APPENDIX TO SECTION D.

D4 FUME CUPBOARDS

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D4 FUME CUPBOARDS

1.0 SCOPE

These notes specify the University's requirements with respect to the installation, design and maintenance of general purpose fume cupboards, as well as the testing methods to be used to determine their performance. Fume cupboards covered by this section are intended primarily for use in general chemical operations, but may also be used for special applications providing that the additional relevant features described are incorporated. The make of fume cupboards is to be approved by Facilities Management before purchase and installation.

2.0 GENERAL

There shall be easy access to all component parts requiring service.

A prototype fume cupboard shall be produced for viewing and acceptance by Facilities Management. Allowances shall be made for changes to the cupboard to the approval of Facilities Management before commencement of final units.

All laboratory fittings in fume cupboards are to be powder coated as listed in Facilities Management Mechanical Services Identification Colours Specification.

3.0 STANDARDS

The following standards apply:

AS1259	Sound level meters
AS1345	Identification of the contents of piping, conduits and ducts (incorporating Amdt 1)
AS1444	Wrought alloy steels – standard and hardenability (H) series.
AS1449	Wrought alloy steels – stainless and heat-resisting steel plate, sheet and strip.
AS1469	Acoustics – methods for the determination of noise rating numbers.
AS1482	Electrical equipment for explosive atmospheres – Protection by ventilation – Type of protection.
AS1530	Methods for fire tests on building materials, components and structures. Part 3: Simultaneous determination of ignitability, flame propagation, heat release and smoke release.
AS1682	Fire Dampers.
AS1807	Cleanrooms, workstations and safety cabinets – Methods of test. Parts 1 to 15. Part 16: Determination of sound level in cleanrooms.
AS1826	Electrical equipment for explosive atmospheres: Special protection – Type of protection.
AS2208	Safety glazing materials for use in buildings (human impact considerations).
AS2243	Safety in laboratories series Part 1: Safety in laboratories – general. Part 2: Chemical aspects.

	Part 3: Microbiology.
	Part 4: Ionising radiations.
	Part 5: Non-Ionizing Radiation
	Part 6: Mechanical aspects
	Part 7: Electrical aspects
	Part 8. Fume cupboards.
	Part 9: Recirculating fume cabinets.
	Part 10: Storage of chemicals.
AS2252	Part 1: Biological safety cabinets (class 1) for personal protection.
	Part 2: Laminar flow biological safety cabinets (class 2) for personal and product protection.
AS2430	Classification of hazard areas.
	Part 1: Classification of hazardous areas.
	Part 3: Explosive atmosphere classification of hazardous areas – specific occupancies.
AS2444	Portable fire extinguishers – Selection and location.
AS2700	Colour Standards for general purposes.
AS2982	Laboratory design and construction.
	Part 1: General requirements
AS3000	SAA Wiring Rules.
AS3500	Part 1 – Section 4: National plumbing and drainage code.
AS3689	Automatic fire extinguishing systems using halogenated hydrocarbons.
	Part 1 – Halon 1301 total flooding systems.
SAAHB13	Electrical equipment for hazardous areas.
OFM	University of Western Australia O.F.M. Manual – Electrical Section (available for inspection at Facilities Management).
GMAC	Genetic Manipulation Advisory Committee, GPO Box 2183, Canberra ACT 2601
	Guidelines for Small Scale Genetic Manipulation Work.
	Guidelines for Large Scale Genetic Manipulation Work.
	Guidelines for the Planned Release of Genetically Manipulated Organisms

4.0 DESIGN PROCEDURES

4.1 Risk assessment

The design team will consult with the scientific and technical staff of the client department, and the Manager of Safety and Health Office, to obtain a risk assessment of the materials and procedures to be used during the life of the proposed fume cupboard. It is then the responsibility of the design team or designer to translate this risk assessment into a proper design approach.

All designs must be evaluated using current standards and practices. Design teams should visit similar laboratories and profit by their experiences. Laboratory exposure to infectious and hazardous materials may be fatal, sometimes with a long lead time, so risk assessment and appropriate design are vital components of safe fume cupboard design.

