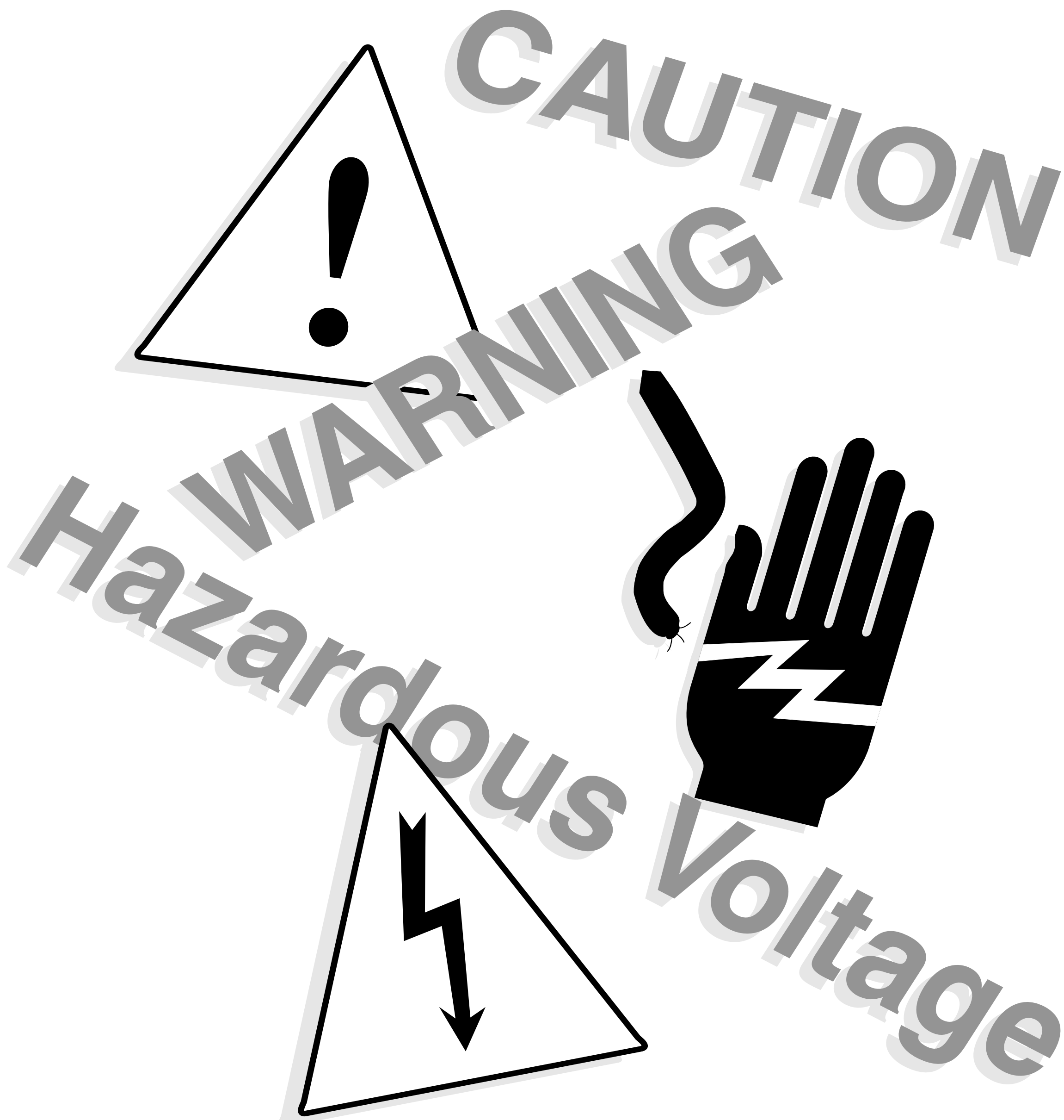
Domino/2300

Safety



Lam RESEARCH

Revision F

Domino/2300™

Safety

BOM Version 571-810271-001

Domino Software Version 1.3

Revision F
September 2000

Revision A July 1998—First Printing (DCN Control)

Revision B September 1998—Second Printing

Revision C February 2000—Third Printing

Revision D March 2000—Fourth Printing

Revision E August 2000—Fifth Printing

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Part Number: 406-240390-002

Safety Preface

The safety guidelines for the equipment in this manual do not purport to address all the safety issues of the equipment. It is the responsibility of the user to establish appropriate safety, ergonomic, and health practices and determine the applicability of regulatory limitations prior to use. Potential safety hazards are identified in this manual through the use of words Danger, Warning, and Caution, the specific hazard type, and pictorial alert icons.

Hazard Levels

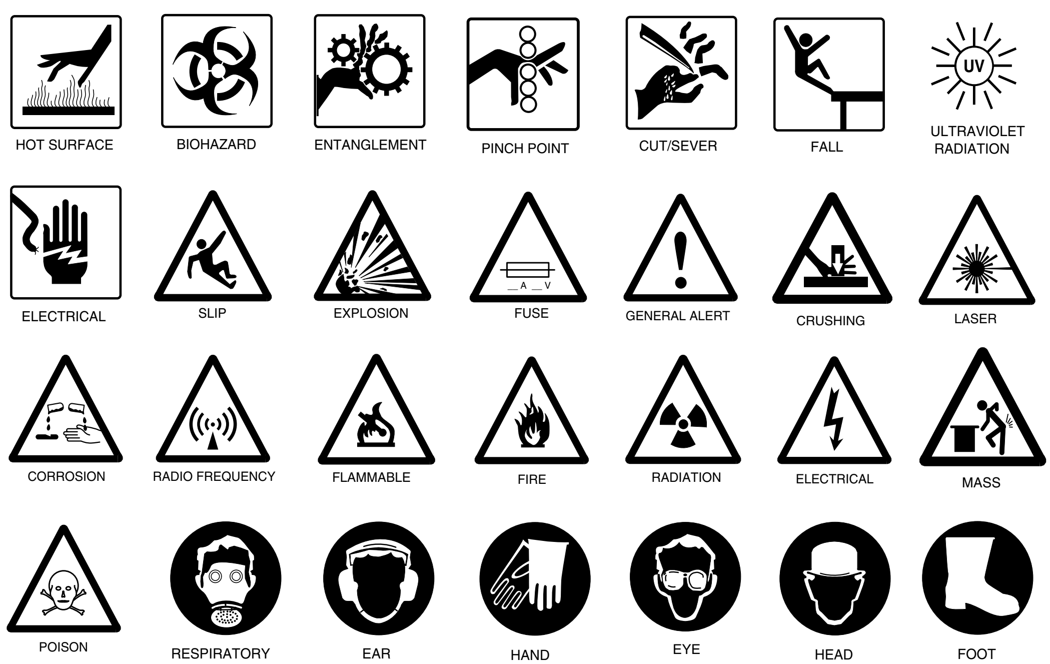
Danger: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This is limited to the most extreme situations.

Warning: Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution: Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It may also alert users against unsafe practices.

Notice: Indicates a statement of company policy (that is, a safety policy or protection of property).

