A Guide to Wet Bench Safety

Mission Statement:
Promote development and sharing of environmental, health and safety best practices and procedures for entities with integrated circuit processes.

Agilent Technologies / Hewlett-Packard

Wet Bench Guidelines
The information and recommendations contained in this publication were compiled from sources believed to be reliable. However the authors make no guarantees as to the sufficiency or accuracy of the information.

This guideline is intended to show what one company has done to address the issue of wet bench safety. As such it may not include information which is important for a particular user. The primary reference sources used for the guidelines are listed in sections 5 and 6. The reader should consult these sources, other references applicable to their operations, and the appropriate individuals in their organization in order to obtain a more complete understanding of the subject.

Note: This document contains intranet links to internal Hewlett Packard / Agilent Technologies documents that will not be accessible to people outside the company.

This document contains links to International Sematech documents that are available only to Sematech member companies.
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Though this is a guideline, there are some statements that state “shall” or “must”. Those terms are used when there is an enforceable code or standard that states specific requirements. These are referenced in section 6.7.

Exceptions to these guidelines may be considered only after review by the EHS and Facilities departments. Any exception should be documented with assumptions about operating and administrative controls.
1.0 OVERVIEW

The purpose of this guideline is to establish minimum design and performance criteria for wet benches used in semiconductor manufacturing and R&D operations in order to assure that:

1) Employees are not exposed to unsafe levels of airborne contaminants.
3) Environmental impacts associated with wet bench use are minimized.
4) Through proper design and construction of wet benches, fire and electrical hazards are reduced and/or eliminated.

2.0 APPLICABILITY

This document contains the minimum guidelines for new wet benches used in semiconductor manufacturing. Paragraph 6.8 also recommends the minimum safety requirements for existing wet benches. Each site should establish a time-table for bringing existing wet benches up to the criteria specified in Paragraph 6.8.

3.0 DEFINITIONS

3.1 **Capture Velocity**: The air velocity at any point in front of the hood opening necessary to overcome opposing air currents and to capture the contaminated air at that point by causing it to flow into the hood usually measured in feet per minute (fpm) or linear feet per minute (lfm).

3.2 **Chemical bath**: Recessed cavity extending from the deck down into the plenum.

3.3 **Combustible Liquid**: A liquid having a flash point at or above 100 degrees Fahrenheit (37.8°C) and less than 200 degrees Fahrenheit (93.3°C).

3.4 **Combustible Material**: A material that will ignite and act as fuel in a self-sustaining reaction. Polypropylene is an example of a combustible material.

3.5 **Ergonomic design**: Designed to meet SEMI S8-95A (Safety Guidelines for Ergonomics/Human Factors Engineering of Semiconductor Manufacturing Equipment) and H&S Manual, Ergonomics Process Standard.

3.6 **Exhausted Vertical Laminar Flow Hood**: The combination of a vertical laminar flow hood and a wet bench; it is used when both hazard control and particle control are required.

3.7 **Explosion-proof**: Electrical devices meeting National Electric Code requirements for use in potentially hazardous environments (Class I, Division 1).

3.8 **Face**: The cross sectional area through which air flow enters.
3.9 **Face Velocity:** The average exhaust flow velocity at the face of an exhaust hood or enclosure; measured in linear feet per minute (lfm).

3.10 **Fire-safe material:** A material that meets FM4910 protocol. (See FM4910 definition.)

3.11 **Fire Suppression System:** A system designed to automatically discharge fire suppression agent upon the detection of low levels of heat, smoke or flame.

3.12 **Flammable Liquid:** A liquid having a flash point less than 100 degrees Fahrenheit (37.8°C).

3.13 **Flash Point:** The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air.

3.14 **FM 4910 Protocol:** Abbreviation for the specification test standard titled, Factory Mutual Research Corporation (FMRC), Clean Room Materials Flammability Test Protocol (Class 4910). This specification test standard establishes testing procedures and maximum levels for Fire Propagation, Smoke and Corrosive products of combustion. A “fire-safe” material meets the following criteria:

- 3.14.1 Fire propagation Index <6.0
- 3.14.2 Smoke Damage Index <0.4
- 3.14.3 Corrosion Damage Index <2.0

**NOTE:** Email from Factory Mutual in May 1999 indicated the Corrosion Index might be dropped because it was not reproducible.

3.15 **Freeboard:** The distance from the top of the sink down to the liquid’s surface.

3.16 **Freeboard Height:** The distance from the top of the solvent or solvent drain to the top of the sink (Bay Area Air Quality Management District Regulation 8, Rule 30).

3.17 **Freeboard Ratio:** The freeboard height divided by the smaller of the length or width of the sink or reservoir.

3.18 **Hazardous Production Material (HPM):** Any gas, liquid, or solid with a degree of hazard rating in health, flammability, or reactivity of Class 3 or 4 as ranked by UFC Standard 79-3 and NFPA Standard 704-M.