Some criteria for consideration include:

(i) The design must satisfy the requirements for safe management of the various types of hazards likely to be encountered.
(ii) The design must facilitate research productivity.
(iii) Safety features designed into the cupboard should closely match the assessed degree of risk of the research.
(iv) The design must be made as flexible as possible since the use of a fume cupboard is likely to change during its lifetime.
(v) The design is economical to operate and construct.

4.2 Safety requirements

In certain installations the University may require fume cupboards to be equipped with alarm devices to detect failure of exhaust air flow and or low face velocity. Devices which monitor the face velocity are recommended. An alarm, which shall be visual and audible, should be extended to all cupboards served by the same exhaust fan.

4.3 Recycling of exhaust air is to be avoided. Construction of a building model and wind tunnel analysis may be required. Exhaust stack height and exhaust exit velocities will be chosen to ensure that exhaust air is safely discharged beyond the building's atmospheric boundary layer, and in such a way that it does not affect nearby buildings.

4.4 PC2, PC3, PC4 containment laboratories

Special GMAC guidelines apply for laboratories, animal facilities, insectaries and plant houses in which some molecular biology, genetic manipulation and some infectious agents may be used.

Laboratories used for less hazardous recombinant DNA research require PC2 classification and no substantial design considerations are required. PC3 classified laboratories involve a higher degree of design, while PC4 laboratories have the most stringent requirements. Detailed specifications for these laboratories are available from the Genetic Manipulation Advisory Committee, PO Box 2183, Canberra, ACT 2601. Telephone (06) 213 6490. The most recent recommendations shall be obtained in order to design laboratory systems. PC2 and PC3 laboratories require inspection and approval by the University of Western Australia Biosafety Committee through the Safety and Health Office. Laboratories classified at PC4 require approval by the Genetic Manipulation Advisory Committee.

5.0 MATERIALS

Procedures and recommendations for the selection of materials and construction are as follows:

(i) Determine the type of effluent that is to be generated in the fume cupboard and handled by the exhaust system.
(ii) Classify types as organic or inorganic, and state whether they occur in gaseous, particulate or vapour form. Also classify decontamination materials if used.
(iii) Determine the concentrations of reagents used and the temperature of the effluent at the fume cupboard exhaust throat. Note that in a Research Laboratory this determination is almost impossible to

make; however, some attempt should be made in determining the likely range of reagents and concentrations used.

(iv) Determine whether a fume scrubbing system will be required.

(v) Estimate the highest probable dewpoint of the effluents.

(vi) Determine the likely ambient temperatures of the spaces in which the exhaust ductwork and exhaust fans will be located.

(vii) Consider the length and arrangement of duct runs and how they may affect the periods of exposure to fumes and the degree of condensation that may occur.

(viii) Determine whether water sprays will be required within ducts and at what intervals.

(ix) Determine the slope and drainage requirements and the means to achieve leakproof joins.

(x) Determine whether exhaust ducts will require external insulation.

(xi) Determine the means of achieving the required fire rating for penetrations through different fire compartments.

(xii) Determine whether the fume cupboard exhaust should operate at 10% of full flow when turned off at the fume cupboard.

(xiii) Select materials most suitable for the application, considering resistance to attack, weight, flame and smoke spread rating, and cost.

(xiv) Determine the method to be used for testing exhaust duct leak tightness.

6.0 CONTAINMENT OF CONTAMINANTS

Containment of contaminants is based on the principle that an airstream entering the face of the fume cupboard will “entrain” the contaminants and carry them to the exhaust, thus effectively preventing the escape of the contaminants from the fume cupboard to the room.

Critical design parameters are as follows:

- Face velocity
- Size of the face opening
- Shape/geometry of the opening surfaces
- Back baffle and plenum arrangement
- Location of exhaust ports from the fume cupboard
- Inside dimensions and location of work area relative to face edge
- Proportional bypass if fitted
- Supply/make up air quantities to room and temperatures and interaction with exhaust air being exhausted through the fume cupboard
- Size and number of exhaust stacks or outlets.