Pictorial Alert Icons



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Domino/2300™

Safety

BOM Version 571-810271-001

Domino Software Version 1.3

Cleanroom Version

Revision F
September 2000

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Revision B September 1998—Second Printing
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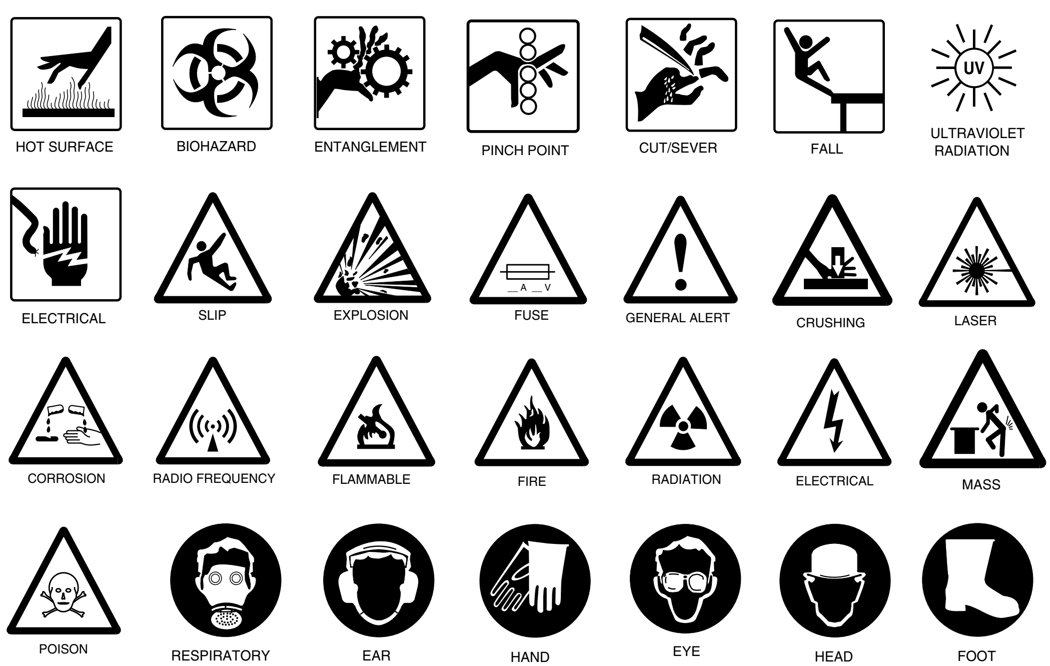

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Contents

Figures

Tables

1
Overview

This manual provides safety information on all Domino/2300 systems available from Lam Research.

The equipment designed and manufactured by Lam uses potentially hazardous energies and substances. Although these systems have been designed to limit the risks associated with these hazards, service and maintenance personnel must still exercise appropriate caution when performing their tasks. The purpose of this manual is to provide service and maintenance personnel with information to aid them in avoiding these hazards when interacting with the system.

While this manual is intended to cover the different hazards associated with the Domino/2300 systems, not all scenarios may be addressed. When faced with a potentially hazardous situation that is not addressed by this manual, personnel should immediately contact their Lam representative.

Manual Conventions

The safety information is presented in more general terms in the forward chapters of the manual, and becomes more descriptive in the individual system chapters.

Changes Since Last Revision

Revision F includes the following changes:

- Updates Chapter 1, "Overview."
- Updates Chapter 2, "Safety Systems."
- Updates Chapter 8, "2300 Poly Process Module."

- Updates Chapter 9, "2300 Poly PM Industrial Hygiene Report."
- Updates Chapter 10, "2300 Metal Process Module."
- Updates Chapter 12, "2300 Strip Process Module."

2
Safety Systems

Lam equipment is equipped with active features that enhance operator and service technician safety, and help to protect persons and property against human error and component failure.

Training

All personnel must have the appropriate safety training.

Emergency Off

All Lam systems include an emergency off (EMO) system to disconnect power when an emergency occurs.

On the Domino/2300 system, large, red palm-sized buttons are positioned a maximum of 10 feet apart. **EMO** buttons are positioned on the UI, the front right side of the TM, and if PM 4 is not installed, a third button is on the PM 4 facie. When any of these **EMO** buttons is pushed, the system is turned off up to the load terminals of the main contactor.

When the EMO is activated for the UPS option, power is shut off up to the load terminals of the main contactor and to the load terminals of the external (customer provided) UPS main contactor.

The voltage for the EMO circuit is 24 VAC and limited to 1 ampere. The circuit is located in the power/control rack.

The global EMO distribution is located at the AC distribution rack. The remote power distribution box (RPDB) reports its EMO state to the global EMO distribution. The PM pump and TCU **EMO** buttons report to the RPDB. The EMO circuit in the AC distribution rack is 24 VAC and limited to 1 ampere. The EMO circuit transformer provides power to the EMO loop for all EMO contacts and all contactor pilot relays, exclusively.

Power to the EMO transformer and associated circuitry remains on after the EMO system is activated.

All EMO events require manual recovery, which means that personnel must go to the module that generated the EMO event to verify a safe condition.

Remote Power Distribution Box

The remote power distribution box (RPDB) assembly is a standard component of each system. It includes the main circuit breaker and circuit breakers for the TCUs and PM dry pumps.

All electrical connections must comply with the requirements of the NEC and local standards.

Typically, certified journeymen electricians install power distribution systems.

The user is responsible for distributing power from the main power/ control rack to the RPDB.

EMO Limitations

Following are the limitations of the EMO system when it is activated:

- When AC power to the turbo pump controller is disconnected, the controller will continue to operate for a few minutes while the pump spins down.
- Power to the system computer is not immediately disconnected. The internal uninterruptible power supply (UPS) supplies power for several seconds then turns off.
- Power to the pressure controller valve of the process module continues (with internal batteries) until the valve is fully closed, then the power turns off.

- Power to the EMO transformer and associated circuitry remains on after an EMO event.
- CB0 (main power) must be open when you are working inside the AC enclosure.
- If the system has the UPS option, some power may be present inside the AC enclosure. CB0 (main power) and the UPS main CB must be open when you are working inside the AC enclosure.

Figure 2–1 shows the interconnections between the TM and PM, and RPDB EMOs. Figure 2–2 shows the electrical connections of the TM and PM EMOs.

Figure 2–1. EMO Interconnect Diagram

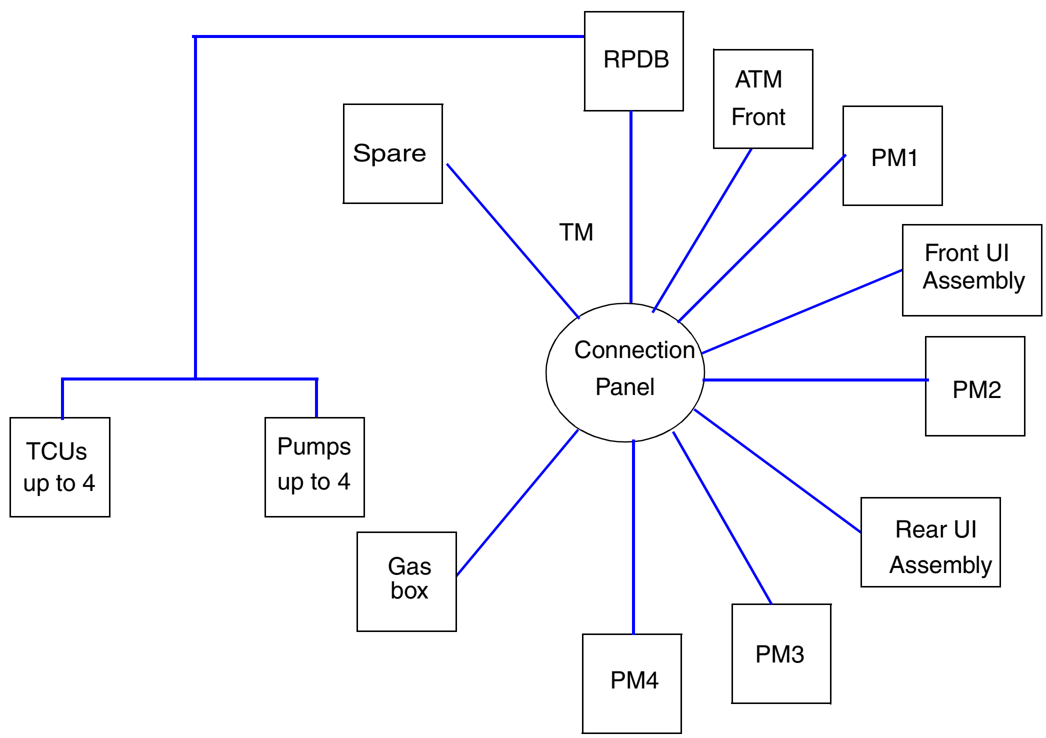
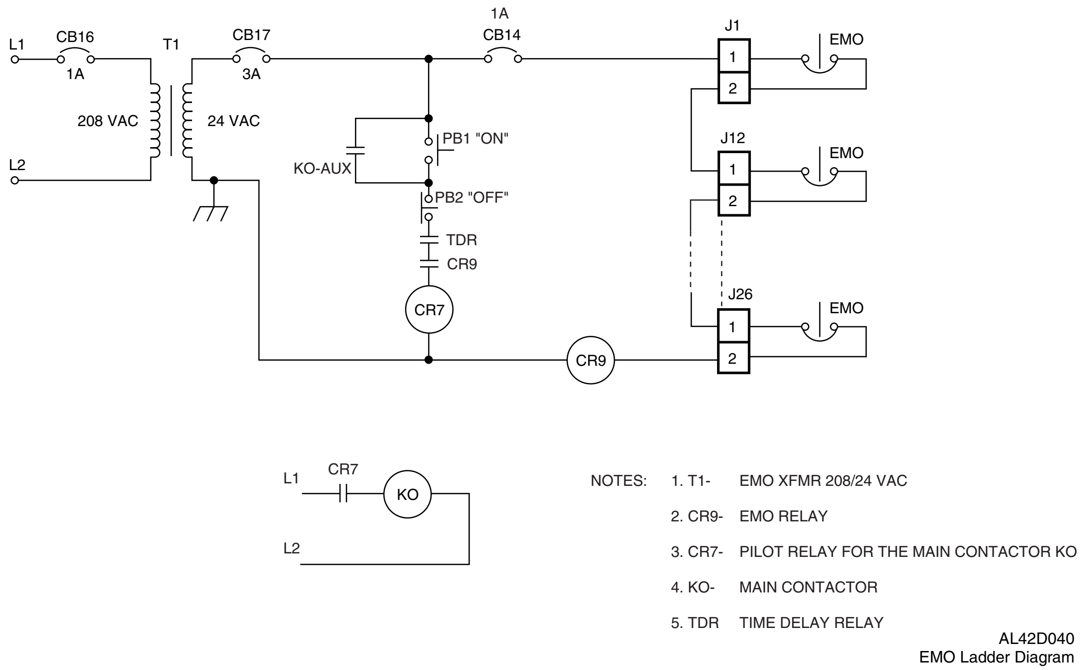


