CODE OF PRACTICE

SAFETY FEATURES OF CHEMICAL WORKSTATIONS

Issue 1 : 1 st March 1994

Published by theSerniconductor Safety Association (Europe) on behalf of the Microelectronics Semiconductor Manufacturing Joint Working Group

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This document is based on current best practice. Where requirements are stated as mandatory it may not always be possible to meet all of the objectives. A balance must be made, however, between the scale of the risk involved and the cost of the remedial measure in terms of expenditure, time, effort etc. to ensure that the outcome is 'reasonably practicable' in keeping with Health and Safety legislation.

Whilst this Code has no official legal status, it gives a clear indication of what should be achievable in practice. It therefore provides a specific guide as to what is likely to be reasonably practicable, and may be used by the industry and health and safety enforcing authorities accordingly.

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T ABLE OF CONTENTS

Microelectronics Semiconductor Manufacturing Joint Working Group

The above Group, which is largely responsible for the compilation of these guidance notes, consists of representatives from manufacturers 0 f semiconductor devices, equipment and materials suppliers, trades unions and the Health and Safety Executive. The group was set up on an informal basis in 1985, with the general objectives of providing a forum for the discussion of health and safety issues affecting the industry and publishing guidance where appropriate. The Secretariat of the Joint Working Group is provided by the Engineering National Interest Group of the Health and Safety Executive.

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1 PURPOSE

This Code of Practice describes the recammended safety features af chemical warkstations (also commonly known as wet benches, wet sinks and wet haods)
used in the semiconductor and microelectronics industries. Ch em ical workstations are also used in research facilities. phata labaratories, specialist electroplating workshops, optical laboratories and, in particular, in th e pharmaceuticals .industry> Although this document deals specifically with chemical workstations as used in semiconductor manufacturing processes in the UK, the safety features may be applicable to. ather areas of usage.

2 EXPLANATION OF SEMICONDUCTQR MANUFACTURING PROCESSES

2.1 Approximately five major processing steps are universal to all silicon and related semiconductor devices: oxidation, phatolithography. etching, doping (diffusion and ianimplantation), and metallisation, .In addition all processing steps may be preceded by chemical cleaning stages.

2.2 As part af the photolithographic process, unpalymerised areas af photoresist have to. be removed from the surface of the silican wafer. This is done using a water or solvent based developer which is applied by either immersion, or spraying on to the surface of the coated wafer.

2.3 The developed wafer is then selectively etched using chemicals ar by other means.

2.4 The remaining photoresist is then stripped from the wafer prior to further processing. Chemical processes are available, often carried out in temperature-controlled baths.

2.5 Chemical processes may be acid or alkali based, or may use solvents. Whatever the medium, the processes are aften carried out at chemical workstations, and this Cade of Practice addresses the safety features which should be incorporated.

3. DESIGN PARAMETERS

Two criteria must be met during chemical workstation design, namely, the protection of personnel (operators, maintenance technicians, engineers, etc.) from exposure to process chemicals and emissions, and protection of the product from ambient contamination.

3.1 'ACID' WORKSTATION

This type of workstation shall be constructed of material which is resistant to the acids or other corrosive chemicals likely to be used, preferably with fire retardant properties (e.g. fire retardant polypropylene).

3.2 SOLVENT WORKSTATION

All solvent workstations shall be constructed to minimise the risk of fire.
The main carcase material should, where reasonably practicable, be constructed from stainless steel. Should a thermo-plastic material be used for carcase construction, anti-static and fire retardant properties will be essential. In addition, other precautions will also be necessary (e.g. use of stainless steel liners).

3.3 BATHS

Vessels within the workstation, containing chemicals, may be known as baths, tubs, tanks, or 'hot-pots'. For the purpose of this document the term 'bath' will be used throughout.

3.3.1 Baths must be constructed from materials compatible with proposed contents and conditions of use. A process may require the use of aggressive chemicals or may require heating.

3.3.2 Where baths are manufactured irom 1hermoplastic materials construction may be achieved by any suitable moulding process. For baths constructed from sheet material all joints should be welded and shown to be leak-free.

3.3.3 Where baths are manufactured from stainless steel, all. joints must be welded and shown to be leak-free.

3.3.4 Baths may be stand-alone units, or may be connected to a recirculation, reclaim or drainage system. Where piping is to be connected directly to the bath, joints must be leak-free. Joints should be made by seal-welding in the case of thermoplastics. Metal to metal welding of a stub section should be used in the case of stainless steel baths.

3.3.5 Any couplings used in pipework systems must be compatible with the bath contents. Particular care should be taken in the choice. of gaskets, o-rings or any other coupling components to ensure their suitability for the conditions of use.