7.0 PERFORMANCE

7.1 Flow Control

Flow control is afforded by the back baffle and horizontal slots. One horizontal slot shall be located at the bottom of the back baffle to draw air across the top of the working surface and under the working surface when it is suspended. Another slot shall be located at the top to exhaust the canopy and at least a third shall be located midway on the back baffle. The openings provide regulation of exhaust distribution to maintain face velocity within the requirements of AS2243.8. The openings shall be set and the settings made known to the University.

7.2 Face Velocity Control

In accordance with AS 2243.8, face velocities at the sash shall be 0.5m/s + 0.1m/s. Terminal supply air velocities in the vicinity of the fume cupboard shall be limited to a maximum value of 0.18m/s.

7.3 Containment

Corner and intermediate posts, deep deck lip depressions and projecting service fittings near the face produce air turbulence and potential loss of containment. Plain entry edges produce a vena contracta at the surface and fumes generated in this area are likely to escape from the fume cupboard enclosure. Aerofoil shapes at the entry edges correct this condition. Sinks and service fittings should be located at least 170mm inside the hood face and deck lips should have minimal projections.

7.4 Radioactive Work

The radiotoxicity and quantity of radioactive material determine the quantity that can be safely handled in a fume cupboard. Large quantities of radioactive material of high activity are generally handled in heavily shielded cells or glove boxes, maintained at negative pressure to the cell or boxes environment via a continuously filtered exhaust. AS.2243.4 and the University's registration conditions under the Radiation Safety Act. for radioactive work apply. For high level radioactive glove box exhaust systems, flanged and gasketed joints with quick disconnect fasteners will provide minimum exposure time to decontamination personnel.

7.5 Perchloric Acid

Perchloric acid fume hoods (most with scrubbers) are required for research involving work with perchloric acid. Nearly all metal and organic perchlorates are explosive, and many of them are extremely shock sensitive. Perchloric acid may also cause spontaneous ignition of some organic materials. Perchloric acid deposits in ductwork can become a major explosion hazard, thus internal water spray systems for periodic washing of the duct surfaces are mandatory. In general, designers should consult AS.2243.8 for more detailed information.

7.6 Hydrofluoric Acid

Hydrofluoric Acid can be fatal if split on skin and great care is required in its use. Fume cupboard may require scrubbers. See AS2243.8 for more information.

7.7 Microbiological Work

Microbiological safety cabinets are covered in AS.2252.1 and AS.2252.2. In some cases, fume cupboards may be adequate for some microbiological work, providing that the discharge does not carry pathogens into the environment.

8.0 FANS

Fans shall be of the centrifugal type with a pressure-flow characteristic that allows “constant” flow with pressure variations, or a flat flow-pressure loss profile.

Fans shall generally be of the centrifugal type and shall be belt driven. The fan motor and drive assembly shall be located externally to the duct for ease of servicing. In general, fans shall comply with the appropriate Clauses in AS.2243.8.

The complete fan and motor drive assembly shall be mounted on a rigid galvanised steel frame which, in turn, shall have sufficient vibration isolation from any building structural components.

Vibration mounts shall be of a type to ensure that no greater than 2% of vibration is transmitted to the underlying structure. Waffle pad mounting shall also be installed to prevent high frequency sound transmission. The support system shall be arranged to ensure the fan is restrained and that no flanking vibration paths have been established.

9.0 FUME DISCHARGE DUCT VELOCITIES

Duct velocities shall comply with the appropriate Clauses in AS.2243.8 for vapours, gases and smokes.

The discharge velocity shall be between 10m/s and 15m/s and should be discharged through a flue of sufficient height to penetrate the building boundary layer.

All bends in fume cupboard exhaust ducts should be sweep bends.

The fume cupboard duct should proceed by the shortest path incorporating a minimum of horizontal sections to the discharge point above the building. It is desirable that horizontal sections slope back to the fume cupboard, but where this cannot be achieved, the horizontal section shall be fitted with drains connected to the fume cupboard drainage system to carry away condensate and wash-down water.

Care must be taken to ensure the integrity of duct work joints on the discharge side of the fume cupboard exhaust fan.