Figure 2–2. EMO Ladder Diagram



Lockout/Tagout for Main Circuit Breaker Disconnect Handle

A lockout is a method of keeping equipment from being energized and endangering workers.

Use standard lockout devices for main circuit breaker handle lockout and tagout. The main circuit breaker handle shall be placed in the safe position (OFF). A lock shall be attached to the handle (special opening are dedicated for that) so that the equipment cannot be energized.

In a tagout, a written warning shall be attached to the lockout device.

Lam recommends that you carefully follow the lockout and tagout procedures described in this manual before servicing the TM. These procedures must be performed only by authorized technicians.

The 2300 system provides signal "EMO circuit closed" to the remote control unit. This signal is generated by normal opened dry contacts of a relay which are connected to pins 1, 2 of the AC rack connector J28.

The 2300 system can connect your EMO device into the system's EMO daisy-chained circuit, using the AC rack connector J34.

Note The 2300 system is required to be bottom facilitied based on the industry standard. The main disconnect device is mounted with line terminals down and load terminals up.

You should obtain from a local jurisdiction, if necessary, a "code variance" in advance.

Environmental Regulations

Environmental regulations and requirements vary by the geographic location or governmental jurisdiction in which the product is installed.

Environmental requirements for process equipment include the following categories: air emissions (HAPs, PFCs, VOCs), water effluent, and solid or liquid hazardous wastes. In addition, semiconductor industry developed performance requirements are emerging in the areas of water and energy use efficiency. Lam participates in and tracks these developments.

Material Safety Data Sheets

Lam recommends that Material Safety Data Sheets (MSDS) be obtained from the chemical suppliers and maintained in the manual.

Point-of-Use Abatement

Point-of-use (POU) emission abatement systems treat air emissions from specific semiconductor processes. A typical POU system may serve one to four similar process modules. POUs remove compounds of interest before they enter the facility's main exhaust ducts. By contrast, facility-level abatement systems treat the collected exhaust of an entire facility or a large area within it.

Several types of POU systems treat specific classes of effluents such as HAPS. Currently, Lam is engaged in several research and development efforts for these systems.

The SEMATECH transfer document, *Point-of-Use Control Systems for Semiconductor Process Emissions*, provides guidance in the identification and selection of POU systems for particular process applications. In all cases where POU equipment is used with Lam products, it is essential that the user investigate and comply with all environmental regulations of the jurisdiction where the equipment is installed.

HAPs Regulation Management

Some qualitative and quantitative HAPs emissions data for the Domino transport module exists.

Hazardous Waste

Some of the maintenance procedures for the Domino/2300 system expend waste products. Treat all waste as toxic. If disposal is required, please observe the proper OSHA-approved or facility-approved disposal practices.

Table 2–1 shows the chemical byproducts accumulated during regular maintenance of the process modules:

Table 2–1 .Hazardous Materials Used for Preventive Maintenance

Material	Quantity per wet clean
6 percent H2O2 with DI H2O on 40 each 9 x 9 lint-free polyster wipes	
Isopropyl alcohol on 20 each 9 x 9 lint-free polyester wipes	
Dry wipes (9 x 9 lint-free polyester)	20 each
Latex gloves	12 pairs
Nitrogen and inline gas filters (796-091775-001)	1 each

Ergonomics

Use proper lifting and handling techniques when working on the system. Improper ergonomic handling may result in injury. Some tasks outlined in this manual may require excess reach by personnel of shorter height. Lam recommends the use of a suitable foot stool, stepladder, or appropriate means when performing these tasks.

Energized Electrical Work Types

The *Environmental, Health, and Safety Guidelines for Semiconductor Manufacturing Equipment* (SEMI S2-0200) defines four types of electrical work. The four types are as follows:

Type 1	Equipment is fully deenergized.
Type 2	Equipment is energized. Energized circuits are covered or insulated. Type 2 work includes tasks where the energized circuits are or can be measured by placing probes through suitable openings in the covers or insulators.
Type 3	Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are no greater than 30 volts alternating current (VAC) root mean square (RMS), 42.4 VAC peak, 60 volts direct current (VDC), or 240 volt-amperes in dry locations.
Type 4	Equipment is energized. Energized circuits are exposed and inadvertent contact with uninsulated energized parts is possible. Potential exposures are greater than 30VAC RMS, 42.4VAC peak, 60 VDC, 240 volt-amperes in dry locations. Potential exposures to radio-frequency currents, whether induced or via contact, exceed the limits in Table A5-1 of Appendix 5, SEMI S2-0200.

The applicable electrical work types are indicated in the Safety section at the beginning of each procedure.

Lockout/Tagout

A lockout is a method of keeping equipment from being energized and endangering workers. When using lockouts the following conditions may exist.

- A disconnect switch, circuit breaker, valve, or other energy-isolating mechanism is put into the safe or off position.
- A device is often placed over the energy-isolating mechanism to hold it in the safe position.
- A lock is attached so that the equipment cannot be energized.

In a tagout, the energy-isolating device is placed into the safe position and a written warning is attached to the device.

Lam recommends that you carefully follow the lockout and tagout procedures described below before servicing the unit. These tasks should only be performed by qualified and authorized technicians.

Note Use standard lockout devices for pneumatic and liquid lockout/tagout.

Electrical Isolation

Shutdown

▶ **To shut down the system for electrical isolation,**

1. Before servicing, inform all affected personnel that the unit is to be shut down for servicing, and that all electrical power sources are to be locked out.
2. Shut down the unit using normal shutdown procedures. See *2300 Poly Process Module Operation*.
3. Lock all the electrical power sources in the disconnect position with a padlock that you can only open with a key.

Note Power to the EMO transformer and associated circuitry remains on after an EMO event. Always lockout/tagout the main circuit breaker in the AC rack when working inside the AC or DC box.

4. Attach written warnings to the locking devices.
5. Verify that all electrical power has been disconnected by attempting to restart unit at the control panel, and by observing that the *power on* light is off.

Start-up After Servicing

▶ **To start-up after servicing,**

1. Check that you remove all hand tools and other foreign objects from the unit.
2. Restore all guards and enclosure panels to their normal operating positions.
3. Check the area around the unit to ensure that all personnel are at a safe distance.
4. Verify that all controls are in the off or neutral positions.
5. Remove the locks and tags that were placed on the electrical power sources.
6. Notify all area personnel that unit is to be energized.
7. Energize the unit.

Process Gas Isolation

You generally need to isolate the process gas when performing maintenance on a gas panel or when opening the gas delivery system.