3.19 **Heated Bath:** A heated bath is a bath containing liquids above room temperature. This is achieved by a device used to heat liquids by transferring heat from heating elements to the liquid.

3.20 **Hot Plate:** An electrical heating device that operates by conducting heat.
through the wall of a container and into the liquid.

3.21 **Immersion Heater:** A device used to heat liquids by immersing an electrically heated element directly into the liquid to be heated.

3.22 **In-line IR Heater:** A system to heat liquids. Very useful with large baths of chemicals. The chemical in the bath is circulated and passes through "tubing" that is surrounded by heat-lamp like devices.

3.23 **Laboratory Fume Hood:** A device enclosed on five sides except for the exhaust face which is designed to draw air inward by means of mechanical ventilation, operated with insertion of only the hands and arms of the user, and in which hazardous substances are used. This **Wet Bench Guideline does not apply** to laboratory fume hoods.

3.24 **Laminar Flow Bench:** An enclosure designed to draw, filter (through a HEPA filter), and provide clean air to a work surface. In a vertical laminar flow unit, the air is drawn and filtered through the top of the unit to provide a down-flow of clean air to the work surface. With a horizontal laminar flow unit, the air is drawn and filtered through the rear of the unit across the work surface towards the operator. These units ARE NOT designed for handling or storage of hazardous materials, but rather, for particle control.

3.25 **LFPM:** Linear Feet Per minute. Also abbreviated lfm.

3.26 **LEL:** "Lower explosive limit" is the minimum volume percent of a substance in air that can be ignited. This is synonymous with the Lower Flammable Limit (LFL).

3.27 **LFM:** See LFPM.

3.28 **Lip Exhaust:** Exhaust slots at the top edge of workstation deck.

3.29 **Make-up Air:** Air supplied to a building or a space to replace air that is exhausted.

3.30 **Modify vs Move:** To modify a workstation means that some essential element of the plenum or process operation has been changed, e.g. change chemistry, add heat sources. Moving a workstation without changes to the physical configuration of the bench or its process flow is not considered a modification, e.g. the same bench is used for the same purpose but in a different location.

3.31 **OS&Y Valves:** "Outside screw and yoke" valve-used for isolating a section of an automatic sprinkler system.

3.32 **PEL:** Permissible exposure limit as defined by OSHA.

3.33 **Plenum Exhaust:** Exhaust provided for a workstation cavity.

3.34 **Safe Level:** (referring to airborne contaminant concentrations) \( \frac{1}{2} \) of the Occupational Exposure Level (such as TLV, PEL). The reference in SEMI
S2 to <1% of TLV, PEL is for ventilation design.

3.35 **Significant Modification:** Change of a wet bench that increases the health, environmental or safety hazards. A change in plumbing system, a change in the heating systems or change in sink size is typically a significant modification. Moving a wet bench to a different location is not considered a significant modification.

3.36 **Slot Exhaust:** Slots located above the source, designed to draw contaminants away from the operator.

3.37 **Splash Shield:** Device used to alter the direction of air flow; secondary benefit from the use of a splash shield is that it provides limited protection for the operator against splashes.

3.38 **TLV:** Threshold Limit Value as defined by the American Conference of Governmental Industrial Hygienists (ACGIH)

3.39 **UEL:** "Upper explosive limit" is the maximum volume percent of a substance in air that can be ignited. This is synonymous with the Upper Flammable Limit (UFL).

3.40 **Wet Bench:** A workstation that may be free-standing or enclosed on as many as three sides and is used for chemical processes. The configuration of these units usually includes sink or wells locally exhausted (through the plenum below the deck). In a free-standing unit, the work surface may be partially or completely perforated for exhaust, as well as for drainage of liquids. An enclosed unit will most likely have adjustable slots in the back wall and may also have front lip exhaust.

3.41 **Wipe Sample Results:** The method used to determine if surface contamination is acceptable is taken from the Industrial Hygiene manual. The criteria is: “A wipe standard does not exist, however, one simple generic approach that is often used follows the steps below:

3.41.1 take the airborne standard (e.g., 10 µg/m³ for arsenic, 50 µg/m³ for lead...);

3.41.2 use the average amount of air inhaled during an 8-hr shift, 10 m³;

3.41.3 assuming total retention of the inhaled material during the shift, calculate an effective dose (e.g., 100 µg for arsenic, 500 µg for lead...);

3.41.4 apply it to the typical surface area that is wiped to obtain the sample, 100 cm², to obtain the "standard" for the material (e.g., 100 µg/100 cm² for arsenic, 500 µg/100 cm² for lead.).

3.42 **Work Station:** A space or independent principal piece of equipment using hazardous production materials where a specific function, laboratory procedure, or research activity occurs. Approved cabinets shall serve the

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work station whenever flammable liquids are used. The station may contain ventilation equipment, fire protection devices, hazardous materials sensors, electrical devices, and other processing and scientific equipment.