Where a fume cupboard exhaust duct passes through fire rated compartments in a building other than the one in which the fume cupboard is located, the exhaust duct shall be clad or enclosed in a fire resistant material to preserve the integrity of the fire rating of each compartment traversed by that exhaust duct.

10.0 CONSTRUCTION

Lining materials in all fume cupboards shall be impervious with a smooth finish. All welds shall be dressed to a smooth finish.

Fume cupboards for use in biological, pathological and radioactive laboratories shall have an internal base (which may be under the working surface) which is coved up to the walls. All interior surfaces shall have smooth finishes. The work surface shall be flat. The fume cupboard shall be capable of containing any spillages.

The fume cupboard sash shall comply with the appropriate Clauses in AS.2243.8.

a) Ordinary window or plate glass and wire glass shall not be used as a fume cupboard sash.
b) Laminated glass has a poorer thermal shock resistance than toughened glass and the plastic interlayer may weaken through organic chemical attack. Laminated glass may have sharp edged blisters being projected under explosion conditions; however, it is designed to remain in place if fracture occurs.
c) Transparent plastic materials may be used as they may have a higher impact resistance than glass and are not etched by hydrogen fluoride. However, their temperature resistance and surface hardness are inferior to glass and some may shatter dangerously in an explosion.
d) Toughened glass is usually the material of choice for fume cupboard glazing. Under conditions of explosion blunt grains of shattered glass would be ejected, but these should only cause superficial injuries to persons hit by them.
e) Toughened laminate anti-explosion glass may be used.

All joints in PVC or polypropylene shall be welded by forming a vee and filling with a minimum of three runs of weld.

All joints exposed to view or the air stream shall be shaved flat and buffed to produce a neat finish.

The structure shall be reinforced where necessary; however, any reinforcement shall not interfere with the airflow through the fume cupboard.

Where bolted joints are required in a PVC or polypropylene fume cupboard, UPVC bolts shall be used. No penetrations for fixing shall be made through the wall of the work zone.

11.0 FUME CUPBOARD FLOOR

The entire bottom of the fume cupboard shall be a one piece, fully moulded section incorporating a full width runnel to rear.

The flow shall have a grade of 1:50 fall towards the rear runnel.

A removable 25mm thick epoxy resin cast sheet shall be fitted in the base to provide a horizontal work surface and ventilated bottom catchment or sump area.

Also include a hump at the front and an upper level service shelf to the left and right hand sides.

Care shall be taken to seal all joints around the floor to ensure against leakage of fluids which may be spilt. For PVC or polypropylene fume cupboards this seal shall be welded.

The sash shall be counterbalanced and all materials used in the counter-balance gear shall be acid and alkali resistant and as far as practicable be located outside the contaminated air zone.

An extruded air deflection strip shall be fitted to the bottom of the sash. The wire supporting the sash and lead counter-balanced weights shall be 3mm diameter stainless steel. The pulleys shall be machined and sized to take 3mm stainless steel wire and shall include press fit roller bearings. The pulley housing shall be easily removed if required.

12.0 BAFFLES

The fume cupboard shall contain a minimum of three baffles positioned to provide maximum air control to the face of the fume cupboard.

The function of the baffles is to form a rear plenum with low level, intermediate level and high level extract slots. The baffles shall be readily removable for cleaning. The top and bottom slots shall be adjustable from 2 mm to 20 mm for final balancing of the fume cupboard air flow except where the final balance has been pre-set at the factory.

The velocity of air passing through the extract slots in the rear baffles shall be greater than 7.5m/s. The edges of the baffle shall be rounded to prevent wind whistles.

13.0 SITING

As the most hazardous laboratory work is generally carried out in a fume cupboard, this item should generally be the first item to be located when planning a laboratory layout.

In general, the fume cupboard shall be located away from the main circulation areas, doorways, opening windows and emergency and egress paths. Note that care must be taken to locate fume cupboards away from doors as:

- movement of personnel is concentrated near the doors;
- major air turbulence is generated by the opening and closing of doors;
- the fume cupboard is a major hazard area and shall be located as far as possible from egress points.