3.3 Baths (continued)

3.3.6 Baths may be an integralpart ofthework surface or maybe removable units suitably mounted in the work surface. If the bath is supported by means of a Hanged lip, then the lip must be adequately sized and suitably jOined in order to support both the bath and its contents. For larger baths base mounting may be preferable.

3.4 THE PLENUM

3.4.1 A 'plenum' (see illustrations, Appendix A) forms part of the chemical workstation construction as it provides working volume for the installation of baths and their ancilliary services, a containment for spillage, overflow or component failure and a means of fume extraction.

3.4.2 It shall be constructed of a suitable material compatible with the chemicals in use, and must be fully leak-tight to prevent any ingress 6f chemicals into the structure of the chemical workstatio n.

3.4.3 The plenum must have sufficient strength and rigidity to support the weight of fluids it may be required to contain. If, in addition, it is required to bear the weight of baths and other components, adequate strength must be provided in the construction, usually by the addition of a supporting fram ework.

3.4.4 All joints in the construction of the plenum mustbe properly Y~~19~<;lCin9 s~own to. be leak-proof. In view ofJhearduous pomaitionsofload-bearing (::ind flexing the plEfnum wiHneed to withstand, it is unlikely1hata.singlebeadweld will be adequate. Triple bead welding isconsiderBd to be more appropriate.

3.4.5 Special attention is required where pipework or other services pass through the base of the plenum. Liquids .or . other contamininants may be present in the plenum due to leakage or spillage from the work surface. These contaminants may in turn leak via the feed-throughs to the area underneath the plenum. Use may be made of upstands (see diagram, Appendix A), where flexible pipework, cabling or other services are to be brought through the base.

3.4.6 Consideration should be given to providing installed wash-down facilities within the plenum for the purpose of washing away any spillage residues.'

3.4 THE PLENUM (continued)

3.4.7 Where components (such as valves, level sensors, . thermocouples, actuators and sensing devices), require wiring to run through the plenum, then adequate sheathing protection is necessary to prevent the ingress of aggressive liquids or fume. Components mounted within the plenum must be similarly proof against such ingress.

3.4.8 As far as possible, mains voltage services within the plenum itself should be avoided. Preference is given to either the use of non-electrical alternatives (e.g. pneumatically actuated valves), or use of ultra-low voltages,
Where the use of mains voltage cannot be avoided for heaters, then the electrical installations must be adequately protected. An unsatisfactory installation may be in breach of the Electricity at Work Regulations 1989.

3.5 DRAINAGE

3.5.1 Due consideration should be given to the siting of drainage lines and associated components. They must be accessible for inspection and maintenance purposes.

3.5.2 Acid and solvent drains must be kept separate. Acids should be drained to a suitable neutralisation point; solvents should be drained to dedicated solvent waste tanks. In all cases drain lines must be constructed of a material compatible with the fluid in transport.

3.5.3 Only fully compatible chemicals shall be run into common drainage lines. Whilst this code refers to 'acid' workstations, other non-acid materials such as alkalis, cyanides or strong oxidisers may also be used in chemical workstations.

3.5.4 In certain cases it may be necessary to use incompatible chemicals in different areas of a workstation. In such cases provision must be made within the plenum for total separation of the drainage catchment areas under each position where those chemicals are being used.

3.5.5 Where baths are of the free-standing type, (Le. no external drains or couplings), these may be emptied by aspiration using an installed water jet pump. In such cases, full provision of suitable compatible pipework shall be made to enable the aspiration process to be carried out safely and effectively. The advantage of aspiration techniques is that
dilution of the chemical being ejected occurs at the point of . aspiration before it reaches the drainage system.

3.5.5 (continued)

Where aspiration is used for the emptying of baths containing chemicals with a high heat of dilution (e.g. concentrated sulphuric acid) provision should be made to prevent syphoning or back-flow.

3.5.6 Ball valves, diaphragm valves or air operated shutter valves in the drain lines may become fouled by debris from the process preventing pbsitive closure. Where this is likely to occur suitable filters must be inserted in the drain line upstream of the valves. These must be accessible for inspection and maintenance purposes.

3.6 FUME EXTRACT SYSTEM

3.6.1 The design of the fume extract system will depend on the application involved, but in all cases must be sufficient to prevent hazardous fumes and vapours from reaching the operator's breathing zone.
Efficient fume extraction is also necessary to prevent damage to equipment from corrosive fumes and to avoid build-up of flammable vapours.