4.0 DESIGN CRITERIA

4.1 General

New wet benches should be evaluated against the SEMI S2 and SEMI S8 guidelines. Any discrepancies noted during these evaluations should be addressed by the local EHS department. Existing wet benches should be evaluated against the minimal acceptable guidelines listed in paragraph 6.8.

4.1.1 Sinks containing chemicals should be located in the back row of the deck. (Rinse stations are typically in front.)

4.2 Ventilation

The term “adequate ventilation” needs to consider several factors. These include health hazards, fire hazards and quality of workplace issues. In general, ventilation should maintain airborne concentrations in the employees’ breathing zone to below \( \frac{1}{2} \) of occupational exposure limit. (Typically the OSHA –PEL; ACGIH-TLV or other country’s recognized airborne exposure limit.) (Be sure to include maintenance operations also.) Adequate ventilation also should assure concentrations below 10% of the LEL outside of the ventilation exhaust system. This is a “shall” requirement per UFC 5101 unless equipment within 5 feet of the wet bench is constructed to meet Class1 Division 2 electrical requirements. Adequate ventilation can also be defined as the absence of odors if odors are adversely affecting employees and/or adversely affecting production. The absence of chemical odors in the workplace should be a goal. SEMI S2 guidelines recommend controlling exposures to <1% of PEL, TLV in their design criteria.

Adequate exhaust may be achieved through exhaust slots around sinks, lateral exhaust slots in the rear of the bench, plenum exhaust, lip exhaust or any combination.

Laminar flow in a cleanroom environment often means typical ventilation control methods need to be modified to assure adequate exhaust is achieved. Paragraph 6.9 gives some alternative evaluation methods.

4.2.1 To help provide adequate capture velocity, wet benches should have the following design criteria:

4.2.1.1 A splash shield that:

4.2.1.1.1 Hangs down from the vertical laminar flow unit or extends outward from the wet bench control head case toward the front of the wet bench.

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4.2.1.1.2 Is hinged, flexible, removable or slides to allow access to the bench

4.2.1.2 Side baffles that extend along side of the deck

4.2.2 Sinks containing chemical baths should have slot/lip exhaust designed with sufficient velocities to capture and control any airborne contaminants. (See ACGIH Industrial Ventilation Design Criteria – Reference in 23rd edition Page 3-10 Figure 3.9 titled “Flow capture/velocity”)

4.2.3 The face of the wet bench where ventilation face velocities are measured is defined as the plane between the splash shield, the front edge of the sinks containing the chemicals and the side baffles. The average face velocity of the plane should be at least 100 fpm with no point less than 80 fpm and no point should be greater than 120 fpm. Higher flow rates have been shown to cause eddy currents that can actually increase emissions into the employee working area. Higher flow rates also do not support our company’s energy conservation principles. See the H&S Manual, Section 535.082 for evaluation methods. Heated chemicals, carcinogens or compounds with high vapor pressures may need alternative capture methods. Contact your EHS department for determining specific needs for these situations.

4.2.4 A means to determine adequate ventilation should be in place on all wet benches.

4.2.4.1 The preferred device is one that provides a continuous reading. These devices include (but are not limited to):

4.2.4.1.1 Magnehelics,
4.2.4.1.2 Photohelics
4.2.4.1.3 Incline manometers
4.2.4.1.4 Sail switches

Readings must be recorded and documented at least monthly, and records must be maintained for 5 years per corporate Hewlett-Packard/Agilent Technologies H&S manual requirements. If using these methods, an annual check, compared to a primary standard, needs to be completed. Also, these devices must be maintained per manufacturer recommendations.

4.2.4.2 Other methods that meet corporate requirements include quarterly evaluations with velocity measuring devices. (See Hewlett-Packard/Agilent Technologies H&S Manual Section 535.082 for minimum requirements.)

4.2.5 Ventilation performance must be recorded and maintained for 5 years
4.2.6 Methods for Evaluating Ventilation Systems

4.2.6.1 Laminar flow requirements in a clean room often complicates exhaust ventilation measurements. Other test methods may be beneficial in evaluating the adequacy of wet bench ventilation. Paragraph 6.9 describes the various systems. Some alternative methods are:

- 4.2.6.1.1 Dry ice visual observations
- 4.2.6.1.2 Water mist visual evaluation
- 4.2.6.1.3 Tracer gas analysis per SEMI F15
- 4.2.6.1.4 Smoke tubes measurements may also be useful in areas where particulate generation is not a concern.

4.3 Electrical

Electrical installations must conform to the applicable standards (National Electric Code and/or OSHA NRTL Certifications 29CFR1910.303 and .399). Some jurisdictions require a third party electrical certification in addition to the equipment meeting SEMI S2. In Europe, the equipment must meet CE electrical requirements -- EN60204-1 (TEC204-1).

4.3.1 Electrical equipment and devices within five feet of a wet bench in which flammable liquids are used shall comply with the requirements of the NEC for Class I Division 2 hazardous locations. (UFC 5101)

(ЕНЦIЮiЮ):If adequate air removal within the wet bench can provide a non-flammable atmosphere, (less that 10% LEL measured outside of the wet bench) on a continuous basis, the requirement for Class I, Division 2 locations does not apply.

