “forks” on which to hang hydraulic hoses vertically. These would be up to 2m long readymade hydraulic hoses, the sizes being from 60mm diameter to 15mm diameter – allow for a total of 50 hoses.

The store is have good lighting and must be lockable.

6.2.35 Rough Workshop

R6.127 A Rough Workshop is required for maintenance of deck equipment (wire terminations etc) with a clean area, welding (electric & gas) and bench to work on.

Glider and mooring maintenance shall be carried out in this workshop so therefore a wet space, which has to be easily cleanable. I shall be fitted with network, power points, deck matrix and stowage of a small ROV (HYBIS)

Rough Workshop shall contain benches and workshop area, also with trolley/small fork lift and overhead rail accessibility from the working deck.

The overhead monorail shall have a c apacity of 3t at SS5. Hoist speed shall be 3m/min, with two speeds available. The rack and pinion drive for the hoist trolley shall have a speed of 5m/min.

NERC Guidance on Design of Safe Laboratories

Version 1.5 **Date of Issue: March 2015**

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 e,g, 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.

Disposable consumables: 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.

Glassware: 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.

Laboratory waste: 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 hi gh 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 s ufficient. 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. H owever, air change rate is a r elatively 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 c alculated on v olume 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 s upplemented 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

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

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 to segregation of cylinders of incompatible gases should be given 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.

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.

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
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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 then they should or strain themselves getting them 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 castors of which there are many types. One design has 'soft' wheels so have a built-in resistance to easy 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)

Inner Plane:

(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;

Robustness test (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 s ecure to prevent misuse of the contents.

8.4 Adequate storage space (e.g. a bu nker 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 t hat any necessary decontamination is carried out.

9.3 **Tacky mats** may usefully be i nstalled 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 pr ovided: it must never be us ed 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.

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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.
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APPENDIX 4

NERC GUIDANCE SAFE STORAGE AND INSTALLATION OF GAS CYLINDERS

Version 1.7 ***Date: March 2013***

BACKGROUND

Gas cylinders are widely used across NERC for activities ranging from providing special gases for laboratory equipment through engineering uses to field and medical applications. The main hazard from gas cylinders arises from the large amount of stored energy they contain due to the pressure of the compressed gas within them. If the pressurised gas is released in an uncontrolled manner this can cause considerable damage. Uncontrolled release and flying particles (including the cylinder itself) can occur from failure of the cylinder or its fittings and may arise if it is involved in a fire or it suffers damage in a collision. Gas cylinders also present a hazard from their contents which, even if not directly hazardous by nature of their flammable, toxic, corrosive or oxidising properties, can still cause an asphyxiant hazard by displacing oxygen. The inherent weight and size of cylinders may also present a physical hazard during transport and manual handling or if they topple.

The main causes of accidents from gas cylinders are:

- *poor storage*
- *poor handling*
- *poor installation*
- *faulty equipment and / or design (e.g. faulty or incorrectly fitted/specified valves and regulators)*
- *poor examination and maintenance*
- *unplanned releases of gas*
- *hidden damage*
- *inadequate training and supervision.*

This guidance is concerned with the storage and installation of gas cylinders. It is not primarily intended to cover their safety when in use or their standards of maintenance, transport or manual handling.

DEFINITION OF GAS CYLINDER

Gas cylinder is the term that is commonly used to describe the portable pressurised container used to store and transport gas but the correct legal definition of a gas cylinder is 'transportable pressure receptacle'. Another term used to describe a gas cylinder is 'gas bottle' but this term is generally frowned upon and is not used in this guidance.

Gas cylinders are generally made of carbon steel, stainless steel, aluminium or a composite (e.g. aluminium wrapped in carbon fibre for lightweight breathing air cylinders). They will contain either a gas at standard temperature and increased pressure (e.g. oxygen or nitrogen); a liquefied gas at standard temperature but increased pressure (e.g. carbon dioxide) or a gas dissolved at standard temperature in a solvent (e.g. acetylene in acetone on an inert matrix). It is also possible to have a pressurised container with a gas that is liquefied at reduced temperature and increased pressure. Such gases are termed cryogenics (e.g. liquid helium) and the containers are commonly termed pressurised dewars. Cryogenics are covered by a separate NERC guidance document.

PERIODIC INSPECTION AND TESTING

Gas cylinders must be manufactured to an appropriate approved standard, of which there are a number according to type of cylinder and date of manufacture. Cylinders will have been examined after manufacture by a relevant inspection body to verify they have been manufactured correctly and conform to the appropriate design standard. The cylinder shall be marked with a stamp or other indicator of the relevant inspection body. Cylinders and valves must be examined at specified regular intervals which are now covered by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG Regs) which implement the European 'ADR' regulations. However, there shall be varying requirements / periods according to date of manufacture, type of construction and application and the Regs which applied. The inspection period is typically every ten years for industrial gases but can be shorter for special cylinders. The body of the cylinder shall be permanently marked by the inspection body to show the date of the last periodic examination. The applicable BS EN standards which lay down inspection regimes are referred to at http://www.hse.gov.uk/cdg/pressure.htm.

Cylinders which have been kept in storage for long periods of time, e.g. exceeding five years, may be out of date for their inspection. This is one of the reasons why cylinders stocks need to be managed and cylinders shall not be kept in storage for extended periods. Stocks shall be rotated in storage to help ensure the oldest filled cylinders are used first. Cylinders that are no longer required shall be returned to their supplier or otherwise safely disposed of. Another reason for not storing cylinders for extended periods is the cost as a rental charge may be in place on supplied cylinders.

MARKING / COLOUR CODING OF CYLINDERS and HAZARDS OF GASES

All gas cylinders must be clearly marked to show what they contain and the hazards associated with their contents. Unfortunately a variety of colour coding systems have been used in the past, which even varied from application to application (e.g. medical / non-medical) as well as from country to country. Cylinders of special gases and mixtures have often been sourced from overseas. The colours shall now be standardised across Europe for medical and industrial gases, although some aspects are optional. The hazard warning colours that shall be displayed across the shoulder on new cylinders (which may be in concentric bands or quarters if more than hazard is possessed) are, in ascending order of hazard:

Inert: ***Bright green***

Oxidising: ***Light blue***

Flammable: ***Red***

Toxic: ***Yellow***

The BCGA Technical Information Sheet TIS6 (based on the relevant BS EN Standard 1089-3 2011) gives the most recent colour coding system for European supplied cylinders. The following table gives a summary of the main categories of gases, their hazards and the warning sign colours. Some gases will exhibit more than one of these hazards e.g. carbon monoxide is both toxic and flammable.