Be sure to remove hazardous gases from gas panel (gas box) prior to servicing.

Shutdown

▶ **To shutdown the process gas,**

1. Close the manual gas supply valve(s) on the inlet side of the gas panel.
2. Apply a locking device over each gas supply valve handle and lock with a padlock that you can only open with a key.
3. Attach written warnings to the locking devices.

Start-up After Servicing

▶ **To start-up after servicing,**

1. Unlock and remove the locks and tags on each gas supply valve handle.
2. Open the manual gas supply valve(s) on the inlet side of the gas panel.

Chemicals Used During Maintenance

The following chemicals are used in the maintenance of the process module:

- Isopropyl alcohol (IPA)
- Deionized (DI) water
- Hydrogen peroxide solution (for tungsten only)
- Fomblin® grease
- Hydrogen fluoride

Lam Recommendations

▶ **Use the following guidelines when performing routine maintenance on the reaction chamber:**

1. Wear appropriate protective gear, including arm guards, apron, goggles, and solvent-compatible gloves. This protective gear is essential to protect against human contact with toxic materials and vapors.
2. Clear the surrounding area of all personnel not wearing appropriate protective gear.
3. Prepare the chamber for pump and purge cycles by running the plasma clean recipes.These plasma clean recipes were developed to help neutralize chlorine-based by-products in the chamber prior to opening.

4 Perform a nitrogen purge before beginning work on the process chamber or any chemistry-carrying parts. Perform a minimum 60 pump-and-purge cycles prior to opening a chamber configured for non-toxic gases, and 240 cycles for systems using hydrogen bromide. If you run a plasma clean just before opening the chamber, then 60 cycles is sufficient. Because fab operation procedures vary, industrial hygiene air sampling tests are advised and/or required when qualifying specific procedures to ensure compliance with TLV and PEL specifications. Consult the maintenance procedures for details. The pump-and-purge process is vital to reducing toxic chemical concentrations.

5 Perform maintenance activities in a well ventilated area. Air circulation will help prevent excessive build-up of vapors due to the residual chemistry that may remain after the pump-and-purge cycles have been performed.

Potentially Hazardous Operations

Some procedures required for system maintenance involve potentially hazardous operations. Specific hazards are indicated by warning labels on the system and by prominent warnings and cautions in the system maintenance and operation manuals. Safety information, including the electrical state of the system during a given procedure, if applicable, is provided at the beginning of each procedure in the system maintenance manual. Operators and maintenance technicians need to be aware of potential hazards and applicable safety information, and take appropriate precautions.

All systems should be operated and maintained by qualified personnel only. Failure to observe this important restriction could result in death or injury to persons or damage to equipment. Lam offers extensive training courses to ensure that users have the training to perform their functions skillfully and safely. Lam strongly advises that operators and maintenance technicians working on a particular system only perform tasks that are consistent with their levels of training and experience.

Table 2–2 lists potentially hazardous operations and recommended procedures for minimizing dangers.

Table 2–2 .Hazardous Operations

Operation	Danger	Recommended Procedure(s)	Hazard Alert
Chemical			
Opening the reaction chamber.	Residual gases may be present from recent processing of wafers and/or recent maintenance activities (such as gas calibrations). Reaction by-products could react with air to release hazardous gases.	Run chamber clean process, then perform the recommended number pump/purge cycles required. Ensure the plasma clean recipe is run. Turn off the 24 VDC actuators switch located on the main circuit breaker panel of the process module.	Failure to observe this precaution could result in exposure to toxic chemicals which could cause injury.
Inspecting or performing maintenance inside the chamber.	Residual gases may be present from recent processing of wafers and/or recent maintenance activities (such as gas calibrations). Reaction by-products could react with air to release hazardous gases.	Do not insert head into the reaction chamber.	Failure to observe this precaution could result in exposure to toxic chemicals which could cause injury.
Inspecting or performing maintenance inside the chamber.	Anodized surfaces could be scratched.	Take care to avoid scratching any anodized aluminum surfaces.	Failure to observe this precaution can result in premature wear of parts and/or shift in process results. It can also cause arching and burns, depending on the location of the scratches.
Handling of ceramic chamber parts.	All ceramic chamber parts are brittle and could break if dropped or bumped.	Take care when handling any ceramic parts not to drop or bump them.	Failure to observe this precaution could result in breakage of parts and the possible creation of sharp edges.
Cleaning ceramic chamber parts.	If the ceramic chamber parts are exposed to excessive moisture, a potential outgassing problem may exist.	Ensure the ceramic chamber parts have been thoroughly baked out.	Failure to observe this precaution could result in excessively high leakback rates.

Table 2–2 .Hazardous Operations (continued)

Operation	Danger	Recommended Procedure(s)	Hazard Alert
Electrical			
Troubleshooting in AC/DC power distribution box.	Live terminals inside cover. Extreme hazard of electric shock if cover is removed with doors open and power on.	No regular maintenance is required. Troubleshoot only after lockout/tagout has been performed.	Failure to observe this precaution could result in serious injury or death.
Troubleshooting roughing pumps after performing an emergency off (EMO).	Electrical shock from hazardous voltage.	Lockout and tagout of power to the roughing pumps before servicing.	Failure to observe this precaution could result in serious injury or death.
Troubleshooting ESC power supply with the cover off and the interlock bypassed.	Electrical shock from hazardous voltage.	Performed by only qualified technicians informed of this precaution to work on ESC power supply with the cover removed.	Failure to observe this precaution could result in serious injury.
Calibration of components in RF system.	Exposure to non-ionizing radiation. Risk of electric shock and/or burn.	Turn off all generators from both the control screen and the circuit breakers prior to disconnecting any RF cables. Always securely connect RF cables prior to turning on power to the module and/or generators.	Failure to observe this precaution could result in serious injury or death.
Thermal			
Cleaning a hot reaction chamber.	Burns to personnel, potential fire if wrong cleaning chemicals are used.	Turn down chamber wall temperature prior to starting pump/purge. Use cleaning chemicals recommended by Lam only.	Failure to observe this precaution could result in burns caused by contact with hot chamber elements. Potential flash fire if acetone or other similar high pressure solvent is used.
Removing hot ESC cap with TCU running or lines not drained.	Burns to personnel, contamination to reaction chamber caused by TCU fluid.	Turn down electrode temperature. Turn off TCU and drain lines.	Failure to observe this precaution could result in burns caused by high pressure, high temperature TCU fluid spray. Chamber contamination caused by TCU fluid spraying around the chamber.

Table 2–2 .Hazardous Operations (continued)

Operation	Danger	Recommended Procedure(s)	Hazard Alert
Removing gate valve when it is still hot.	Burns to personnel.	Turn down the reactor temperature. Allow to cool prior to removal.	Failure to observe this precaution could result in burns to hands and fingers unless unit is allowed to cool prior to removal.
Service/cleaning the gate valve while hot.	Burns to personnel.	Follow the pressure control procedures in this manual. Turn down temperature to ambient and allow to cool.	Failure to observe this precaution could result in burns to hands and fingers unless unit is allowed to cool prior to removal.
Servicing reactor cartridge heaters.	Burns to personnel.	Turn down all reactor temperature channels to ambient and allow to cool. Prior to removal, unplug heater(s) from power source.	Failure to comply could result in severe burns and a potential fire if the hot heater contacts a flammable surface.
Exposing the TCP coil.	The TCP coil and TCP window may be at a very high temperature.	Wait one half hour after operation of the upper RF.	Failure to observe this precaution could result in exposure to very hot parts.
Water Spill			
Replacing RF generators or turbo pump.	Water spill.	Turn off main power to the module and turn off water source to the process module. Disconnect the lowest line in the system and drain water into a catch pot. When disconnecting other lines, have wipes handy to soak up spills.	Failure to turn off water or drain lines could result in a water spill.
Mechanical			
Manually opening the gate valve.	The turbo pump could be running and the chamber at atmosphere. The gate valve should never open if the 3 torr switch is not mated.	Ensure that both the pump and chamber are at vacuum or that they are both at atmosphere.	Failure to observe this precaution could result in catastrophic failure of the turbo pump and damage to the pumping system.