4.3.2 An emergency off device [EMO (emergency machine off) or EPO (emergency power off)] should be installed to interrupt all power to the wet bench in the case of an emergency. This device should be placed in accordance with the recommendations of SEMI S8.

4.3.3 All electric heaters should have ground fault protection (SEMI S3)

4.3.4 Controls should be located away from the wet surfaces and their placement should not require the operator to reach over any hazardous process. Controls should be located in the head case or in front of the wet bench and should meet SEMI S8 guidelines.
4.3.5 Electrical equipment within the head case of the wet bench does not need to meet Class 1 Division 2 requirements if the head case is purged with an inert gas on a continuous basis. {NEC 501-8(a)(3)}

4.3.6 Electric junction boxes, wires and connections should be mounted in a non-combustible surface.

4.3.7 A means of lock-out/tag out should be readily accessible.

4.4 Materials of Construction

4.4.1 Materials used in the construction of wet benches should be compatible with the chemicals and processes for which the wet bench is used.

4.4.2 Materials used in construction should meet FM 4910 protocol. (See definitions) SEMATECH has tested several materials that meet the FM4910 criteria and has determined the materials will not adversely affect production. (SEMATECH TECH TRANSFER DOC #98123623A-ENG) http://www.sematech.org/public/docubase/abstract/3623aeng.htm

4.5 Fire Prevention and Protection

4.5.1 Prevention is the first defense to eliminate fire hazards in wet benches, Protection is the second choice. There are two fire hazards that need to be addressed: 1) The hazard posed by the use of combustible materials in the construction of the bench and 2) The hazard posed by the use of combustible or flammable liquids in an otherwise noncombustible bench. No bench should include both combustible construction and the use of flammable or combustible liquids.

4.5.1.1 New wet benches should be made of fire safe materials – meeting FM4910 protocol.

4.5.1.2 New connections of exhaust ducts and drain lines should be made of fire safe materials.

4.5.1.3 Whenever possible, process liquid heating should be done using heat transfer systems using hot water or other noncombustible heat transfer media.

4.5.2 Fire Protection must be considered when a fire hazard can not be prevented through design.

4.5.2.1 Wet benches with combustible/flammable liquids must have fire protection. Fire suppression systems must be of adequate design. Some examples include fine mist water spray, FM200 and high pressure CO2.

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4.5.2.2 Detection of fire should be accomplished using an UV/IR sensor. When the sensor is activated, the fire extinguisher agent should automatically discharge. In addition, a means to manually activate the fire suppression system should be provided. Discharge of the fire suppression system must activate an audible and visual alarm and disable all electrical inputs to the bench. (UFC97 8003.1.11) However, the exhaust ventilation for the bench should remain functional. (FM7-7 2.5.1.3 fire protection for wet benches and other process tools) In addition to electrical sources, bulk chemical delivery systems and other possible conditions that increase the risk of fire propagation should also be shut down.

4.5.2.3 Wet bench manufacturers and FM should be consulted to properly design a fire suppression system, especially the placement of fire suppression discharge heads.

4.5.2.4 Sprinkler coverage of the horizontal work surface of the wet bench shall not be obstructed. If coverage is blocked (e.g., by vertical laminar flow hoods, sashes, splash shields, etc.), additional sprinkler heads should be installed. In lieu of additional fire sprinklers, a fire suppression system could be installed.

4.5.2.5 Exhaust Ducts

4.5.2.5.1 Exhaust ducts greater than 10” in diameter and made with non-fire safe materials must have sprinkler heads or other approved fire suppression system. The first head shall be placed between the wet bench and the duct damper. It must also be within two feet downstream of the wet bench connection. (UFC Article 5101.11)

4.5.2.5.2 A sprinkler head shall be required if the duct is greater than 10” in diameter and carries flammable gases or vapors. (97UFC5101.11) The ICSG recommends this if >10% LEL concentrations are routinely anticipated.

4.5.2.5.3 Wet benches made of fire safe materials and that do not contain combustible solvents are the only tools exempt from duct fire protection.

4.5.2.5.4 The sprinkler head, and its connecting piping within the duct should be coated with a corrosion inhibitor (such as bee's wax), if necessary, to prevent corrosion. The head should be accessible through an access port.
for periodic visual inspections. Sprinkler heads shall be inspected for corrosion on an annual basis.

4.5.3 For fire prevention and protection of existing wet benches, see 6.6.2.

4.5.4 Maintenance of fire suppression systems.

4.5.4.1 Proper maintenance is important to assure a system will function when needed. Be sure to follow manufacturer’s recommendations regarding routine maintenance.

4.6 Heating Devices

4.6.1 Whenever possible, process liquid heating should be done using heat transfer systems using hot water or other noncombustible heat transfer media. Another option would be to remotely heat the chemicals themselves in a properly designed heat exchanger that is external to the tool.