Category	*Hazard Diamond*	*Risk Phrase / Hazard*	*Comments*
Oxidant	*Green and Yellow*	*R8: Contact with combustible material may cause fire* *H271: May cause fire or explosion; strong oxidiser*	*Strongly support combustion but are not themselves flammable e.g. oxygen or nitrous oxide*
Inert	*Green*	*Asphyxiant in high concentrations*	*Do not generally react with other substances but can cause asphyxiation by displacement of oxygen e.g. argon, nitrogen.*
Toxic	*White*	*R23: Toxic by inhalation* *H331: Toxic if inhaled*	*Cause serious health effects on inhalation e.g. carbon monoxide, hydrogen sulphide*
Very toxic	*White*	*R26: Very toxic by inhalation* *H330: Fatal if inhaled*	*Cause very serious health effects on inhalation e.g. death e.g. phosphine, arsine*
Flammable	*Red*	*R12: Extremely flammable* *H224: Extremely flammable liquid or vapour*	*Will cause fire or cause explosion if mixed with oxygen or air and exposed to source of ignition e.g. hydrogen, acetylene*
Pyrophoric	*Red*	*R17: Spontaneously flammable in air* *H250: Catches fire spontaneously if exposed to air*	*If in contact with air can spontaneously ignite e.g. silane*
Corrosive	*White with dissolving hand symbol*	*R35: Causes severe burns* *H314: Causes severe burns and eye damage*	*Causes severe burns and damage to the eyes/ respiratory system if inhaled e.g. Cl_2*
Cryogenic	*Green*	*Asphyxiant in high concentrations and may cause frostbite*	*Causes cold burns but can also displace air as liquid evaporates so causing asphyxiation due to lack of oxygen e.g. liquid nitrogen*

STORAGE / INSTALLATION HIERARCHY

The size and number of gas cylinders in use or storage shall be kept as small as practicable, having regard to the task(s) being performed and the need to maintain supply.

The hierarchy of storage options for gas cylinders is:

- *In a safe place in the open air*
- *In specially designed, dedicated and well-ventilated gas cylinder storage/manifold rooms e.g. with two opposing walls that are 50% open to air*
- *Inside buildings in gas cylinder cabinets (see Appendix A).*

An alternative approach shall dispense with gas cylinders altogether and use gas generators. These are commonly and successfully used to produce hydrogen for gas chromatography and nitrogen for mass spectrometry. Acetylene generators are also available.

Where none of the above is reasonably practicable, the gas cylinder shall be secured in a safe place close to the point of use and removed to storage in one of the above locations as soon as possible after use.

It may not be possible or desirable for storage of cylinders of medical gases or breathing air to be stored in the open air but nevertheless the aim shall be to minimise the number and size of cylinders stored within buildings, allowing adequate ventilation and protection from fire or other damage.

GENERAL STORAGE ISSUES

Cylinders shall be inspected on receipt as placed in storage and on removal from storage prior to installation for signs of obvious damage. They shall not be accepted or installed if there are obvious signs of damage (e.g. bent valves) but returned to the supplier.

Rotation of stores of gas cylinders to ensure that the first purchased gas cylinders are used before the last purchased shall be encouraged. Gas cylinders shall not be kept for extended periods. The size and number of the gas cylinders purchased shall be matched to the anticipated usage.

Where gas cylinders containing toxic or flammable gases are brought into buildings, they must be removed to safe storage (see hierarchy of storage options above) when not in use. An exception can be made for 'lecture bottles' (small portable gas cylinders, typically of about 500ml volume used to supply gas for relatively small-scale laboratory experiments) provided they are inside fume cupboards or kept in a suitable mechanically extracted ventilated storage cupboard e.g. beneath a fume cupboard or a purpose built storage facility.

When stored outside, gas cylinders shall be in a safe, dry, well-ventilated and secure location. The storage area shall ideally be provided with simple protection to protect the gas cylinders from the weather and direct sunlight (e.g. by a lightweight roof which has no pockets to trap escaped gas such as a ventilated apex) or in a cupboard with mesh or louvred doors. Storage areas and approaches, e.g. where unloading of cylinders occurs, shall be as flat and level as possible to ease mechanical handling issues.

Gas cylinders must not be allowed to stand or lie in water.

Seals or covers shall be kept in place on the valves of cylinders that are not in use to help prevent dirt or dust or other contaminants entering, which may affect gas quality, cause corrosion and prevent a good seal being obtained once connected to a supply. 'Empty' cylinders shall always have their valve shut although gas cylinders shall never be run to zero pressure and left totally empty.

The hazardous properties of the gas (including factors such as if it is unstable or susceptible to decomposition if subject to heat or shock as is acetylene) will also need to be considered when determining storage requirements / locations and may include enhanced requirements for ventilation, separation or keeping them cool.

When storage and use of gas cylinders inside a building is unavoidable, due consideration must be given to the:

- *Separation/segregation from other activities and incompatible materials*
- *Provision of adequate ventilation*

- *Detection of leaks*
- *Protection from involvement in fire*
- *Materials handling aspects and safe access routes to bring gas cylinders into the building, avoiding the need to manually lift or accompany them in lifts*
- *Supporting/securing gas cylinders upright*
- *Maintenance of safe means of escape*
- *Possible need for explosion relief/prevention and for protected electrical equipment appropriate to any hazardous area classification when flammable gases are being stored / used.*

All storage areas, laboratories, rooms or cabinets where gas cylinders are located shall have warning signs displayed to indicate the presence of gas cylinders, hazards (e.g. flammable or toxic) posed by the gases together with any precautions that must be taken e.g. 'No naked lights/sources of ignition'. Gas cylinders shall not be taken into or stored in unventilated rooms, which would include most cold-rooms.

Gas cylinders must be kept away from sources of heat e.g. direct sunlight that could cause an uncontrolled rise in the temperature of the contents leading to over-pressurisation and possible catastrophic failure of the gas cylinder. In rare cases it may be necessary warm gas cylinders intentionally, in which case stringent precautions shall be taken to prevent the cylinder overheating.

Full, part-used and empty gas cylinders shall be segregated and clearly labelled. Labels with tear-off sections that are removed as the cylinder progresses through its life-cycle are available to indicate the current status of the cylinder.

Gas cylinders shall be secured upright and restrained at all times to prevent them falling over with consequent possible damage to persons, facilities, equipment or the gas cylinder and its fittings. They must also be protected from violent contact with other objects such as vehicles.

Gas cylinders shall not be allowed to come into contact with electrical apparatus. A separation distance of at least 50mm between gas cylinders/gas pipework and electrical services shall be ensured, except where electrical apparatus is purpose designed and installed for gas pipework applications e.g. auto-shut off, changeover systems and heaters on CO_2 supplies.

Cylinders of oxidant gases (e.g. oxygen and nitrous oxide) must be kept separated from cylinders of flammable gases or other flammable material, either by a distance of at least 3m or by a 30-minute fire-resisting wall. More detailed information on minimum separation distances is given in the BCGA Guidance Note GN2.