Table 2–2 .Hazardous Operations (continued)

Operation	Danger	Recommended Procedure(s)	Hazard Alert
Manually opening the gate valve.	The valve may close. A potential pinch point may exist during certain maintenance situations.	Do not insert hands in the valve while it is closing.	Failure to observe this precaution could result in a pinched hand by the valve while it closes.
Many maintenance operations require reaches which may be excessive for smaller operators.	The operator may sustain injury (such as a strained muscle), or lose their balance and fall.	Provide suitable step stools and ladders for the task at hand. Do not use the process module as a ladder or step stool.	Failure to observe this precaution could result in injury.

Manual Mode

Only factory-trained personnel should operate the system when it is in manual mode, because many of the software interlocks are bypassed when the system is placed in the manual mode. Operating personnel should use the system only when the system is in automatic mode.

Interlocks

The Domino/2300 system is interlocked to protect against single fault hazards. These interlocks protect against human error or equipment failures that could allow exposure of personnel, facilities or community to hazards or directly result in injury, death or equipment loss. They are implemented in circuitry that is independent of the system controls. All of these interlocks will report alarms to the user interface if they are activated. They are also copied in the system control software.

Human Safety Interlocks

Human safety interlocks used to protect against injury of personnel rely only on electro-mechanical devices that are dual compliant. Microprocessors and integrated circuits are not used.

Equipment Interlocks

You can implement equipment interlocks to protect the wafers or subsystems from damage by using integrated circuits that comply with UL991. Only static logic circuits are acceptable. Microprocessor based circuitry or clocked circuits are not used.

Transport Module Interlocks

Slot Valve Close Signal to PM Interlocks

A maximum of four PMs can be connected to the TM, each with an independent interlock signal. TM interlock circuitry provides the slot valve close signal to each associated PM to interlock the chamber gas delivery valves.

Slot Valve Open Delta Pressure Interlock

To prevent opening a slot valve across a differential pressure, the “at atmosphere” and “at vacuum” pressure switches on both sides of the valve must match state with each pair at the opposite state (see Table 2–3).

Table 2–3 .Slot Valve Open Delta Pressure Interlock

TM at ATM	PM at ATM	TM at VAC	PM at VAC	Valve State
0	0	0	0	No action
0	0	0	1	No action
0	0	1	0	No action
0	0	1	1	OPN
0	1	0	0	No action
0	1	0	1	No action
0	1	1	0	No action
0	1	1	1	No action
1	0	0	0	No action
1	0	0	1	No action
1	0	1	0	No action
1	0	1	1	No action
1	1	0	0	OPN
1	1	0	1	No action
1	1	1	0	No action
1	1	1	1	No action

Batch Transfer Arm Extension Interlock

Extension of the batch transfer arm is disabled unless all the following conditions are met:

- The loadlock outer door safety sensor is not blocked.
- The loadlock outer door is open.

You can only bypass this interlock by a command from a password-protected maintenance screen on the operator interface. Once the screen is exited, the interlock is automatically reactivated.

Loadlock Lasers

The lasers located in the loadlock are interlocked with the loadlock door so that the laser cannot be activated unless the loadlock door is closed and clamped shut. You can only bypass this interlock by using a command from a password-protected maintenance screen on the operator interface. Once the screen is exited, the interlock is automatically reactivated.

Loadlock Door Interlocks

The automated door motion is interlocked for both human safety and equipment safety.

Human Safety Interlock: The automated door-up motion is interlocked with a human safety interlock using safety certified sensor and relay. The sensor is located such that the operator is protected from all pinch points. The output of the sensor is sent to the load lock node, where it activates a normally open relay. In case the safety beam is interrupted, the relay will go to the default open position, disabling the door motion. This circuit is independent from equipment safety interlock.

Equipment Safety Interlock: The automated door up, down, in (clamp) and out (unclamp) motions are interlocked using programable logic device (PLD) and optoisolators. PLD has an internal latch, which overrides UI door movement commands and opens the door if during door up movement, the door safety beam is interrupted. To clear an internal latch, you must remove the door up command, and should not interupt the door safety beam, the door up sensor shall be false and the door down sensor shall be true. The functionality of the equipment safety door interlocks is summarized in Table 2–4.

Table 2–4 .Loadlock Door Interlock Conditions

Action	Door In	Door Out	Door Up	Door Down	Door Interrupt	Door Latch	ATM	Vac
Door Out							T	F
Door In			T	F				
Door Up	F	T			T	F		
Door Down	F	T						
Door Safety Latch Set			F	F	F			
Door Safety Latch Clear			F	T	T			

T=True condition, switch is actuated.

F = False condition, switch is not activated.

Gas Safety


GENERAL ALERT

Warning

Chemical Hazard: Hazardous gases may be used on the Domino/2300 system. Consult the material safety data sheets or equivalent material safety information for chemical hazards.

The plasma clean recipes shown in the preparation steps outlined in the applicable PM operation and maintenance manual help neutralize chlorine-based by-products in the chamber prior to opening.

If the plasma clean recipes are run on the system, perform the pump-and -purge procedures a minimum 60 cycles prior to opening a chamber configured for non-toxic gases and 60 cycles for systems configured for corrosive gases, depending on process recipes and wafers between cleans. Because fab operation procedures and chemistry vary, industrial hygiene air sampling tests are advised and/or required when qualifying specific procedures to ensure compliance with threshold limit value (TLV) and permissible exposure limit (PEL) specifications. It is also recommended that 240 pump-and-purge cycles be run for systems using hydrogen bromide, and 60 pump-and-purge cycles for non-toxic gases.

Gas Leak Detection Strategy

Containment of hazardous gases and detection of leaks are provided by a combination of on-board features and facilities infrastructure. The first priority is leak prevention, which is provided by physical containment, including back-up or double containment. The next priority is assuring proper evacuation of gases should containment systems fail or internal subatmospheric pressures fail to be maintained.

On-board safety systems continuously monitor chamber vacuum. Should this fall out of specification, a red alarm is signaled, the system returns to a safe, standby state, and the operator is notified through the user interface.

Additional gas containment features include:

- A differential-pressure switch interlock in the gas box that shuts off all gas being supplied to the system if the gas box exhaust is lost.
- Vacuum interlocks on the reaction chamber that cut off the flow of process gases and any RF power being supplied whenever vacuum integrity is lost.
- Gas panel provided with scrubbed exhaust connection.
- Upper chamber/upper match housing provided with scrubbed exhaust connection.

Lam recommends that you provide an additional level of protection by augmenting the containment features described above with leak detectors located in the breathing zone in work areas adjacent to the main reaction chambers and in the scrubbed exhaust from the on-board gas panel.

In the event that detection of hazardous production materials is required by regulations in place at the customer's site, Lam recommends that the sample point be located one foot downstream of the exhaust port.

Lam also recommends the following:

- The exhaust duct material is compatible with the exhaust gases and not subject to degradation with exposure to hazardous and/or corrosive materials.
- Each vacuum pump exhaust has overpressure protection in compliance with SEMI S2-0200 safety guidelines.
- Measure the exhaust performance close to the system end of the exhaust line (approximately 10 duct diameters optimum) using an anemometer to estimate volume flow based on linear flow measurements.
- Provide an audible and visual alarm on the chase side of the equipment to alert personnel of inadequate exhaust flow.

Gas Panel Safety

The 2300 poly PM gas panel is designed for fail-safe operation under all reasonably foreseeable failure conditions. During failures, the gas panel prohibits gas flow and contains gases in a scrubbed enclosure to prevent the contamination of the environment and exposure to operating personnel.

POISON

Warning

Chemical Hazard: Hazardous gases may be used on the 2300 poly PM. Consult the material safety data sheets (MSDS) or equivalent material safety information for chemical hazards.

The plasma clean recipes helps neutralize chlorine-based by-products in the chamber prior to opening.

If the plasma clean recipes are run on the process module, perform a minimum of 60 pump-and-purge cycles prior to opening a chamber configured for non-toxic gases, and 60 cycles for systems configured for corrosive gases, depending on process recipes and wafers between cleans. Because fab operation procedures vary, industrial hygiene air sampling tests are advised and/or required when qualifying specific procedures to ensure compliance with threshold limit value (TLV) and permissible exposure limit (PEL) specifications. It is also recommends that you perform 240 pump-and-purge cycles for systems using hydrogen bromide, and 60 pump-and-purge cycles for non-toxic gases.