3.6.2 In a conventional laboratory fume cupboard,fume containment is achieved by ensuring $ufficientextraction airflow across the face of the fume cupboard, usually in the range 0.5 to *O.gm/s* (1 00-175fpm). Open faced chemical
workstations in maintenance andchemicalhandHhg areas. outside the cleanroom,in which verticallaminar flow (VLF) clean air is not provided, should meet this criterion.
Chemical workstations in the cleanroom rely on high capture velocities at the worksurface being achieved through worktop and plenum design, and do not require such high face velocities. On the contrary, high face velocities are avoided, to minimise the amount of particle contaminated air liable to be drawn in from the operator area. Units with integral VLF canopies are set up so that the extract volume flow exceeds the clean air flow through the filter by about 10%. This excess flow provides an ingress of air at the front edge of the workstation to avoid the escape of fumes, but limits the amount of dirty airflow to the front of the work-surface. The work within the station and the layout of baths can be planned to avoid this front edge.
The volume airflow required for efficient fume capture in free-standing cleanroom chemical workstations should be determined by design study and airflow pattern smoke tests during commissioning, a.s it will vary with worktop layout and plenum construction.

3.6.2 (continued)

As a guide, [for preliminarv estimation only], a volume airflow of up to 80cfm per square foot of Worksuriace is a typical requirement.

3.6.3 All stations should have physical barriers (som etimes .known as eye shields or face shields) to provide splash protection and to enhance fume extraction. These shields should be constructed of at least 6mm thick clear PVC or equivalent and should be easily removable for maintenance access. Eye shields on solvent stations should be constructed of wire re-inforced glass or stainless steel for fire protection.

3.6.4 As well as fitted eye shields, chemical workstations should be equipped with full top and side panels, where the basic module design allows it, te> maximise local extraction ventilationpertormance. The fume extraction should be capable of controlling both emissions from the baths and anyemJssion resulting from process transfer

3.6.5 Provision should be made in the extract ductwork for drainage of residual liquids. Spray from processes within the workstation, when extracted, tend to accumulate and will flow to the lowest point in the extract system.

3.6.6 Provision must be made in the extract ductwork for airilow measurement and adjustment. The fitting of airflow or pressure sensing devices to detect extract failure, linked to an audible alarm system, is recommended.

3.6.7 Where chemical workstations are fitted with integral VLF canopies, it is recommended that the power supply to the blower fan in the canopy is interlinked with the extract failure alarm to avoid fumes being blown into the cleanroom in the event of extract failure.

3.6.8 Extract and VLF adjustment controls should be designed and mounted to avoid unauthorised adjustment.

3.7 1-AYOUT

3.7.1 Where possible, the process baths should be in a single line. It is important to consider the variable length of reach of the workforce; baths in tandem may tempt the operator to duck below. the chemical workstation safety shield in . order to reach the rear bath.

3.7.1 (continued)

Where it is not possible to rearrange the baths in this way, it is important that the baths Gontaining particularly hazardous chemicals are sited to the rear of the working surface. This will avoid the need for operators to reach over hazardous materials when placing work in the baths at the rear of the chemical workstation.

Rinse baths of de-ionised water should therefore be situated at the front of the chemical workstation working surface along with other ancilliary items such as glove wash units, spray guns, vacuum wands, etc.

3.7.2 All baths shall be clearly marked to indicate their contents. This may be achieved by the use of indelible signs located on the front of the module.

3.7.3 Drainage pipework should be designed using the minimum number of joints in order to lessen the risk of leakage. Provision should be made for drainage and thorough flushing out of all chemical pipework prior to maintenance or modification.

3.7.4 Chemical workstations should not be equipped with storage racks on the rear face of the module, as these could constitute a splash hazard should any items fall from the shelving into the chemical baths.

3.7.5 When standing at the workstation an operator needs to be as close as possible to the front edge of the working surface. To facilitate this, provision should be made for a recess along the bottom edge of the module enabling the operator's feet to fit comfortably under the module.

3.7.6 Careful consideration shall be given to the positioning of controls such as process timers, displays, warning buzzers, temperature controllers, automatic dump/rinse controls. This should take into accountaccessibilityJor the operation and maintenance of such controls and the fact thatsuch controls may need to be protected from any aggressive fumes or splashes.

Visual displays should be located at eye level above the rear of the relevant bath. Where control devices are necessary, the means of operating these, wh et her pneumatic or electrical, should be situated on the front panel below the work top level.

3.7.7 To allow maintenance to be carried out outside the clean area of the workstation, consideration should be given to siting control electronics, valves and other ancilliary systems .so as to be .accessible. i.n .the .adjoining service chase adjacent to the chemIcal workstation module.