Single cylinders of oxygen and fuel gas may be kept together on a mobile trolley and used for oxy-fuel cutting/welding provided the trolley is returned to safe storage overnight. Guidance on the use of compressed gases in welding and similar operations is given in the HSE Booklet HSG 139.

Cylinders of LPG must be stored in approved stores. They shall be returned to safe storage when not in use. It is permissible to store a small number (e.g. less than 5) of disposable cartridges/canisters of LPG in flammable solvent cupboards in laboratories where such items are in continuous use. LPG cylinders used to provide a local flammable gas supply where there is no plumbed natural gas shall be kept outside a building and piped to the point(s) of use. Where this is not possible or is undesirable due to the distance of pipework involved, LPG cylinders may be kept in a ventilated gas cylinder storage cupboard within or close to the laboratory.

Gas cylinders will normally be fitted with a regulator when installed. Guidance on regulators is given in Appendix B.

References

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   'The Safe Storage, Handling and Use of Special Gases in the Micro-Electronics and other Industries', CP18 (Revision 2), British Compressed Gases Association, 2005
3. *'The Safe Use of Compressed Gases in Welding, Flame Cutting and Allied Processes', HSG 139, HSE, revised 2002*
4. *'Storage of full and empty LPG cylinders and Cartridges', Code of Practice No 7, UK Liquefied Petroleum Gas (UKLPG), 2004*
5. *'Reduced Oxygen Atmospheres: The management of risk associated with reduced oxygen atmospheres resulting from use of gases in the workplace', Guidance Note GN11 (Revision 2), British Compressed Gases Association, 2007*
6. *'The Safe Use of Oxy-Fuel Gas Equipment (Individual Portable or Mobile Cylinder Supply), CP 7 (Revision 5), British Compressed Gases Association, 2008*
7. *'Safe Cylinder Handling and the Application of the Manual Handling Operations Regulations to Gas Cylinders', Guidance Note GN 3 (Revision 2), British Compressed Gases Association, 2010*
8. *'Fire safety storage cabinets. Safety cabinets for pressurised gas cylinders', British Standard BS EN 14470-2:2006.*
9. *'Safety of Pressure Systems: Pressure Systems Safety Regulations 2000', HSE Approved Code of Practice, L122, 2000.*
10. *Carriage of Dangerous Goods and U se of Transportable Pressure Equipment Regulations 2009 (SI 2009 1348)*
11. *Pressure Systems Safety Regulations 2000 (SI 2000 No 128)*
12. *'Cylinder Identification Colour Coding and Labelling Requirements', Technical Information Sheet TIS6, Revision 1, British Compressed Gases Association, 2005*
13. *BS EN 1089-3 2011: Identification of Contents of Industrial Gas Cylinders (note: some cylinders may still display colours under the old BS 349 'Transportable Gas Cylinders, Gas Cylinder Identification (excluding LPG), Colour Coding' which has now been withdrawn)*

Appendix A: Gas Cylinder Storage Cabinets

(Note: much of the guidance in this appendix is based on advice contained in the BCGA publication 'The Safe Storage, Handling and Use of Special Gases in the Micro-Electronics and other Industries')

A gas cylinder storage cabinet is a purpose-built enclosure designed to provide safe containment of gas cylinders when they are installed within buildings. Their purpose shall provide protection, fire security, separation and ventilation to safely disperse any leaks etc. There is a standard, BS EN 14470-2:2006, that covers this application and cabinets which comply with it are very well built and of very high quality. However, the standard goes beyond the minimum required and cabinets built to comply with it are extremely expensive. It is possible to have cabinets purpose built by specialist suppliers which suit the particular needs of a situation.

Gas cylinders storage cabinets should:

- *Be of a fire resisting construction offering at least 30 minutes protection against the passage of flame. As a minimum sheet steel of 2 mm nominal thickness shall be suitable but cupboards with up to 2 hrs fire resistance are available.*
- *Be provided with forced extract ventilation whose discharge shall a safe location. For flammable gases the ducting will need to be fire resisting up to the point of any dAer.*
- *Have their inlet and extract points fitted with automatic dAers to cut off air supply shall the cabinet become exposed to a fire;*
- *Be labelled to give a indication of the nature of the hazards presented by their contents*

The cabinet may contain spare cylinders and any auto-shut off or changeover devices but empty cylinders shall be removed to an external storage area as soon as is practicable.

Gas cabinets shall be dedicated to a specific gas or class of gas (e.g. flammable / inert / oxidising / toxic / corrosive).

If it is desired to store incompatible gases, e.g. flammable and oxidising, alongside each other they must be in different compartments with at least half hour fire protection between them to separate the incompatible cylinders.

The cabinet will need to be of sufficient strength and rigidity to provide effective support for the gas cylinders and associated equipment during normal use and cylinder handling operations. This shall take account of any conditions or operations likely to be encountered, e.g. a toppling cylinder or local fire.

The cabinet door(s) shall be designed to give full opening to allow for changing of cylinders

For operations with extremely toxic or hazardous materials, a small access port may be located within the main door to allow for valve manipulation. The air flow across this port shall be at least 0.5 mps to protect against escape of any leaking gas into the workroom.

If the threshold of the cupboard is not level with the floor, some form of access rA e.g. a hinged drop down design located inside the cabinet door shall be provided to allow heavy cylinders to be more easily manipulated into the cabinet

The cabinet shall be provided with fittings, clamps or chains to securely locate and hold the gas cylinder once installed in the cabinet.

All joints which are regularly broken and re-made when installing cylinders shall be positioned inside the cabinet as well as all associated valves, regulators and connectors.

Fittings shall be adequately supported to avoid strain on joints and components during the connection and disconnection of containers.

There shall be a label and a hazard warning sign displayed on each cabinet identifying the gas within and any potential hazard(s) it presents (e.g. gas cylinder pictogram and wording).

Consideration shall be given to the monitoring of the air inside cabinets containing toxic gases and/or flammable gases to detect leaks.

The cabinet shall be provided with sufficient extraction ventilation with the aim of containing small leaks of gas and minimise their escape to the workroom. However, it is accepted no ventilation system would be able to deal with a major escape of gas. The extract volume maintain the potential concentration of leaking flammable gases in the extracted air to below 25% of the lower flammable limit, except in the event of a catastrophic leak.

The ventilation system shall be provided with a control and monitoring system of high reliability, to give warning of extraction ventilation failure.

Electrical equipment shall be excluded from within the cabinet as far as is practicable but if it is essential to locate it within the cupboard (e.g. auto-changeovers) it shall meet any relevant standards e.g. if the gas is flammable, at least Zone 2 requirements.