4.6.2 The heating of any flammable/combustible liquid shall only be done in a noncombustible (metal) bench or tool.

4.6.3 Preventive maintenance and testing of all safety interlock systems should be conducted as follows:

4.6.3.1 At least monthly, low liquid level and high temperature interlocks should be tested to assure proper operation.

4.6.3.2 All electrical connections to heating systems and their controls should be visually inspected at least semiannually. (FM also recommends an IR scan of all electrical components annually)

4.6.4 Heating sources for wet benches should incorporate the following

4.6.4.1 A non-combustible outer jacket/enclosure

4.6.4.2 A liquid temperature control (e.g., thermocouple controller feedback)

4.6.4.3 A heater over-temperature interlock

4.6.4.4 A liquid level interlock

4.6.4.5 A ground fault protection

4.6.4.6 A manual reset

4.6.5 The interlocks listed above should interrupt power to the heating elements and activate an alarm if the set points are reached. Activated interlocks must be manually reset prior to allowing resumed operation of the bath. Float-type liquid level sensors shall not be used for corrosive applications. Optical or capacitance sensors are recommended. All safety devices must be successfully tested prior to the initial use. All safety devices should be placed on a regular
preventative maintenance schedule to be tested at least annually or as recommended by manufacturer or per local requirements. FM recommends monthly checks of interlocks, 7-7 2.4.2, 6a

4.6.6 SEMI S3 and NFPA 318 Paragraph 8-4 should be reviewed for guidelines in the design of heated chemical sinks.

4.7 Ergonomic Considerations

4.7.1 SEMI S8 criteria should be used in the design of wet benches.

4.7.2 If manual filling of sinks is required, systems should be added to the wet bench to eliminate the ergonomic and safety hazards associated with this task.

4.7.2.1 Maximum reach distance to the point of pour - 325 mm (13") (measured from the front edge of the module to the point where the chemical flow from the bottle enters the module)

4.7.2.2 Pour height - minimum 900 mm (35") - maximum 1025 mm (40") (vertical distance from standing surface to average hand position during pour)

4.7.2.3 Hand and arm clearances when pouring - minimum width 550 mm (22"), minimum height - bottle height plus 130mm (5").

4.7.2.4 Visual clearance - If pouring directly into a bath where visual access into the bath is required, the module should be designed such that all operators can view the bath without obstructions and without bending or twisting.

4.7.2.5 If pouring into a module where the level of the chemical is not readily seen or requires non-neutral postures to view, an indicator light or other mechanism for visually alerting the operator that the module is full should be present.

4.7.2.6 Whenever possible, a funnel or other mechanism should be provided to reduce the precision associated with the pouring task.

4.7.2.7 Whenever possible, a funnel or other mechanism should be provided upon which the operator may rest the weight of the bottle during the pour.

4.7.2.8 If a sash is required on a wet bench for proper ventilation design, the minimum opening required is 400 mm (15”). (This may need to be adjusted depending on the height of the work surface and the anthropometric measurements of the operator.)

4.8 Layout Considerations
4.8.1 Wet benches should be designed so that the deck surface is at a comfortable height for the expected operator(s). This should be within a range of 850 to 925 mm (34”-36”). Additionally, the depth of the work surface should range from 450 to 550 mm (18-22”). Depths greater than 550 mm (22”) should include robotics or other reach enhancement designs.

4.8.2 The deck surface of a wet bench should be longitudinally divided into a front (safe) zone, and a rear (hazardous) zone. All chemical processes should occur in the hazardous zone, so operators need never reach over chemical baths. Placement of hazardous processes in the rear of the work station also improves contaminant capture by the local exhaust ventilation.

4.8.3 Aspirators, chemical drains, air or nitrogen guns should be positioned so operators are not required to reach over hazardous processes. Aspirators should only reach the compatible classes for which they were intended. The recommended location would be at the sides of the deck.

4.9 Environmental Considerations

4.9.1 Solvent baths should (This is a requirement in areas that fall under the Bay Area Air Quality Management District) be designed with sufficient freeboard to minimize solvent vapor emissions; this freeboard shall be maintained as long as solvent is kept in the bath. The freeboard height shall be at least 75 percent of the smaller surface of the two dimensions, length or width. [Note: The Bay Area Air Quality Management District requirements state, “All unheated solvent sinks containing VOC with a vapor pressure higher than 30 mm Hg at 20 degrees C AND all heated solvent sinks shall have a freeboard ratio greater than or equal to 0.75, unless one of the following requirements is satisfied. All sinks which are subject to a freeboard ratio requirement shall be clearly marked to indicate the liquid level corresponding to the minimum allowed freeboard ratio and this level shall not be exceeded.”]