If a plasma clean recipe is not run on the process module, perform a minimum of 60 pump-and-purge cycles prior to opening a chamber configured for non-toxic gases, 120 cycles for systems configured for corrosive gases, 240 cycles for systems configured for hydrogen bromide, and 60 cycles for non-toxic gases.

Greenhouse Gases

At this printing, Lam is involved in a perfluorocarbon (PFC) leadership group with some of the leading semiconductor companies in an ongoing effort to meet future environmental regulations for wafer fabrication. This includes efforts to reduce and/or eliminate the use of global warming gases (PFCs) and ozone-depleting chemicals (CFCs). The technology today requires the end user to use some PFCs and CFCs for processing semiconductor devices, but whenever possible less hazardous process chemicals are replacing the more hazardous substances used in wafer fabrication.

The primary concern for the Domino/2300 system is the use of sulfur hexafluoride (SF_6) used in the baseline process for tungsten etch. Trifluoromethane (CHF_3) is another PFC sometimes used in both aluminum and tungsten etch. If a fluorine-containing process gas is used in an etch reactor there is the possibility of the production of PFCs by the plasma process, since they are thermodynamically stable. Future restrictions of PFCs are possible and may require that the process be optimized or the effluent be treated to reduce the emission of PFCs.

Seismic Protection

The transport module complies to SEMI S2-0200, section 19, Seismic Protection when secured at the eight TM locations (as shown on 253-810068-001) and installed on the ground level of a building secured with ductile anchors with a length to diameter ratio greater than 8, in any seismic condition or region. When the TM is populated with the process modules, secure each PM at the seismic locations specified on the PM's facility drawing.

When the TM is installed on building levels other than at ground level, seismic analysis of the installation site is required to determine if the TM standard configuration will meet S2-00. In cases where seismic loading is more severe, additional seismic bracing may be required. Contact Lam for availability of severe seismic bracing kits.

Servicing the MFCs

When performing the pump and purge cycles on the MFCs prior to servicing, it is important to make sure there is no trapped gas between the MFC primary and secondary valves. Use this procedure to ensure that the gas is removed and that you purge the gas and perform a proper pump-and-purge cycle to remove the nitrogen. The key to this procedure is to observe the pump/purge action on the operator or maintenance interface screen.

▶ **To service the MFCs,**

1. Turn off the hand valves on the gas inlet line and lock them out.
2. Flow the gas on the **Maintain\Chamber** window by giving the maximum set point value for each gas.
3. Check the monitored flow value for each gas and make sure the gas flows goes zero.
4. Make sure the chamber manometer goes to base pressure.
5. Change the set points of the MFCs to zero on the **Maintain\Chamber** window.
6. Activate the gas panel pump-and-purge cycle from the **Maintain\Gas** window**.**
7. Check the MFC flow on the **Maintain\Chamber** window. The MFC should cycle from maximum flow to zero with every pump-and-purge cycle.

8. See the maintenance service manual to determine needed pump/purges for the gas or gases that require servicing.
9. When the MFC service is complete, leak check the fittings that were opened.
10. Perform a pump-and-purge cycle on the MFC with nitrogen, using the number recommended in the maintenance manual.
11. Perform a purge cycle of the MFCs of the nitrogen gas by setting the MFC setpoints to the maximum flow.
12. When the MFC monitored flow goes to zero, set the MFC setpoints to zero.
13. Unlock and open the hand valves on the gas inlet line and charge the gas lines.

Lifting Safety

Many of the components of the Domino/2300 system are heavy. When performing maintenance operations, use proper lifting techniques, lifting aids and multiple personnel. Most heavy objects are identified with labels.

RF Shields

The 2300 poly process module is designed with several RF shields. RF shields must be properly installed onto the system whenever engaging RF power. Do not activate the generator(s) if the covers on the upper or lower match are removed. The cover ensures safety, shielding operating personnel from the effects of RF Power. All operating personnel must use caution when working in the vicinity of RF power.

3
Hazard Labels

Lam Research systems include safety hazard labels to alert end-user personnel to the hazards present. Service and maintenance personnel should read this manual, along with the maintenance and operation manuals for detailed information on how to avoid or minimize these hazards.

Hazard Classifications

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This is limited to the most extreme situations.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a potentially hazardous situation which, if not avoided, could result in moderate or minor injury. It may also be used to alert against unsafe practices or equipment damage.

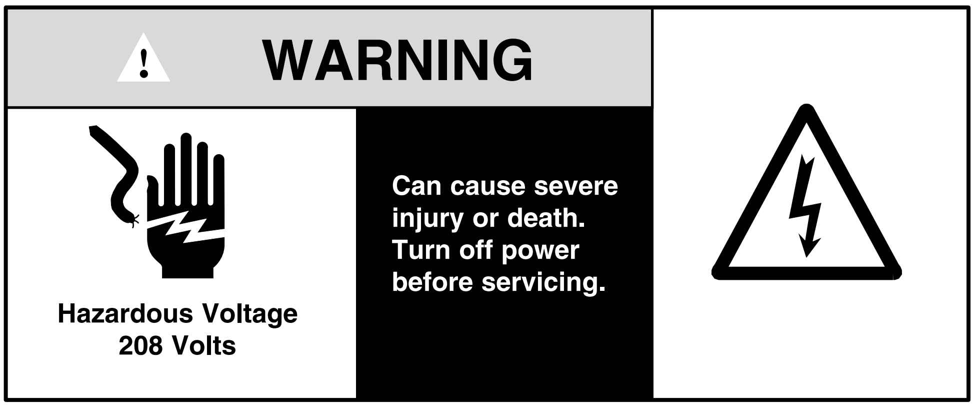
These designations help users identify the level of hazard present. This system is also used in the maintenance manuals.

NOTICE indicates a statement of company policy (for example, safety policy or protection of property) or identifying areas where additional safety-related information is provided.

Specific Hazard Labels

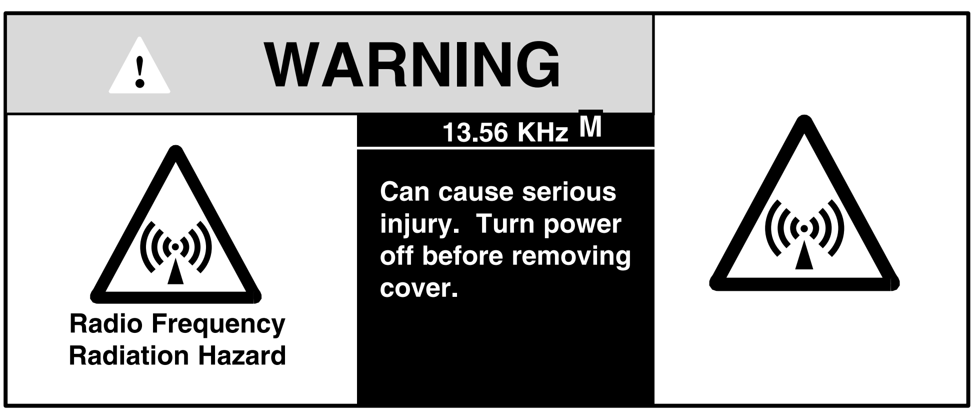
Hazardous Voltage

Warning labels fixed to external barriers that protect against contact with hazardous voltages inform personnel of the voltage hazard.



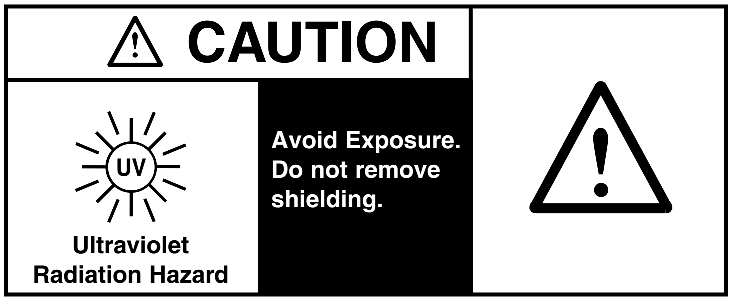
Hazardous RF Energy

Warning labels fixed to external barriers that protect against contact with hazardous RF energy inform personnel of the RF hazard.