It is best practice to have automatic gas/electrical shutdown of the cylinder supply in the event of ventilation failure or by interlocking to a gas detector within the cabinet or elsewhere.

The cabinet and all the equipment within the cabinet shall be electrically bonded to earth.

Gas cabinets may share the same extraction ducting providing reactions between incompatible gases are not possible within the ducting and back feeding of an incompatible gas is not possible in the case of failure or shutdown of the extraction system.

Appendix B: Gas Cylinder Regulators

Introduction

A regulator is a device to control the pressure of gas supplied from a gas cylinder (or piped gas supply) and may also control flow. Regulators reduce the high pressures of the high pressure gas supply to lower pressures that can be safely used in an operating system. They may have one or more indicator dials, be fitted with flow indicators and flow control devices.

Regulators are pprecision instruments and must be handled and stored with care to avoid damage to their sensitive springs, diaphragms, valve seals, gauges etc. When disconnected and stored the pressure adjustment knob shall be screwed fully out to minimise the tension on the springs and diaphragms.

Regulators include a relief device which prevents excessive pressure from developing or releases pressure shall a component such as the diaphragm fail. This will normally be via a safety-back construction which relieves from the rear of the regulator with the light-metal safety back blowing off. However, this does not mean that it can never fail via the front. This is why the operator shall always stand away and to one side when operating a regulator

General Requirements for Regulators

1. *A gas cylinder regulator may form part of a pressure system under the Pressure Systems Safety Regulations 2000 (PSSR) and so be subject to a written scheme of maintenance containing requirements as to inspection and maintenance.*

2. *Unless specifically agreed by the competent person under the PSSR, regulators shall be replaced, or sent for servicing/reconditioning, after five years in use or, if used with corrosive gases, more frequently - possibly every two years.*

3. *The regulator shall have markings which indicate the pressures up to which it can safely operate. A regulator shall never be used to control pressure from a cylinder containing gas that is above its design pressure. Ideally they shall also be marked to indicate the gas (or class of gas) for which they are designed to be used.*

4. *All regulators shall be labelled with a unique identifier and subject to regular inspection with a central log of all regulators on site kept to allow compliance with PSSR.*

5. *Where a regulator is not in regular or constant use, it is best practice to keep a central stock of regulators from which users draw and return as needed. This allows better control, compliance with inspection regimes and helps ensure a stock of the correct regulator for each application is available.*

6. *Regulators must be in good condition and only be used for the type of gas for which they are designed, being constructed of a suitable material that is compatible with the gas being used and purity required.*

7. *Care with corrosive gas applications is required. Regulators fitted with a purging connection are available which allow them be purged with an inert gas after use.*

8. *Do not modify regulators, remove their inlet connections as fitted by the manufacturer or connect adaptors unless this has been approved and undertaken by a competent person.*

9. *Damaged regulators must be r emoved from use and sent for repair by competent persons.*

10. *Where regulators supply gas to equipment or apparatus containing liquid and the gas is introduced directly into the liquid, the risk of suck-back must be protected against. This can be by means of non-return valves in the supply line or catch pots created by using empty in-line intermediate containers.*

11. *Liquid supply, liquefied or dissolved gases shall be controlled in accordance with supplier's instructions.*

12. *Regulators for flammable gas cylinders need to be installed in conjunction with a flashback arrester (on both fuel and oxygen supply for oxy-acetylene or oxy-propane equipment with non-return valves close to the welding torch).*

13. *NOTE: with the gas store there MUST be an outlet to route out user supplied gas lines for specialist gases, for specialist gas standards and unusual gases. Then there must be corridor 'trays' so as to make easy routing of scientist provided gas lines into all the various science labs. Scientists WILL bring their own gas lines (eg: Copper and Teflon) as a matter of course. The ships gas lines fixed in will mainly be used for gas supplies that are not critical to experiments or quality.*

APPENDIX 5

NERC GUIDANCE ON SAFE USE OF CRYOGENICS

Version 1.7 **Date: March 2015**

BACKGOUND

This guidance document provides information and advice on the hazards that may arise and suitable precautions that may be necessary when using, storing, and transporting low temperature liquefied or solidified gases (commonly referred to as cryogenics). The risks from use of cryogenics are considerable and have led to deaths in laboratory situations from asphyxiation due to oxygen displacement.

DEFINITIONS

Cryogenic liquid – A liquid produced from a gas that can be liquefied, and in some cases solidified, by the application of pressure and cooling within the temperature range -75^{o}C to -270^{o}C. Examples of materials likely to be encountered within a research environment, with associated boiling points at atmospheric pressure, are Nitrogen (-196^{o}C), Oxygen (-183^{o}C), Helium (-269^{o}C) and Carbon Dioxide (sublimes at -78.5^{o}C).

Dewar – A vacuum insulated container for storing very low temperature liquid gases. Sometimes dewars are considered to only include small open (non pressurised) vessels but in most laboratory situations portable closed pressure vessels with pressure bleed/relief to allow escape of evaporating gas are also called dewars. Larger fixed bulk pressure storage vessels are normally termed 'tanks'.

Dry Shippers - dry shippers contain a cryo-absorbent material in the inner wall which soaks up the liquid nitrogen so there is no free liquid present and holds samples in a vapour phase environment at cryogenic temperatures. This means no spillage of liquid nitrogen will occur during transport and shipping.

Dry Ice – solid carbon dioxide (CO_2) also known as 'cardice'. This is a solid cryogen rather than a cryogenic liquid and sublimes at -78.5^{o}C.

HAZARDS FROM CRYOGENIC MATERIALS

The hazards associated with low temperature liquefied or solidified gases mainly arise from their physical properties. They are:

- Asphyxiation - Rapidly evaporating gases can reduce the oxygen concentration of air by displacement so that it reaches dangerous levels (see table below). Areas with oxygen concentrations below 18% must never be entered. It is recommended that oxygen alarms are set to alarm at 19%
- Cold burns, frostbite and hypothermia from contact with liquefied/solid materials, cold surfaces or gases
- Over pressurisation if the large volume expansion caused by the liquid becoming a gas is confined or trapped
- Fire from oxygen enriched atmospheres generated by the condensation of oxygen onto surfaces
- Materials becoming brittle from the effects of extreme cold and could result in catastrophic failure
- Manual handling risks from delivering/transporting of cryogenic materials and their containers around site may create manual handling hazards.

Effects of lowered oxygen levels

Oxygen content of air	Signs and symptoms of asphyxia
18% - 19%	May affect physical and intellectual performance without person's knowledge.
15% - 18%	Decreased ability to work strenuously. May impair co-ordination and induce symptoms in persons with coronary, pulmonary or circulatory problems.
12% - 15%	Respiration deeper, increased pulse rate and impaired co-ordination, perception and judgement.
10% - 12%	Further increase in rate and depth of respiration, further increase in pulse rate, performance failure, giddiness, poor judgement, cyanosis (blue lips).
8% - 10%	Mental failure, nausea, vomiting, fainting, ashen face, cyanosis.
6% - 8%	Loss of consciousness within a few minutes, resuscitation possible if carried out immediately.
0% - 6%	Loss of consciousness almost immediate, death ensues, brain damage even if rescued.