4.9.2 All chemical baths should have a lid in place whenever the bath is not in use; this is to prevent evaporation of the chemicals. This lid should be affixed to the wet bench, but should not block or hinder airflow when opened (e.g., a retractable cover). If possible, it is desirable for the lids to be self-closing / normally closed, particularly when solvents are used. [Note: The Bay Area Air Quality Management District requirements state: BAAQMD Regs: 304.1 All solvent sinks containing VOC shall be provided with a cover unless the sink is abated by an approved emission control device as described in subsection 304.5. These covers must remain closed unless production, sampling, maintenance, loading or unloading procedures require

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4.9.3 Wet benches should be designed with means of preventing chemical spills. This may include lips or sills, or diversion to secondary containment or a drainage system.

4.9.4 Consider various exhaust abatement systems when installing a wet bench. Point of use systems may have the highest destruction efficiency and lowest cost. Also, separation of exhaust streams is warranted, i.e. solvent versus corrosive. Separation of acidic and alkaline exhaust also is warranted if your site has opacity issues. This typically is caused by ammonia and chloride combining in the exhaust stream.

4.10 Chemical Use

4.10.1 Quantities in a wet bench (workstation) shall not exceed:

4.10.1.1 * 15 gallons of flammable, combustible, or poisonous liquids.

4.10.1.2 * 25 gallons of corrosive liquids.

4.10.1.3 * 12 gallons of oxidizing liquids.

4.10.1.4 * 20 pounds of corrosive or oxidizing solids.

* UFC Article 51 allows a doubling of these quantities if a filtering system (re-circulation system) is connected to the wet bench.

4.10.2 Baths of incompatible chemicals should not be contained within the same wet bench. If there is a need to have baths of incompatible chemicals within the same wet bench, then a physical separation between incompatible chemicals shall be provided to prevent contact in the event of leakage or breakage occur. Any exceptions shall be reviewed and approved by the local EHS department.

4.10.3 Canisters used to dispense chemicals should be constructed with a material compatible with the chemical(s) being used or stored.

4.10.4 Pressurized containers of hazardous production materials shall meet the following criteria:

4.10.4.1 Be placed in a fully ventilated enclosure.

4.10.4.2 The canister shall be constructed of at least 18 gauge (1.2mm;0.0478”) steel for flammable and combustible chemicals.

4.10.4.3 Piping between the canister and the wet bench must be secondarily contained. (i.e. a spill tray – coax piping not required.)
4.10.4.4 If the chemical is flammable, the additional criteria must be added to the design. (UFC 7903.1.3.5)

4.10.4.4.1 Tubing must be metal braid/Teflon, flexible steel, or welded metal tubing. If chemical compatibility issues need the tubing to be of combustible materials, the outer piping needs to be of fire safe material.

4.10.4.4.2 Pressurized containers of Class 1 and Class 2 flammables are allowed in containers of less than 20 liters (5.3 gallons).

4.10.4.4.3 If dispensed using pressure, the gas must be inert.

4.10.4.4.4 The canister must have a pressure relief device.

4.10.4.4.5 Bonding and grounding procedures must be in place.

4.10.5 All chemical containers shall be marked with approved hazard communication labels. Approved labels include chemical identity and hazard warning appropriate to that chemical.

4.11 Other Issues

4.11.1 Decommissioning and decontamination of wet benches should be completed before they are removed or shipped. (For a recommended procedure see paragraph 6.6)

4.11.2 If ozone is used in the wet bench, the ICSG Semiconductor HPM Gas Safety Standard should be reviewed regarding delivery and monitoring recommendations.

4.11.3 A New Equipment Purchase process (Hewlett-Packard/Agilent Technologies H&S Manual Section 535.100) shall be followed with each purchase requisition for a wet bench. A form addressing this process must be reviewed and approved by EHS, or their designated representative, before a purchase order is issued. It is strongly recommended that arrangement be made with equipment suppliers to review internal requirements prior to the construction of the tool. See paragraph 6.4 for an example of the new equipment purchase process.

4.11.4 Prior to equipment being released to engineering and production, an EHS review and check sheet should be completed. See paragraph 6.5 as an example.

4.11.5 Seismic Considerations -- Wet bench construction must be designed to withstand general seismic activity expected in the local seismic rating zone. In seismic zones, wet benches must be seismically braced against movement that would damage chemical lines, drain lines, and exhaust connections. For additional seismic considerations, see SEMI

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5.0 REFERENCES AND TECHNICAL GUIDANCE

5.1 See Code Reference Table (paragraph 6.7) for specific code references


5.3 Water Mist Generator Procedure


6.0 Guidance Documents

6.1 Wet Bench diagram and terms

- Magnehelic
- Headcase
- Wet Bench lateral exhaust slots
- Robot Arm For Wafer
- Open Front with hinged shields and plexi-glass sides
Wet bench diagram and terms

Rear Bath
Process Chemical

Face plane of wet
bench – for face
velocity measurements

Front Bath/
Water
6.2 Fire Suppression Systems

6.2.1 Refer to the FM 7-7 17-12 Semiconductor Fabrication Facilities Loss Prevention Data Sheets. Section 2.5 of the May, 99 version discusses Fire Protection for Wet Benches and specifically the requirements for fine mist water spray, CO2 and FM200.