Care must be taken in siting room supply air registers and the like. Reference must be made to the appropriate Clauses in AS.2243.8; however, the University reserves the right to specify a more stringent requirement based on the risk assessment described in Clause 4.1 of this specification.

The designer shall ensure that the proposed siting of the fume cupboard complies with Section 5 and the information in AS.2243.8.

14.0 COMMISSIONING

Each fume cupboard shall undergo commissioning tests in accordance with the appropriate Sections of AS.2243.8. However, the following modifications shall be made to the method of determining face velocity for by-pass fume cupboards having a constant exhaust rate irrespective of sash position.

14.1 The fume cupboard shall exhibit the following performance characteristics when tested as specified:

(i) Total exhaust air from the fume cupboard shall be as nominated for the associated exhaust fan.
(ii) With the sash fully open, the average face velocity shall be 0.5m/s.
(iii) With the sash door closed to a position 50mm above the front sill, the average face velocity shall be 0.6 m/s.
(iv) The noise level of the fume cupboard shall not exceed 50dBA when measured on the centre line and one metre away from the sash.

14.2 Working aperture test

The working aperture should be divided into squares of a maximum of 300mm sides.

The streamlines shall first be established using smoke tests. This will enable the direction of flow to be established and also enable areas of turbulence to be recognised.

A hot wire anemometer will be used to measure the velocities at each point in the established grid. The University has a 54N50 low velocity flow analyser and may be temporarily used under the supervision of the University staff. The University will test the flow characteristics of the cupboard independently of the Sub-Contractor.

Mean and effective velocity distributions should be obtained from the velocity readings. The variation about the mean at each point should not be greater than 15% of the mean value at that point.

The face velocity through the working aperture shall be the mean of the mean value at each test point. The mean values at each test point shall be within ± 15% of the overall mean.

Details relating to smoke generation and testing are described in the Appendices and main body of AS.2243.8. A completed copy of both the smoke test and face velocity test tables shall be forwarded to the University upon conclusion of the tests. Care shall be taken in determining the effect of the smoke upon items in the test area.

14.3 640mm Opening

The fume cupboard face area shall be divided into a grid consisting of 4 columns or 4 vertical measuring points, the lowest position being under the aerofoil sill where one is fitted. The measuring points shall be evenly spaced and shall divide the face into equal area rectangles above the sill. At each measuring point a series of 10 readings of face velocity shall be taken at 5 second intervals. The variation about the mean at each point shall not exceed ± 15% of the average face velocity.

14.4 50mm Opening and door shut position

Three measuring points on an even horizontal spacing shall be taken above and below the sill where one is fitted. The measuring point above the sill shall be located at the mid height of the aperture. Tests shall be carried out as specified above.

Smoke tests, as directed, shall also be performed so that the flow patterns under varied flow conditions may be observed.

14.5 Testing Label

The person performing the test shall affix an adhesive label to the lower right hand corner of the sash stating that the fume cupboard has been tested according to AS2243.8 and showing: Date of test: Smoke Test result: Average face velocity m/s: Date for next test: Signature:

15.0 ELECTRICAL SERVICES

All electrical services shall be in accordance with AS.2430.3 and AS.3000. Services will only be installed by a Contractor approved by the University who may be required to provide proof of his qualifications to the University upon request.

15.1 Thermal Detector

The fume cupboard exhaust air outlet shall be fitted with a thermal detector. The detector shall be 'Landis and Gyr' catalogue No.RAK12-0091 or approved equivalent thermostat with a range of 40 to 100ºC. The detector shall be adjustable in increments of 2º and its probe within the air stream shall be enclosed within heat-shrink PVC tubing.

For non air-conditioned laboratories the detector shall be set to activate at a temperature of 55ºC±5º. For air-conditioned laboratories the detector shall be set to activate at a temperature of 45ºC±5º

Activation of the detector shall initiate the following functions:

- activate the solenoid valve controlling the water spray in the fume cupboard
- isolate any piped flammable gas supply to the fume cupboard
- isolate the GPOs on the fume cupboard
- start the fume cupboard exhaust fan (if not already operating).