3.8 REDUCING RISK OF PERSONAL EXPOSURE TO HAZARDOUS CHEM ICALS

Chemical workstations are often used as a means of avoiding personal exposure to hazardous materials, in compliance with the Control ot Substances Hazardous to Health Regulations 1988 (COSH H). This section of this Code *of* Practice addresses the design parameters for physical controls; the use of Personal Protective Equipment (PPE) will be pursued further in section 8.

3.8.1 Immersion and agitation of jigs or boats carrying process product in baths should be automated whenever possible. Automation minimises the risk *of* hazardous chemical exposure to personnel.

3.8.2 Pouring *of* chemicals can be avoided by the use *of* closed chemical delivery systems (see 3.13). When pouring and mixing are unavoidable, the chemical workstation should have sufficient free space available *for* that operation to be carried out with minimum risk to the operatof'. Allowance must be made for any fume generation which may occur during open pouring/mixing processes.

3.8.5 Where chemical delivery systems, and waste collection systems are located separately from the chemical workstation, fume extraction may be necessary to minimise exposure during filling and venting.

3.8.6 Air flow patterns at the workstation should be monitored at frequent intervals. One possible way of doing this would be by using proprietary 'smoke' tubes to show the effectiveness *of* fume extraction.

3.9 STORAGE

It may be practical and convenient to design chemical storage in to the chemical workstation module, below the work surface. If so, suitable provision must be made *for* spillage containment and., fume extraction.

3.10 FIRE PRECAUTIONS

3.10.1 All chemical workstations should have the means to prevent the spread of fire through the exhaust ductwork. This may be through the use of sprinkler systems, cut-off dampers, etc.

Where sprinkler systems are to be used,it is important that these are incorporated into the ~hemical workstations at the design stage as retrofitting is difficult and costly.

3.10 FIRE PRECAUTIONS (continued)

3.10.2. Where fire suppression systems are fitted, they should be connected to an independent electrical supply, separate from the chemical workstation and should be labelled accordingly. Consideration should be given to the provision of an un-interruptible power supply.

3.10.3 The Montreal Protocol is phasing out the production of halons. Where new systems are 10 be installed the use of halons as an extinguishing medium is not recommended.

3.10.4 As an effective risk management measure, consideration should be given to fire resistant trunking in . extract systems. Chemically resistant ductwork which is also fire resistant, is commercially available.

3.10.5 Where fire detection systems are in operation, periodic testing is essential.

3.11 LABELS

3.11.1 It is essential to set up a clear system of labeHi ng for chemical workstations and baths to show the chemicals in use and associated hazards.
Labels must be easily read at normal working distances, and resistant to chemical damage. They should be positioned carefully to avoid any ambiguity or uncertainty.

Suitable warning signs should be posted to indicate all the chemical hazards present in the workstation.
Emergency and First Aid measures (such as showers, eyewash and emergency shut-off) should all be clearly marked.
All safety signs must comply with the Safety Signs Regulations 1980 (SI 1980/1471), and must conform to British Standard 5378 in colour and design.

Note that new Safety Sign Regulations are expected in 1994, implementing the European Parliament Safety Sign Directive 92/58/EEC.

3.12 ELECTRICAL SAFETY

3.12.1 Protection from hazardous electrical potentials in a chemical workstation must be achieved, wherever .necessary, by measures such as earth bonding of exposed conducting materials. The fitting of circuit breakers for circuit protection and the use of residual current devices are mended~~ccc

3.12 ELECTRICAL SAFETY (continued)

3.12.2 Consideration may be given to the provision of low vOltage supplies, (e.g. supplies from a 11 OV centre-tapped transformer or isolation transformers).

3.12.3 All electrical components and wiring should be clearly identified by labelling, colour-coding and numbering, with reference to "as installed" drawings and wiring diagrams.

3.12.4 All electrical components should be readily accessible for repair and maintenance. Electrical connections should be shrouded.

3.12.5 All electrical equipment must be suitably protected against ingress from moisture, flammable liquids and vapours and from corrosive fumes.

3.12.6 Lighting over chemical workstations must be adequately housed to prevent corrosion of electrical fittings. Trim and other components which are likely to corrode should be avoided to prevent contamination of the chemical workstation by falling debris.

3.12.7 All wiring should preferably be multi-stranded.

3.12.8 When mounting Emergency stop buttons, reference should be made to SS 5304, Safety of Machinery, Section 5, for details of correct positioning of such devices.

3.12.9 Consideration should be given to inert gas purging of electrical/electronic control equipment, where necessary, to prevent ingress of fumes, vapours, etc.

3.13 CHEMICAL SUPPLY UNITS (CSU's)

3.13.1 Many of the more modern chemical workstations have chemical supply systems installed. These have the advantage of avoiding the hazards associated with carrying and pouring chemicals by hand, and can be designed to minimise product contamination. CSU's may be located adjacent to the chemical workstation, or may be installed in service chases or chemical handling rooms at a distance from the cleanroom (even on different floor levels).