Effects of CO_2 enrichment

CO_2 poses an intoxication risk which is actually more serious than asphyxiation and occurs at lower displacement levels. CO_2 has been assigned a Workplace Exposure Limit (WEL) of 0.5% (5000 ppm) averaged over an 8 hour working period of 1.5% (15,000 ppm) averaged over a 15 minute short term exposure.

Dangerous conditions with elevated CO_2 levels cannot be detected by a low oxygen alarm alone. CO_2 forms a key part of the biochemical mechanism involved in the breathing reflex and high levels act as an intoxicant or narcotic which depresses and eventually suppresses breathing. Inhaling levels above 10% CO_2 will rapidly lead to death, which will occur even if there is an adequate level of oxygen to support life.

CO_2 in air	Signs and symptoms of narcosis
1% (10,000 ppm)	Slight symptoms; possible increase in breathing rate
2% (20,000 ppm)	Breathing becomes deeper – 50% above normal
3% (30,000 ppm)	Laboured breathing – 100% above normal, increased pulse rate, reduced hearing, headaches
4% – 5% (40,000 ppm – 50,000 ppm)	As for 3%, but after 30 minutes exposure signs of poisoning evident with a choking sensation
5% - 10% (50,000 ppm – 100,000 ppm)	Characteristic sharp acidic smell apparent, heavily laboured breathing, ringing in ears, visual disturbances, loss of consciousness within minutes
> 10% (> 100,000 ppm)	Rapid loss of consciousness with risk of respiratory arrest and death, concentrations > 20% are immediately life threatening

Metal surfaces in contact with liquid nitrogen can generate oxygen enrichment as liquid nitrogen is at a temperature below the boiling point of oxygen so may allow it to condense out of the atmosphere. If there is any possibility of collection or enrichment then precautions may be required e.g. threads on pipework must be kept clean and free from grease and fitted with PTFE sealing tape.

The degree of risk will vary according to the location of use (e.g. levels of ventilation), the specific material, the delivery container, the volume and pr essures within containers.

Risk assessment shall be necessary to cover activities involving the use, storage or transportation of cryogenic materials. The following sections suggest controls to reduce risk from the handling of cryogenic materials to an acceptable level.

STORAGE OF BULK QUANTITIES OF DRY ICE

Dry ice can be purchased or produced in a solid, powder or pellet form. Supply as a solid block shall be avoided as its use will require breaking up into smaller usable sized pieces which will give a risk of generating flying particles. Dry ice will usually be delivered in bags and can be kept in specially insulated storage chests. Excess material or residues of dry ice shall left in a safe place, ideally in the open air or in a very well ventilated position such as a fume cupboard, to safely evaporate. Much condensation may be generated during this process. Dry ice shall not be disposed of in sinks as this can cause failure of the drain due to extremely low temperatures and allow accumulation of CO_2 in drains.

Dry ice shall ideally be stored in specially designed insulated trunks or chests which can reduce sublimation to about 2% per day depending on how full they are kept. When collecting dry ice from the chest care the user must take care not to place their head inside the chest or breathe its internal atmosphere as it shall be contain high levels of CO_2, even if it is nominally empty.

The best place to locate a dry ice storage chest is outdoors in a well ventilated location. Where the dry ice storage chest is located within a building the storage area must be sufficiently well ventilated to adequately dilute releases of gaseous CO_2. Remember the atmospheric levels of CO_2 sufficient to cause risk are well below those of other non-toxic cryogenic gases and an oxygen meter would be insufficient to warn of the hazard.

Dry ice shall not be put in an unventilated storeroom or freezer/cold room or any other enclosed space that may be entered as it will rapidly evaporate to generate an unsafe atmosphere.

Dry ice shall not be placed directly in a conventional fridge or freezer as it may damage the device due to the extreme low temperatures.

It is practice in some areas to place spare/unused dry ice in -80º C freezers in order to preserve stocks for longer periods of time. This shall be discouraged as even though the temperature will theoretically be below the sublimation temperature CO_2 will still be generated and create an unsafe atmosphere. A -80º C chest freezer will act as a trap to hold and retain any evaporated CO_2 so if a person's head enters and breathes the inside atmosphere this could lead to immediate loss of consciousness and falling into the chest. If only infrequent use of relatively small quantities of dry ice is required, consideration shall be given to obtaining a dry ice maker.

If it can be justified as being essential that dry ice is stored in a -80º C freezer, an upright style, which does not require the user's head to enter its interior and whose vertically hinged door allows safe escape of trapped CO_2 at low level when opened, shall be used. In addition, stringent precautions such as keeping the freezer locked to prevent unauthorised access and suitable signage shall be in place.

STORAGE OF BULK QUANTITIES OF CRYOGENIC LIQUIDS

Static bulk storage tanks are often used for cryogenic liquids at sites where there is large usage. The location for bulk storage tanks of cryogenic liquids shall be in a safe, well-ventilated and secure location, preferably in the open air. For smaller bulk storage vessels located in the open air, it may be desirable for them to be provided with simple roof cover for protection from the weather and direct sunlight. Tanks of greater than 500l capacity must be located in the open air.

Choice of location for bulk storage vessels shall take into account:

- The size of the tank
- Nature of surface on which tank is located, especially if liquid oxygen is stored

- Space/clearance for installation and maintenance of the tank and its fittings
- Access for filling or dispensing from the tank
- Clearance distances to ensure ventilation/dispersal of vapours, protect neighbouring activities and protect against build-up of unsafe atmospheres e.g. away from basements or pits
- Protection from fire and impact from vehicles etc.
- Security to prevent unauthorised access/interference

Bulk storage tanks are pressure vessels and shall be subject to a written scheme of examination which specifies the nature and frequency of planned preventative maintenance, the safety provisions to prevent over-pressurisation and any routine inspections necessary. Large bulk storage vessels in the open air shall be kept clean and painted white to minimise solar heat gain.

Bulk storage containers of liquid cryogenic liquids shall be located on impervious concrete surfaces rather than tarmac. This is especially important for liquid oxygen as contact with hydrocarbons can lead to spontaneous ignition. The areas shall be free from drains as a spillage or leak of a cryogenic material may cause cracks shall it enter drainage.

Signs to warn of the dangers from 'Extreme cold' shall be clearly displayed, especially where there is a possibility of contact with cold surfaces as this is more likely to result in burns than direct contact with the gas.