6.3 Acceptable Heating Sources

6.3.1 Refer to the FM 7-7 17-12 Semiconductor Fabrication Facilities Loss Prevention Data Sheets. Section 2..4.2 Process Liquid Heating Equipment of the May, 99 version for FM’s recommendations.

6.4 Capital Equipment Purchase Process

6.4.1 The Hewlett-Packard/Agilent Technologies H&S manual forms can be found in section 5 of the following New Equipment Purchase document.

6.5 Installation and Start-up Permit

6.5.1 The following SEMATECH Document can be used as a guideline.
http://mirror.sematech.org/public/docubase/abstract/3579axfr.htm

6.6 Equipment Decontamination / Decommissioning procedures

6.6.1 See the Wet Bench Removal Procedures flowchart.
Wet Bench Removal Procedures

(Before Disconnecting Drain lines or Exhaust Ducts)

1. Designate process personnel to clean sink.
2. Clean inside horizontal and vertical surfaces thoroughly to remove any chemical residues. Wipe air plenum surfaces. Flush sink plenum. Flush Drain (1)
3. Test surfaces with pH paper and a few drop of clean water.
4. Were Corrosives in use?
   - Yes: Test surfaces with pH paper and a few drop of clean water.
   - No:
     - Metals or metal salts in use:
       - Yes: Close exhaust damper and tape off exhaust from inside of the hood.
       - No: Request EHS to take wipe samples.
     - Is pH >9 or <5:
       - Yes: Request EHS to take wipe samples.
       - No: Request EHS to take wipe samples.
5. Results: Below criteria(2)
6. Close exhaust damper and tape off exhaust from inside of the hood.
7. Remove air velocity tags carefully and send to health and safety Dept. Send original to HVAC
8. Remove and dispose of chemical labels, sink number and process notes etc from sink
9. Place a “Safety Shutdown Tag” on equipment
10. Environmental attaches decontamination tag
11. Submit WO to facilities for physical removal of sink from area
12. Facilities to disconnect drain services and cut exhaust connection
13. Facilities to cap all disconnected services
14. Facilities to dispose of sink as a Non Hazardous waste
15. Facilities to evaluate for possible exhaust re-balancing

(1) For benches containing corrosives, rinse with water. For benches containing organic solvents, rinse with appropriate solvent.
(2) See Definition “Wipe Sample Results”

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# 6.7 Wet Bench Code Reference Table

<table>
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<td>Chemicals in back Row</td>
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<td>4.2 Ventilation</td>
<td>≤50% OEL</td>
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<td>&lt;10% LEL</td>
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<td>Electric heaters need GFCI</td>
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<td>4.4 Materials of Construction</td>
<td>Meets FM4910 protocol</td>
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<td>4.5 Fire Prevention and Protection</td>
<td>Non-combustible heat transfer mechanisms</td>
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<td>Fire protection for flammable liquids</td>
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<td>4.6 Devices</td>
<td>Heating Devices</td>
<td>Process liquid heating using noncombustible heat transfer media</td>
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<td>The heating of any flammable/combustible liquid shall only be done in a noncombustible (metal) bench or tool</td>
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<td>Preventive maintenance and interlock check</td>
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<td>Float-type liquid level sensors shall not be used for corrosive applications</td>
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**Wet Bench Code Reference Table**

**Required** | **CA Code** | **Guidelines**
---|---|---
Unobstructed sprinkler coverage | X | X |
Sprinkler for exhaust ducts >10" | X | | X X |
Corrosion inhibitor coated sprinkler head in exhaust duct | | | X |
Shut down of power sources upon fire suppression discharge | | X |
Local Alarm for Fire suppression systems | X | | X |

---

**Wet Bench Guidelines**

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### Wet Bench Code Reference Table

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<td>Ergonomic Considerations</td>
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<td>Front safe zone and rear hazardous zone</td>
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<td>Position of aspirators, chemical drains, air/nitrogen guns</td>
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<td>Environmental Considerations</td>
<td>Manual filling of sinks</td>
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<td>Freeboard ratios</td>
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<td>Lid on chemical baths</td>
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<td>Design for preventing chemical spills</td>
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<td>Exhaust abatement and separation</td>
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<td>Chemical Use</td>
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<td></td>
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<td>Incompatible Chemical not allowed in the same bench</td>
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<td></td>
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<td>Canister's construction material must be compatible with chemical</td>
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<td></td>
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<td>Requirements for pressurized containers</td>
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# Wet Bench Code Reference Table

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<tr>
<td></td>
<td>Labeling of containers</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Other</td>
<td>Decommissioning procedures</td>
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<td>EHS review prior release of equipment</td>
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Agilent Technologies
6.8 Recommendations for existing Wet Benches

6.8.1 The following table gives the ICSG’s recommendations for existing wet benches.

### Recommendations for Existing Wet Benches

<table>
<thead>
<tr>
<th>Chemical Usage</th>
<th>Flammable or combustible</th>
<th>Non-flammable or non-combustible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material of Construction</td>
<td>fire safe material</td>
<td>non - fire safe material</td>
</tr>
<tr>
<td>Heating Source</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Automatic Shut Down Device (1)</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Manual Shut Down Device (2)</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Wet bench fire suppression system (3)</td>
<td>Prohibited</td>
<td>R</td>
</tr>
<tr>
<td>Exhaust duct fire suppression system (4)</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

(1) Automatically shuts down power (i.e. electrical, pneumatic, chemical dispense) within the wet bench upon detection of flame or over-temperature condition.