3.13.2 Chemical supply lines should be installed within containment pipework or ducting, which should be connected to suitab~e drainage. A leak detection system should be provided. Additional leakage containment should be installed where pipework runs over occupied areas and walk~ways

3.13 CHEMICAL SUPPLY UNITS (CSU'S) (continued)

3.13.3 Pumped and pressurised systems should be designed to include means of over-pressure protection. Where corrosive and otherwise hazardous materials are involved, all components of the system should be suitably housed to protect personnel in the event of component failure.

3.13.4 Valving should be provided for depressurisCitionand isolation of pipework in theeventofcomponentfaill.lre. Removable enclosures (doors, access panels, etc.) should be interlocked to depressurise/isolate the system on removal.

3.13.5 Where highly flammable liquids are to be dispensed, suitable containment (housing, co-axial pipew()rk) must be provided to control spillage. Ventilation mustbe installed as necessary to prevent the accumulation of flammable vapours. Precautions (such as electrical bonding and choice of suitable materials) should be taken to avoid the accumulation of static charge.

4 HEATERS

4.1 When electrical heating elements are used to heat liquids in baths, special precautions must be taken to prevent overheating. Failure of an automatic temperature controller to shut off the. power to a heating element can cause increased vaporisation of thetiquid in the bath. This can cause a drop in the liquid.leveland subsequent exposure of the heating element. If ,the liquid level drops below the heating element, the liquid. will begin to coolc§psin9 a continuous "on" signal to the heating element controL This will further accelerate the overheating which can result in:~

1. Ignition of:
   (a) the liquid in the bath
   (b) the bath or bath pipework
   (c) residues in the bottom of the bath.
2. Chemical decomposition of:
   (a) the liquid in the bath
   (b) the bath or bath pipework
   (c) residues in the bottom of the bath.
3. Generation of noxious fume or vapour.
4. Ignition of exhaust ducts

4.2 To avoid the dangers of overheating, the following control measures should be incorporated.

4.2 (continued)

4.2.1 Operating controls should include

A liquid temperature sensor and controller

A liquid level sensor with automatic heater cut-off

An independent excess temperature sensor linked to automatic heater cut-off.

4.2.2 Additional safety features may include a heater sheath over-temperature control, and the use of programmable timer switches to cut off power supply outside normal working hours.

5. EYE-WASH STATIONS AND SAFETY SHOWERS

5.1 Whilst eye-wash stations and safety showers may not be considered to be a part of chemical workstation construction, the provision of such items shall be allowed for in the layout of a total chemical workstation facility. An eyewash station should, ideally, be situated as close as practicable to all chemical workstations.
If it is possible to design an eyewash station into a chemical workstation module then every precaution must be taken to ensure - (a) that the position is adequately protected from the presence of any nearby hazard, and (b) that the position is clearly designated as an eyewash station not to be used for any other purpose.

5.2 Safety showers shall also be situated as close as possible to the chemical workstation area where work with hazardous chemicals is being carried out. An ideal position for a safety shower would be between two chemical workstations as a overall part of the construction with an exit from the shower unit passing into a service or less critical area. This way the clean room environment would not be compromised during any emergency involving the use of the shower.

6. MAINTENANCE PROCEDURES

6.1 As previously stated in the introduction to section 3.8, chemical workstations are often used to ensure compliance with the COSHH Regulations. If so, a systematic programme of examination and testing of the workstation is essential. The recommendations in the Approved Code of Practice relating to Regulation 9 of the COSHH Regulations should be followed.

Fume exhaust systems and plant should generally be thoroughly examined and tested at least every 14 months, and key performance characteristics, such as volume flow and static pressure, compared with design parameters. Detailed records of . ."tests. should be kept, and should be retained Jar at least five years.

6.2 During maintenance and inspection the risk of exposure to chemical and other hazards may tend to be greater than in normal use. Precautions should be taken to minimise this risk.
For example, formal written procedures should be established which will alert personnel to potential hazards, and which set out appropriate measures such as the wearing of personal protective equipment, decontamination, electrical isolation, shut-down of dispensing systems, and posting of warning notices.

Consideration should be given to instituting a formal "Permit-toWork" scheme.

6.3 Functional tests on any installed safety or risk managem ent systems should be carried out periodically. These systems may include:

Fire Protection System, including fire sensors, alarm sounders, and damper operation. [Note that extinquishant discharge must be suppressed during test.]
Emergency Off Button
Extract Failure Alarm
Leakage Detection System.