Pressurised dewars must be dedicated to one type of gas unless they have been re-certified for another gas by the manufacturers.

Ice may form on necks of dewars (although not if the correct dewar stopper is fitted), on exposed pipework and vents or pressure reliefs of pressurised dewars. Normally this is not a problem but on rare occasions the build-up is extreme and a plug forms that blocks an essential safety component. This may lead to build up of internal pressure and may result in ejection of the plug under force or even, in extreme cases, failure of the vessel. Expert help shall be sought before attempting to deal with such a condition.

FILLING MOBILE PRESSURISED DEWARS, DRY SHIPPERS, NON-PRESSURISED DEWARS AND FLASKS

When filling or dispensing cryogen at pressurised dewars, ensure the bursting disc or pressure relief valve is not pointed towards the face.

An inspection of the container to ensure no leakage is occurring and the container is sound shall be made prior to filling operations. Where damage is suspected the container shall not be used and defects reported.

Hoses shall be regularly checked to ensure they are not subject to kinking and the braiding is not damaged. These may be indications of internal damage and if identified hoses shall be replaced. Even where no specific damage is identified hoses shall be replaced every 5 years.

Filling of cryostats, dewars and flasks frequently results in vapour clouds and 'spitting' of boiling liquid and spillage. Where possible measures to prevent overfilling shall be taken e.g. dip sticks used to measure the level in the vessel. Other methods include use of phase separators in the end of the filling hose to condense the liquid and slow filling to reduce the amount of splashing and vapour generated.

Significant noise levels, above 90 dB (A), can be experienced during filling mobile pressurised dewars from a bulk storage tank. Silencers can be used to mitigate the risk from noise. Where these are not available ear defenders shall be used.

TRANSPORT OF CRYOGENIC LIQUIDS

Transport of cryogenic material in poorly ventilated spaces, such as lifts, could present a problem shall a spill occur or the lift break down. The following points require attention:

- the load shall travel in the lift unaccompanied
- lifts used shall ideally have a key control over-ride for the operator who can send the lift to a designated floor and, if they have no-one to receive it at the destination, use the stairs to meet it without anyone being able to call or operate the lift
- where there is no key control over-ride, the lift shall be commandeered for the duration of the transportation, ideally with a barrier and signage placed in the lift car across the door in front of the dewar to indicate that the lift is being used to transport cryogenic material and must not be entered. This is likely to require a two person operation - one on the despatch floor, the other on the receiving floor.

Personnel transporting containers around site shall have appropriate training on both the hazards and precautions associated with handling cryogenic material and manual handling of loads. Lone working and manual handling issues shall be taken into account.

Transportable dewars shall not be taken down steps or stairs. Slopes shall be avoided if at all possible. Floor surfaces that dewars are transported across shall be in good condition, smooth and even without holes or depressions such as floor drains. All areas through which dewars are transported shall be well ventilated and have sufficient space/width to not impede the workers or any other staff who may work in that area. Two persons may be necessary to transport dewars to minimise manual handling issues and possibility of spills. Densely populated areas shall be avoided.

If collecting and transporting material that needs to be kept frozen at liquid nitrogen temperatures, the use of dry shippers shall be considered. Dry shippers eliminate the potential for spillage during transit by absorbing the liquid nitrogen into a carrier material, effectively keeping the sample in the gaseous phase. Dry shippers which have been correctly charged contain no free liquid nitrogen and are not considered as Dangerous Goods (DG) for any mode of transport provided the material being transported within them is not a DG e.g. is a non-infectious biological sample. However, liquid nitrogen itself is a DG for all transport modes although there are exemptions. If off-site transportation of liquid nitrogen cannot be avoided, advice from a competent person must be sought e.g. the NERC Dangerous Goods Safety Advisor (DGSA).

Loads containing cryogenic liquids taken in vehicles shall be transported in a separate compartment segregated from the driver and any passengers (the boot of a normal saloon or hatchback shall not be considered a separate compartment). Where this is not possible, the quantity must be kept to a minimum, the driver/passenger compartment kept well ventilated with one or more windows open, care taken to ensure it is secured to prevent spillage and the package is appropriately labelled. Taking a personal alarmed oxygen meter if the cryogen preserved samples are not in a separate compartment of the vehicle is strongly recommended

TRANSPORT OF SAMPLES STORED IN DRY ICE

Materials required to be kept frozen are often transported using dry ice to maintain the temperature of the samples. The material sublimes to a narcotic gas and shall therefore not be carried in poorly ventilated areas. The advice on taking dry ice in a vehicle is the same as given above for a cryogenic liquid except that it is very strongly recommended a CO_2 personal alarmed meter is taken in the vehicle if the dry ice is not in a separate compartment; a low oxygen alarm alone would not give warning of dangerous levels of CO_2 (infra red detectors are best for this application).

Do not seal dry ice in closed vessels as there is potential for generation of pressure and ultimately explosion. The expansion factor of dry ice from solid to gas is 554 and the pressure at which CO_2 may be liquefied by pressure alone is above 5.1 bar. Therefore, unless the sealed vessel is able to withstand such a pressure it will fail, possibly catastrophically, with the sudden release of large amounts of energy.

Dry ice is regarded as a DG for shipment by air but not under UK road transport regulations. Appropriate UN approved packaging which are suitably vented and insulated shall still be used for road transport. For transport by air of dry ice, the outer packaging **must** carry a Class 9 transport diamond (safety sign for miscellaneous dangerous goods), be labelled with the letters and numbers “UN1845” (the UN number for dry ice) and close by the words “DRY ICE” in capital letters, and the net weight in kg of solid CO2 (on filling!). However, many road transport couriers will make a similar stipulation for packages containing dry ice so this is best practice for all shipments.

Always unload the material as soon as possible at the end of the journey to a suitable, well ventilated, storage location. Do not place dry ice in an unventilated cold store. The dry ice in an approved insulated shipper will last approximately three days from initial filling.

The driver must be aware of the symptoms of CO_2 intoxication and what emergency actions are required when transporting dry ice.

INSTALLATIONS FOR USE OF CRYOGENICS

It is possible to postulate a number of types of installation for supply and use of cryogenic liquids in laboratory situations. Where possible it is best to install a bulk cryogen storage vessel or dewar outside the building in a safe accessible position in the open air and pipe the cryogenic liquid in to the point of use within the building. This can be done via specially designed insulated pipework known as Super Insulated Vacuum Lines (SIVL). This type of installation eliminates the generation of vapours within the working room during filling operations, the risk of major spills within the building, reduces the distance dewars need to be transported and eliminates this activity within buildings as well as use of lifts. There are practical limitations on the distance of SIVL can travel but care in the initial design of the facility may assist.

The British Compressed Gases Association has recently published new guidance on biostores that may be of use here (see references).