15.2 Fire Alarm

To connect the fume cupboard to the building fire alarm system, a second thermal detector of the same type shall be located in the fume cupboard exhaust throat and be set to the same operating temperature. This second detector will be linked directly into the building fire alarm system.

15.3 GPOs on the Fume Cupboard

When electrical GPOs are specified for a fume cupboard the requirement will normally be for one double GPO to be mounted at each side. One of these double GPOs is to be an RCD type with a light indicator for power availability feeding the second double GPO which is also to have light indicators for power availability.

For laboratories having electrical GPO Emergency Insulator buttons near the entrance door, the circuit supplying the fume cupboard GPOs shall also be isolated when the laboratory Emergency Isolator is activated.

The fume cupboard GPOs shall not receive power until the exhaust fan has been operating for one minute and power shall be immediately disconnected if the fume cupboard OFF, EMERGENCY STOP or FIRE DETECTOR is activated as required in AS2243.8.

16.0 INSTRUMENTS

For by-pass type fume cupboards with a constant exhaust rate through the fume cupboard, a differential pressure measuring gauge of the 'magnahelic' type, with a range of 0 to 250Pa, shall be mounted on the front panel of the fume cupboard immediately above the sliding sash.

This gauge shall read the differential pressure between the exhaust duct at the rear of the fume cupboard and the room external to the fume cupboard. The normal differential pressure between these points shall be marked on the face of the gauge.

17.0 PIPED SERVICES

Piped services shall be nominated in the Schedule of Performance for the fume cupboards.

Refer to specification section 'Laboratory Valves' for the type of valves to be installed.

Refer to the 'Schedule of Performance-Fume Cupboards' for the number and type of services required.

Deionised water pipework within the fume cupboard shall be high density polyethylene. All other pipework to gas and water outlets shall be in type B copper tube to AS 1432.

18.0 CONTROLS AND OUTLETS

Controls for all services other than deionised water, shall be located on the outer surface of the fume cupboard or the supporting structure. Permission to locate electrical controls in the hazardous zone (Zone 1 AS.2430.1) of the fume cupboard will only be given by the University in exceptional cases after thorough review.

Control knobs and handles shall not protrude beyond the line of the face of the fume cupboard. Controls and their outlets within the fume cupboard shall be colour coded and labelled in English in conformity with Mechanical Services Manual.

19.0 LUMINAIRE

The luminaire in the fume cupboard shall be a twin 18 watt or 32 watt fluorescent unit, mounted behind a translucent UPVC panel which shall be welded or sealed into the top of the work zone. The luminaire shall be accessible for servicing, and it should be connected by a cord and three pin plug so that it can be completely removed for servicing if desired.
The luminaire shall be located in an enclosure which does not connect to the working volume of the fume cupboard.

The luminaire shall be suitably distant from the panel on which it is mounted to substantially avoid heat transferred to the panel from the luminaire.

The luminaire shall be controlled by a switch mounted on the fume cupboard in a location most convenient to the operator.

All wiring and fittings shall comply with relevant sections of AS.3000 and AS.2430.

20.0 GAS

All gas service outlets shall be located on the inner surface of the fume cupboard with controls on the front fascia as in Clause 18 and in accordance with AS.2430.3. In general, all gas piping and fittings shall be in accordance with University gas standards and any other requirements of the relevant statutory authorities. Include solenoid valve and wiring to terminals connected to the fume cupboard controller for emergency shut-off.

21.0 WATER

All water outlets shall be located on the inner surface of the fume cupboard with controls on the front fascia as Clause 18 and in accordance with AS.2430.3. Include solenoid for perchloric acid wash-down. Scrubber fume cupboards will have additional water and drainage services.

22.0 COLOUR CODING

It is required that all service controls and outlets be colour coded and labelled in English to conform to AS.1345 and AS.2700 and Facilities Management Mechanical Services Manual.

23.0 ACCESS PANELS

All removable panels shown on the drawing shall be provided by the Contractor for easy access to components within the fume cupboard.