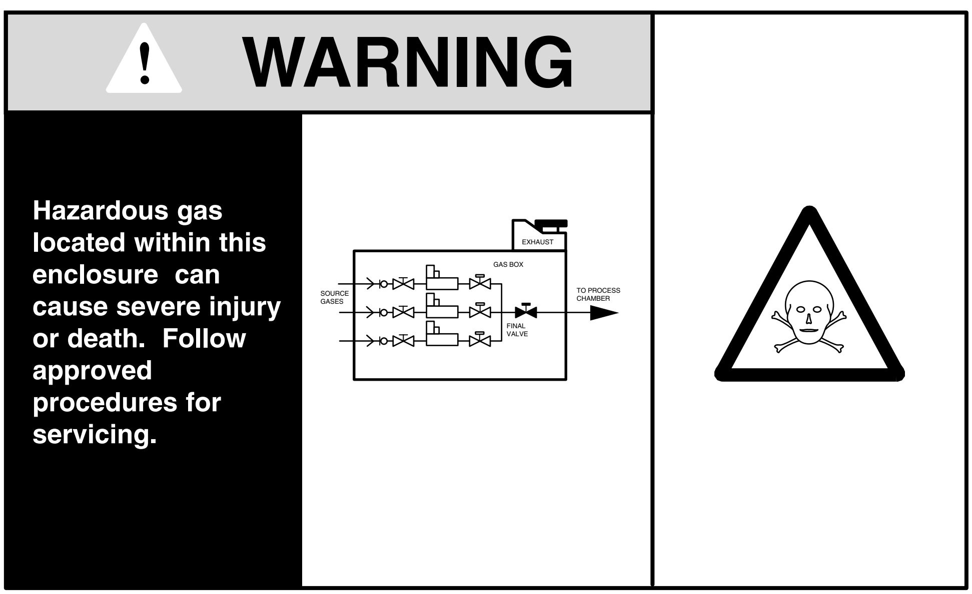
Hazardous UV Energy

Warning labels fixed to external barriers that protect against exposure to UV radiation.



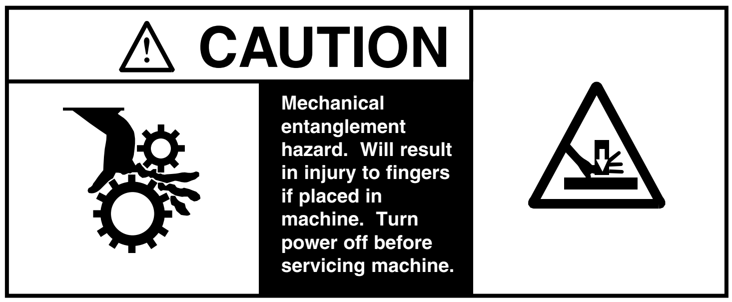
Hazardous Chemistry

Warning labels fixed to external barriers that protect against contact with hazardous chemicals inform personnel of the hazard.



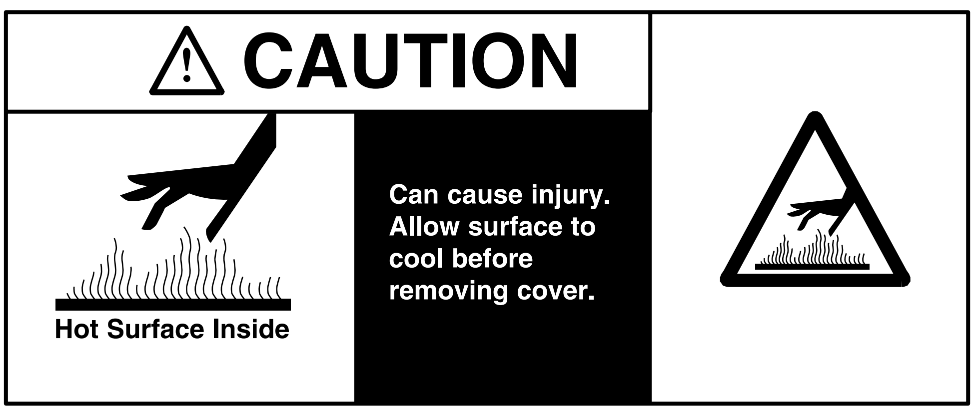
Hazardous Pinch Points

Warning labels fixed to the system where hazardous pinch points exist inform personnel of the need to keep hands and fingers away from potentially hazardous moving parts.



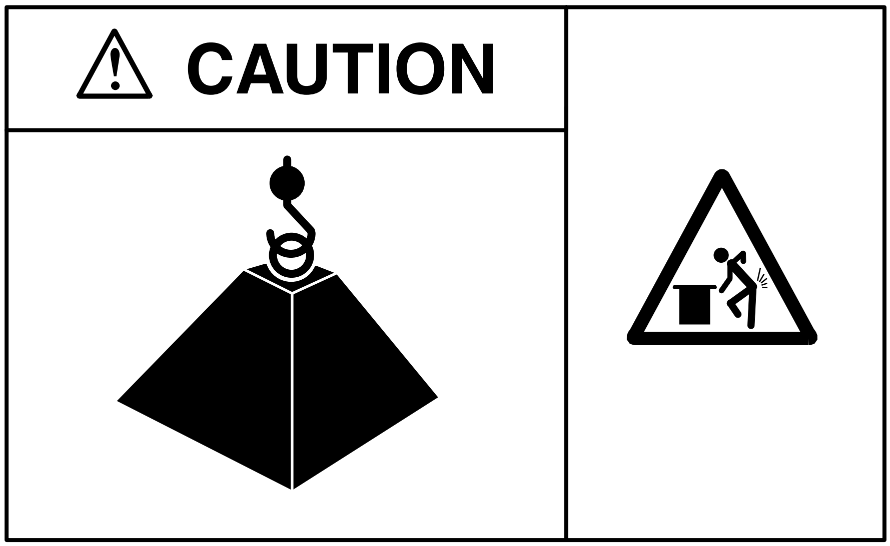
Hot Surface Hazard

Warning labels fixed to hot surfaces inform personnel of the need to keep hands and fingers away.



Heavy Lift Hazard

Warning labels fixed to the system where potentially hazardous heavy lifts are present inform personnel to use caution when lifting the object in question.



Fuse Replacement Warning

Warning labels fixed adjacent to fuse blocks inform personnel of potential fire hazard if a fuse is replaced with another fuse of the wrong rating or type.

Showing the Locations of the Safety Labels on the PM

Figure 3–1 through Figure 3–5 show the location of the safety lables on the 2300 poly process module (PM). Table 3–1 describes the part numbers for the safety labels.