6.4 Electrical testing of the workstation should include earth loop impedance tests, and trip current and trip time measurements on RGDs.

6.5 A visual inspection of the workstation should also be carried out periodically, and should include:

Removal of worktop panels for examination of the plenum
Removal of any debris in plenum or elsewhere, liable to cause obstruction to extract or drain apertures
Inspection of carcass and ductwork for physical damage and deterioration
Inspection of baths, quartzware and accessories for damage and deterioration
Inspection of plenum base, storage base, ducting and other spillage containment for signs of leakage, which may indicate weld failure or other damage.

7. PERSONAL PROTECTION

7.1 In addition to the comments in Section 3.8 of this Code of Practice, it is important that the use of proper and appropriate personal protection, when working with hazardous chemicals in chemical workstations, is thoroughly understood. Effective protection is only achieved by use of suitable PPE, correctly fitted, maintained and properly used.

7.2 Care must be taken to ensure thatwhilstwearing PPE the operator is notput at risk through limited rnobiliW, or limited visibility. The operator mustbefree.to perform tasks within the confines of the chemica.l workstation, which. may require the lifting of heavy components.

7.3 Consideration should be given to the design and layout of the workstation with the possibility that respiratory protection equipment (RPE) may be required to be worn for specific operations.

7.4 Both the PPE at Work and COSHH regulations require employers to provide appropriate PPE and training in its usage to their employees whenever there is a risk to health and safety that cannot be controlled by other means.

8. BIBLIOGRAPHY

The following pUblications may provide useful information and guidance relating to the safe use of chemical workstations. .

Approved Codes of Practice (available from HMSO and HSE Books)

L5 Control of Substances Hazardous to Health (General ACOP) and Control of Carcinogenic Substances (Fourth Edition) 1993

HSE Guidance Notes

HS(G)37 Introduction to local exhaust ventilation.

HS(G)51 Storage of flammable liquids in containers.

HS(G)54 Maintenance, examination and testing of local exhaust ventilation.

British Standards

BS7258: 1990 Laboratory Fumecupboards

Other Publications

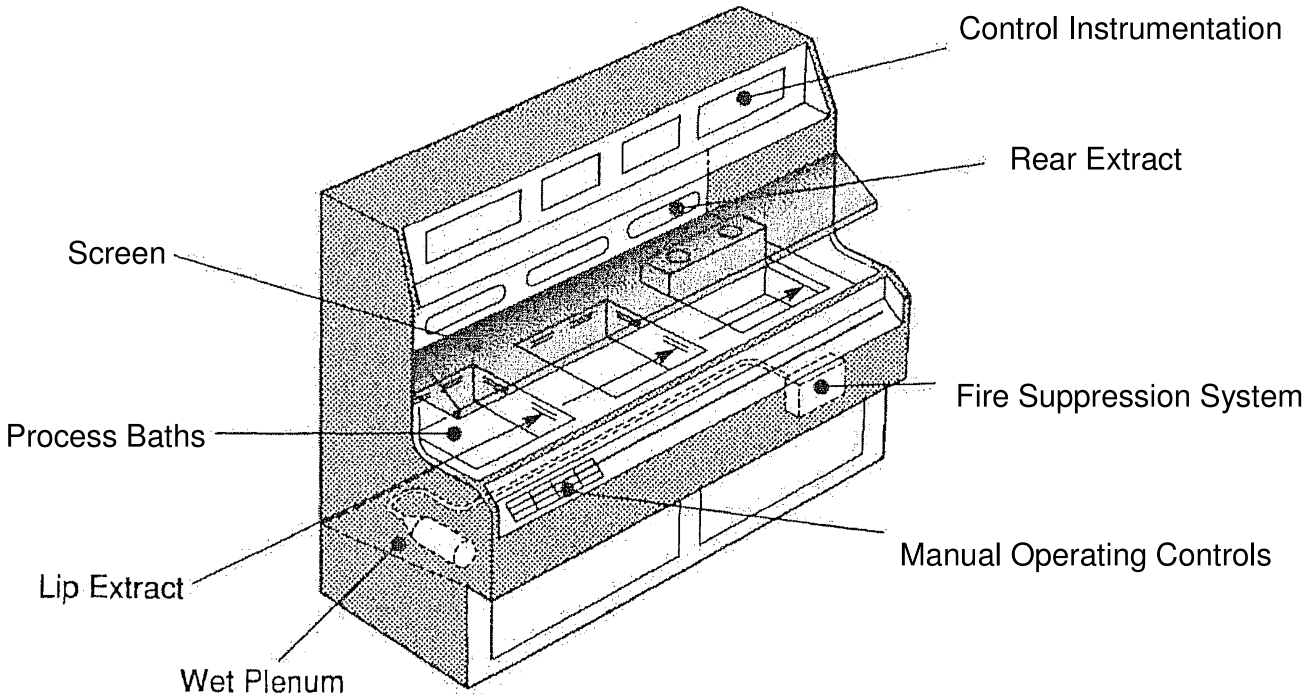
Controlling airborne contaminants in the workplace; British Occupational Hygiene Society, Technical Guide No. 7; Science Reviews Ltd. 1980.