SAFE USE OF CRYOGENIC LIQUIDS

Non-pressurised storage vessels dewars / flasks and cryostats must be designed for this application, dedicated to one specific gas and appropriately labelled. The vessels must be regularly examined for signs of damage or deterioration, maintained as necessary and have an appropriate top to prevent the ingress of water.

Domestic vacuum flasks must not be used to contain cryogenic liquids. They are not designed for such low temperatures and may be inadvertently sealed. The cryogen may shatter the ordinary glass flask or cause the rubber seal to fail and allow leakage into the cavity between the glass vacuum liner and the outer flask wall, leading to an explosion as the liquid rapidly evaporates in a confined space.

The floor / bench surface in areas used for the storage/use of cryogenic materials must be suitable to withstand the effects of freeze/thawing as there will inevitable be small spillages in use. Normal laboratory vinyl flooring is not resistant to these effects (although very heavy grades may have better resistance to cracking) but concrete, steel or epoxy resin flooring is resistant to cold spills. Rooms used with liquid nitrogen shall have vision panels so it is possible to see inside without entering e.g. shall any alarms be triggered.

The potential for asphyxiation arises when gases evaporate during use and are not removed or diluted. The oxygen levels in an enclosed area used to handle or store cryogens will depend on the volumes handled, the likely rate of release, spillages or leaks, the volume of the area, the nature/location of the ventilation combined with the air change rate achieved and localised features such as pits or areas with restricted air exchange.

The asphyxiation risks can be divided into **sudden**, e.g. where there is a spill resulting in rapid generation of high levels of vapour when even well ventilated areas may not be safe, and **gradual** where slow release of vapours may reduce oxygen levels to an unsafe level. P recautions shall be designed to cope with both eventualities. Formulae to allow calculation of likely oxygen concentrations for both situations are given at Appendix C and will help in selection of suitable precautions.

High air change rates shall be provided in any area where cryogenic materials are used. Natural ventilation is unlikely to provide sufficient ventilation for most situations involving cryogenics unless the operation is being undertaken in the open air. A naturally ventilated room may only give an air change rate of 1x an hour or less if the windows are well sealed. I n a v ery well designed naturally ventilated room with permanent large openings to outside atmosphere on opposite sides comprising a total of 1% - 3% of the wall area it may be pos sible to gain 5 ai r changes per hour. Basements pose particular issues if reliance is made on natural ventilation as their air change rates likely to be significantly lower than areas at ground level or above.

At least 10 x air changes are ideally required for situations involving use or storage of cryogenic liquids. This means that in most internal areas forced ventilation shall be required which shall include low level extract, as the cold vapours initially generated shall be heavier than air, as well as ceiling extract (especially if liquid helium is present) and suitable fresh air make-up. The normal forced ventilation rates may need to be supplemented by emergency ventilation to give even higher air change rates of up to 20 x or 30 x an hour to cope with spillages or quenches. This can be triggered by interlocking to the low oxygen alarm. Situations where normal air change rates may be reduced shall be taken into account in any calculations e.g. power failure or ‘night setback’ where there is reduction of air change rates out of normal working hours.

Low oxygen alarms need be installed in workplaces where there is a potential for depletion of oxygen. Such areas will include rooms where large volumes of cryogens relative to the volume of the room and its ventilation rate are dispensed, used or stored and rooms where there is equipment with the potential to generate large volumes of vapours from cryogens in a s hort space of time (e.g. those containing Nuclear Magnetic Resonance or Magnetic Resonance Imaging machines where ‘quenches’ may occur).

The sensors for low oxygen alarms shall ideally be placed at a height of between 1 and 1.5 m from the floor. They can be supplemented by other sensors at a higher level. Location of oxygen sensors at low levels close to the floor shall be avoided. These are liable to give rise to unwanted alarms which create complacency if triggered frequently when there is little risk of asphyxiation e.g. as slugs of cold vapour are momentarily released close to floor level during filling or dispensing operations.

Oxygen alarms shall be set to trigger if the oxygen concentration drops below 19%. The alarm shall give a visible (ie illuminated such as with a beacon) and audible signal both inside and outside the room. The sensors must be subject to at least annual checking, replacement as necessary and calibration. In event of the alarms being activated all personnel must evacuate the room immediately. Signs shall be placed inside the room requiring it is left immediately when the alarm sounds and not re-entered until the alarm has been investigated and the area declared safe by a competent, responsible person. Signs must also be displayed outside the entrance to the room indicating there must be no entry if the alarm is illuminated / sounding. Rooms with low oxygen alarms shall have hazard warning signs displayed outside entrances to warn of the presence of cryogens and the potential for oxygen depletion. If a two stage oxygen alarm system is installed, the first stage 'alert' alarm may be set at 19.5% and the second stage 'evacuate' alarm set at 18.5%. With a very well designed and highly engineered system it may also be possible to link the low oxygen alarm system to a door lock to prevent unauthorised access (although egress from within the room must not be prevented) and to shut off supply of liquid cryogen from outside the room.

The possibility of lone working or working out of normal working when reduced numbers of persons are available to provide assistance shall be taken into account when considering precautions for use of cryogenics.

Good sample management systems shall be in place for storage in liquid nitrogen freezers. This will not only reduce the time taken to locate and retrieve the correct, desired sample but also reduce exposure to liquid nitrogen and generation of vapours. It will also aid other safety aspects such as biosafety and inventory control. Vial lifters are useful aids. Vapour phase freezers are preferred to liquid phase designs. Where samples are stored in liquid phase in screw capped containers, the containers shall have a seal around the outer edge of the cap to prevent liquid seeping into the screw thread which can cause the cap to be forced off with explosive force as the liquid cryogen rapidly warms up and evaporates. All sample containers shall be immediately placed in a fracture-proof secondary container (not glass) after retrieval and during transport, being retained there until thawed.

All staff working with cryogenic materials will need training on the hazards and precautions required to help establish competence. This shall cover as a minimum:

- *Cryogen hazards*
- *General safety precautions relevant to this work e.g. alarms, ventilation systems*
- *Emergency procedures*
- *Use of PPE*
- *First aid*
- *Any other relevant special procedures*

Liquid nitrogen has the potential to condense oxygen from the atmosphere which if it comes into contact with oil or grease can give rise to fire.

Areas and equipment which may have extremely cold surfaces due to the presence of cryogenic material can be labelled 'Caution: Extreme Cold' accompanied by the 'snowflake' symbol.

Equipment such as Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imagining (MRI) use both liquid nitrogen and liquid helium to maintain the temperature of the magnet. Liquid nitrogen is slowly evaporated as it helps maintain the levels of liquid helium around the magnet. Failure of the equipment may result in a 'quench' when the liquid helium within the magnet boils off rapidly, followed by the liquid nitrogen. Low oxygen alarms are normally essential for such installations but may also be linked to an emergency ventilation system which is triggered by the low oxygen alarm to increase extraction rates, ideally as close as possible to the vent points. When the magnets in NMRs and MRIs are brought down to operating temperatures there shall be very large volumes of cryogen evaporated so it is essential that all ventilation systems and alarms are fully operational before this is attempted.