(2) Shuts down power (i.e. electrical, pneumatic, chemical dispense) within the wet bench upon activation of manual button.

(3a) Fire suppression system covers deck, plenum and headcase (if not under inert purge) (This is in addition to house sprinkler system)

(3b) Unobstructed sprinkler protection required

(4) When required, duct material must be of fire safe material and must have sprinkler system in exhaust ducts of >10" diameter within 2 feet downstream of the wet bench/exhaust duct connection.

6.9 Visual Exhaust Check Procedures

6.9.1 Specific guidance for the construction and use of water mist generators can be found in the document titles “Water Mist Generator – Construction & Use.” See the following for additional information. [http://sjntweb1.sj.hp.com/icsg/water-mister.pdf](http://sjntweb1.sj.hp.com/icsg/water-mister.pdf)

6.9.1.1 Guidance on the professional methods for visual checks of exhaust ventilation systems can be found in D.J. Burton’s “Semiconductor Exhaust Agilent Technologies
Ventilation Guidebook” (ISBN 1-883992-08-7), in the chapter titled, “System testing and Monitoring.” The System Testing & Monitoring section of the guidebook contains a paragraph on qualitative tests, including: smoke, water mist, dry ice, etc. This guidebook is designed to be used in conjunction with the ACGIH “Industrial Ventilation Manual.” See attached images.)

6.9.1.2 SEMATECH conducted a study regarding exhaust optimization of wet benches. That information can be found at the following web site.

Sample Specification No. 2

Wet Station Ventilation: Semi-quantitative Test
(after Campbell, see References)

Scope: The method may be used on automatic and manual wet station hoods installed in full HEPA-ceiling cleanrooms.

Equipment: Velometer, DI water vapor generator and a hose with a "T" type wand. (Figure 1), tape measure, recording forms. [If the hood is not equipped with a hood static pressure measuring device, a pitot tube and manometer will also be required.]

Method: 
(1) Visual inspection. Check to see if the hood station is installed correctly. The hood should be configured as shown in Figure 2.
(2) Ventilation measurements. a. Using the velometer, determine the velocity across the plane of penetration. See Figure 3. Divide the total plane area into smaller equal areas and measure the velocity in the center of each area. Average the measured velocities. (3) Area Measurement. Measure the width and length of the plane of penetration. Calculate the total area. (4) Estimation of Q. Multiply Aplane x Vaverage to estimate the volume flow rate Q. (5) Estimation of Q per foot. Divide Q by the length of the section. [Compare this to the hood specifications.] (6) Hood Static Pressure. Record or measure the hoods static pressure. [Compare this to the hood specification.] (7) HEPA supplied First Air measurement. Using the velometer, measure the velocity of the "laminar" air flow directly above the bench. [Velocities of 80-100 fpm are common.] Check several different locations to assure that supply air velocities are uniform across the entire hood.

Vapor test containment measurements. (1) Laminar air split at bench lip. Place the water vapor wand on the front lip of the bench so that the visible vapor trail points vertically. Move the wand in and out from the lip and observe the vapor trail. The vapor should form a Δ-shape just outside the lip. At this location half of the vapor should enter the hood and half should travel down in front of the bench.

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The vapor trail (Δ) should not be located inside the lip or too far into the aisle. When placed 3-4 inches inside the lip, vapor should not exit the front of the hood. (2) Vertical pluming over wells and baths. Place the vapor wand in or over the center of each well with the plume pointed vertically. [Note: Standing in front of the hood may help simulate the actual conditions when the operator stands in front working.] The vapor should rise 3-4 inches and turn down and be collected by the lip exhaust slots, or turn towards the back of the hood. The vapor should not linger over the bath, rise significantly, or exit the front of the hood. For manual stations, place your hand over the vapor plume. The plume should not travel up your forearm into your chest area or escape the hood. [Similar tests can be performed with the robot arm.] (3) Test for section isolation. Place the wand along the leading edge of the side shield separating sections of the bench. Vapor should be contained within the section. (4) Test for unidirectional flow. Place wand so vapor is generated directly into the First Air alongside the headcase. Move the wand slowly from side to side. Vapor should flow uniformly downward along the wall and smoothly into the hood face. The transition from “push” to “pull” can be observed and should be near the plane of penetration. Eddy currents are suggestive of problems. Vapor flowing into and out of the plane of penetration fails the hood test.