Control of Chemicals in the Workplace - a Guide for Managers; Hayes and Iungus, Tolley Publications Co. 1993

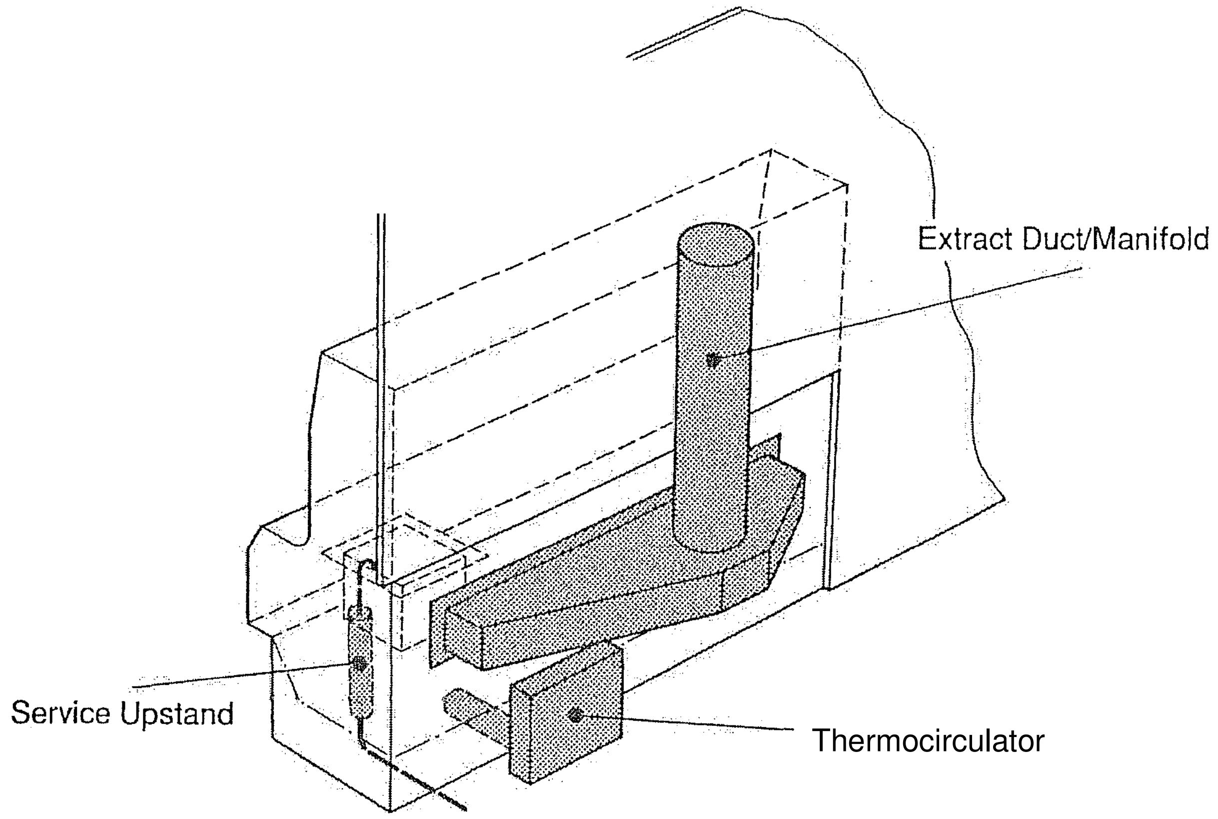
Addresses

'HSE Books, PO Box 1999, Sudbury, Suffolk C010 6FS; Tel; 0787 881165; Fax. 0787313995