Slush or cooling baths are frequently used to control reactions or condense products via cooling loops. Slush baths are prepared by combining materials to generate the desired temperature and range from ice and salt mixtures to solvent and cryogenic mixtures. The following table lists the temperatures of some of the common slush bath compositions but many others are available:

Solvent / additive	***Temperature (^{0}C)***
Ice / salt (3 : 1)	*- 8*
Carbon tetrachloride / dry ice	*- 23*
Acetonitrile / dry ice	*- 44*
Chloroform / dry ice	*- 61*
Ethanol / dry ice	*- 72*
Acetone / dry ice	*- 78*
Hexane / liquid N_2	*- 94*
Ethanol / liquid N_2	*- 116*

Fires have been experienced when the cryogen in the slush bath has all evaporated and the solvents they contain are at room temperature as the flammability of the solvent is then much higher than when they are at their operating temperature.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Appropriate PPE shall be provided to protect hands, face and body. Possible PPE includes:

- safety glasses, goggles or visor (the latter being preferred, with chin and brow protection if possible)
- non-absorbent insulated gloves which either have long or elasticated cuffs to cover wrists and prevent trapping of spilt cryogen
- cryogenic apron
- overalls, preferably of a non woven fabric to avoid liquid penetration,
- safety footwear
- hearing protection, where necessary, when filling or dispensing into dewars from bulk pressurised vessels.

There is no specification for the eye protection to be used when handling cryogenic materials but those specified for use with molten metals may offer better resistance to extreme thermal shock. Polycarbonate is often used. Safety glasses (which only provide protection to the eyes), goggles and visors shall be replaced if they have been directly splashed with cryogenic materials.

It is important that splashes of cryogenic liquid are not be trapped against the body. Pockets or other means of channelling/containing the liquid shall be avoided as shall turn-ups on trousers. Sleeves shall be pulled down over wrists if shorter gloves are worn and trouser hems worn over the tops of safety shoes or boots not tucked in.

EMERGENCY ACTION

If eyes or skin come into contact with cryogenic materials or very cold surfaces, do not attempt to remove frozen clothing or free hands or limbs by forceful action as this will remove layers of skin. The temperature of the affected area shall be raised gradually by immersing the affected area in tepid water. Medical assistance shall be sought immediately.

Oxygen deficiency or high CO_2 can lead to loss of awareness, distortion of judgement or suppression of breathing. As the oxygen levels fall fainting, brain damage and death ensue. Any person suffering the effects of oxygen deficiency shall be removed to open air, provided the rescuer does not place himself at risk. Self contained breathing apparatus is essential to enter areas where there is a likelihood of oxygen deficiency and no attempt at rescue shall be attempted without assistance from competent persons.

Where there is possibility of localised enrichment of oxygen, try to stop release, switch off electrical appliances and extinguish naked lights. Evacuate area and ensure adequate ventilation. Where a person's clothes have caught fire they shall be deluged with water and removed to fresh air.

REFERENCES

1. *British Compressed Gases Association Technical Information Sheet TIS No 7 (rev 1, 2010): 'Guidelines for the Safe Transportation, Storage, Use and Disposal of Dry Ice Products'.*
2. *British Compressed Gases Association CP27 (rev 1, 2004): 'Transportable Vacuum Insulated Containers of not more than 1000 litres volume'.*
3. *British Compressed Gases Association CP36 (rev 1, 2011): 'Cryogenic Liquid Storage at Users' Premises'.*
4. *British Compressed Gases Association CP30 (rev 1, 2008): 'The Safe Use of Liquid Nitrogen Dewars up to 50 litres'.*
5. *British Compressed Gases Association CP25 (rev 2, 2004): 'Revalidation of cryogenic static storage tanks'.*
6. *British Compressed Gases Association Guidance Note GN 19 (2012) 'Cryogenic Sample Storage Systems (Biostores) Guidance on Design and Operation'.*
7. *Medical Research Council and CryoService publication (2010): 'Standards for Liquid Nitrogen Supply: Systems for Life Science Applications', available from CryoService, Warndon Business Park, Worcester, WR4 9RH.*

Appendix C – Calculations For Oxygen Levels When Storing, Transporting Or Using Liquid Nitrogen

A calculation based on the formula to calculate the resulting oxygen concentration shall be undertaken prior to deciding to site a vessel containing liquid nitrogen (although figures to allow calculations for other cryogenic liquids are given) in a workplace. The rate of air changes can be taken into account but situations when these rates fluctuate, e.g. power failure or reduction of air changes over night if applicable, must be taken into account.

Formula to apply for sudden releases of liquid nitrogen (e.g. spillage) where dilution from ventilation is not applicable:

$$\textbf{Oxygen } (O_2) \textbf{ Concentration \%} = \frac{V_o \times 100}{V_w}$$

Where:

V_o = volume of oxygen (m^3)

V_w = volume of available air (m^3), not including above 2m in height

$V_o = 0.21 \times [V_w - (V_t \times \text{the expansion factor of cryogenic liquid})]$

V_t = net tank capacity (m^3)

Liquid nitrogen has an expansion factor (liquid to gas) of 683.

Note: Expansion factors of other liquid cryogens are: oxygen 860, helium 754 and argon 840. Although this calculation cannot be used for dry ice in this format, the expansion factor of CO_2 from solid to gas is 554.

$V_w = V_r - V_i$

V_r = volume of workplace obtained from room/area dimensions: length x width x height (height only up to a maximum of 2 metres).

V_i = volume occupied by objects/furniture/equipment in room.

If the calculation shows the oxygen concentration shall be less than 19.5%, then an action plan will need to be devised and implemented to ensure adequate oxygen levels can be maintained.

Worked example for spillage

A room 4m long x 5m wide x 2.5m high located at ground level houses a large 50 litre (0.05 m^3) unpressurised dewar containing liquid nitrogen and has fixed benches and cupboards with doors beneath measuring 6m long x 0.9 m tall and 0.8m deep but no other 'enclosed' furniture or large items of equipment.

V_w = (4 x 5 x 2 - 2m is used as max room height) – (6 x 0.9 x 0.8) = 40 – 4.32 = 35.68 m^3

$V_o = 0.21 \times [35.68 - (0.05 \times 683)] = 0.32\ m^3$

$$\% O_2 = \frac{0.32 \times 100}{35.68} = 0.9$$

which means there would a serious problem if the whole dewar was spilt as the O_2 in the room would be almost completely displaced by N_2.