APPENDIX A: 1 TYPICAL CHEMICAL WORKSTATION ILLUSTRATION

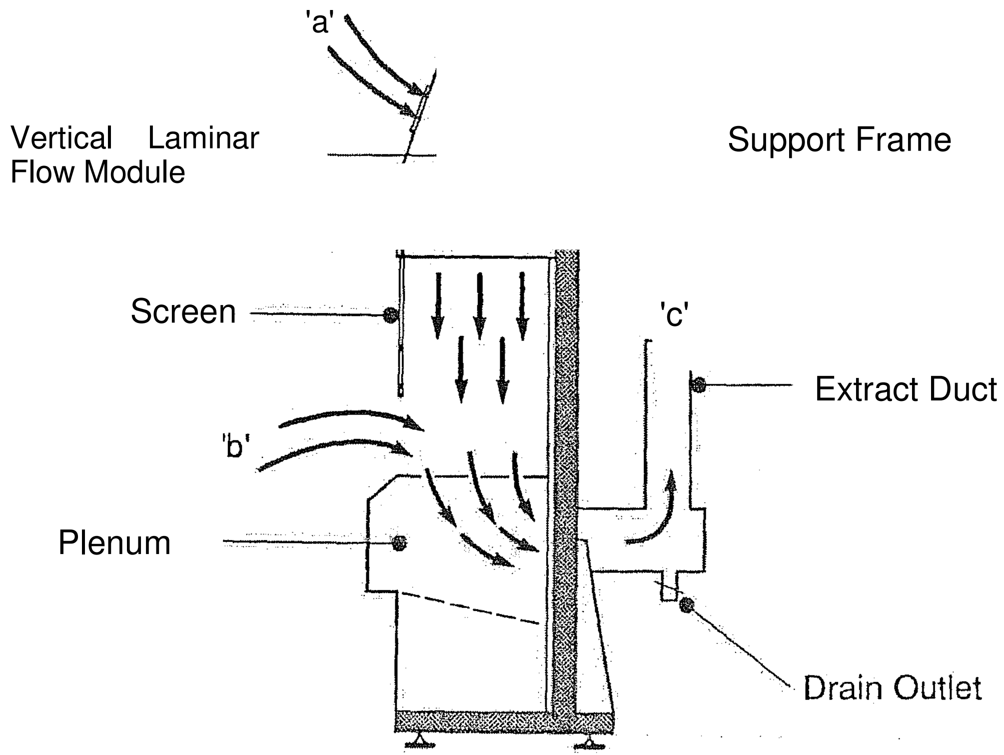


APPENDIX A: 2 TYPICAL SECTION OF CHEMICALWORKSTATION VIEWED FROM SERVICECHASE.



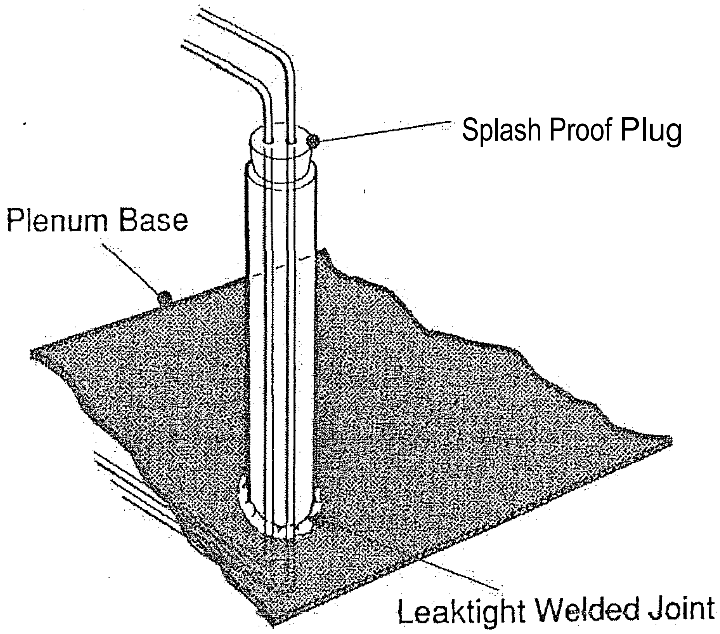
APPENDIX A: 3 CHEMICAL WORKSTATION WITH VERTICAL LAMINAR FLOW

Note: 'a' (Downflow Air Volume) +
'b' (10% of 'a')
== 'c' (Extract Volume)



Section

APPENDIX A: 4 TYPICAL UPSTAND IllUSTRATION



APPENDIX B THE PUBLISHERS

The Semiconductor Safety Association (Europe) operates in the United Kingdom and is a regional organisation of the Semiconductor Safety Association, centred in the United States of America.

Membership of the SSA is drawn from a wide range of high technology industries covering all aspects of the manufacture and use of semiconductor materials and devices. The SSA is active in the United States of America, Canada, Europe, Israel and the Far East including Japan and Korea. Regional organisations in Europe include SSA (Germany).

The Association exists to promote discussion and a *tree* exchange of views and experiences between people involved with health, safety and environmental matters in the semiconductor industry.
Further details regarding membership and general information on SSA(Europe) may be obtained from :

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