Figure 3–1. Label Locations on the Front of the PM

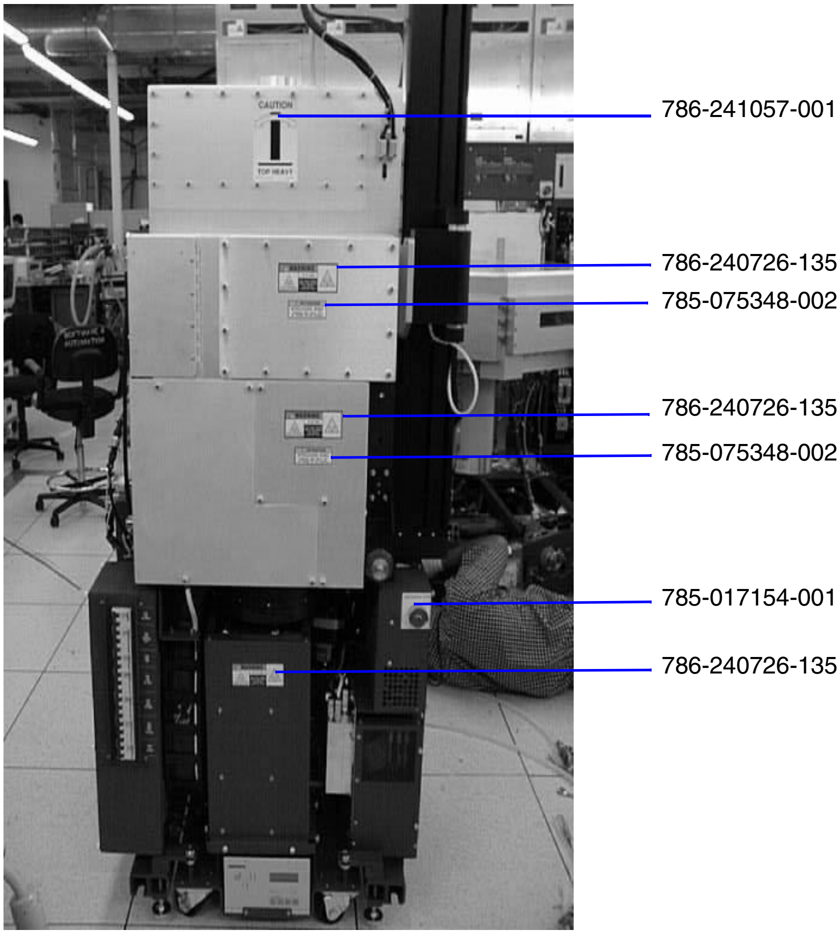


Figure 3–2. Label Locations on the Right of the PM

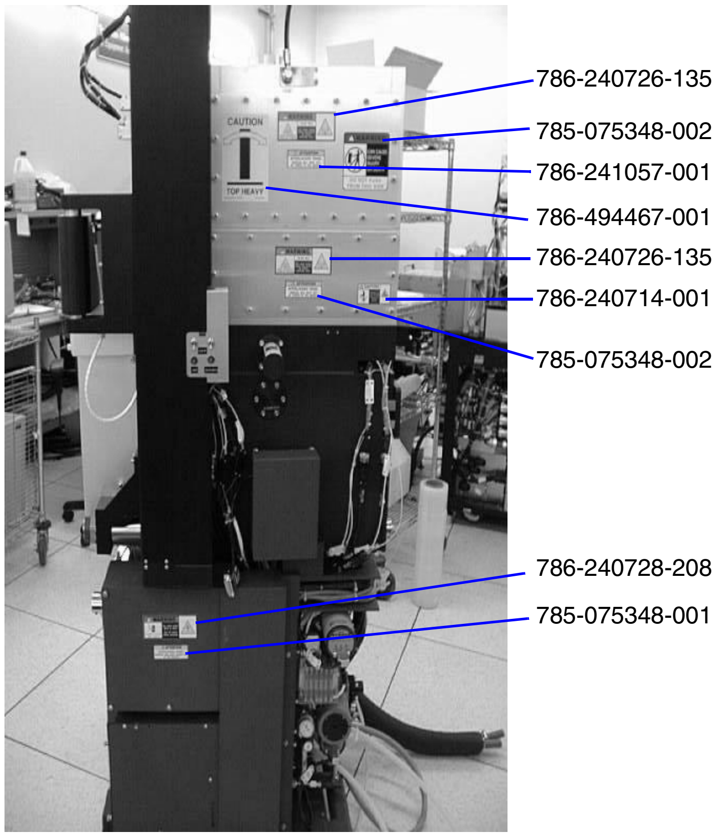


Figure 3–3. Label Locations on theTop Left of the PM

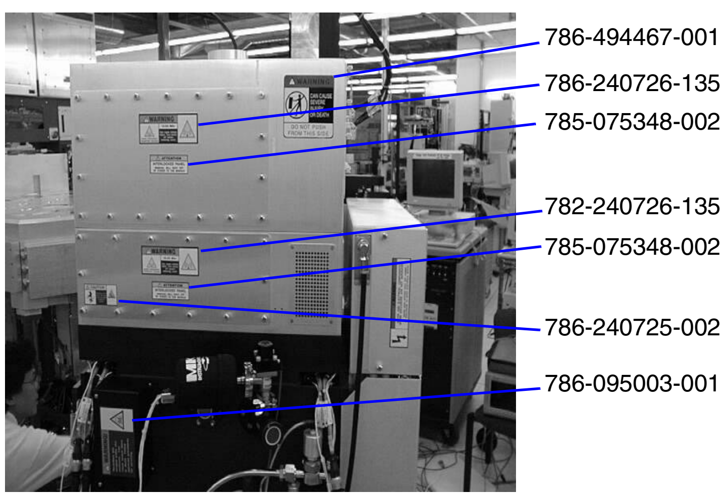


Figure 3–4. Label Locations on the Lower Left of the PM

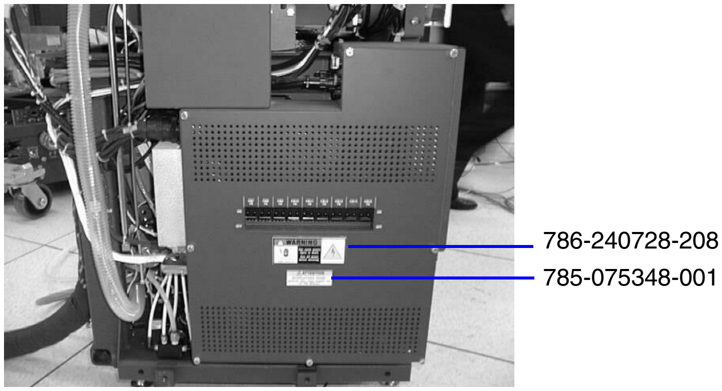


Figure 3–5. Label Locations on theTop of the PM

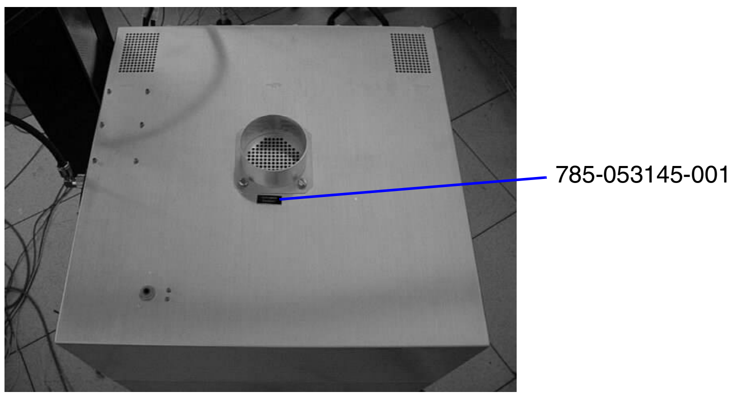


Table 3–1 .Safety Label Descriptions

Part number	Title	Quantity
786-240728-208	Label, ANSI-CIS, Hi Volt, 208 VAC	2
786-494467-001	Label, Don't Push	2
786-241057-001	Label, Top Heavy	2
786-095003-001	Label, Warning, Toxic, Gas	1
785-017154-001	Label, Emergency Stop	1
786-240714-001	Label, ANSI-CIS UV	1
786-240726-135	Label, ANSI-CIS, RF	7
785-075348-002	Label, Attn, Intlk, Pnl, RF Pwr	6

Table 3–1 .Safety Label Descriptions (continued)

Part number	Title	Quantity
785-075350-001	Label, Warning, Wtr & Elec Cmpnt	1
785-053145-001	Label, Scrubber Exhaust	1
786-240725-002	Label, ANSI-CIS, Pinch	2
785-075348-001	Label, Warning, Interlocked Pnl	2

4
Laser Safety Information

The lasers used in the loadlock and wafer aligner are FDA certified for Class 1 for the operator. The lasers themselves, however, are Class 2. The interlock methodology allows them to be certified as a Class 1 product.

Although the lasers are classified as human safety by the FDA, the FDA does not mandate relay logic for the interlock. This is because Class 2 lasers or laser systems emit a visible laser beam and because of its brightness, Class 2 laser light is too dazzling to stare into for extended periods. Momentary viewing is not considered hazardous since the upper radiant power limit on this type of device is less than the maximum permissible exposure (MPE) for momentary exposure of 0.25 seconds or less. Intentional extended viewing, however, is considered hazardous.

5
Chemical Safety

This chapter discusses current and potential future environmental restrictions on the use of PFCs (perfluorinated compounds) with the Domino/2300 system. It is important to distinguish PFCs from chlorofluorocarbons (CFCs). Since the production of CFCs has been restricted by the 1990 Montreal Protocol International Agreement, CFCs are not used in the Domino/2300 system.

The need for PFC control and its technology are under study and evaluation by the semiconductor industry since their use is not regulated. The primary concern for the Domino/2300 system is the use of sulfur hexafluoride (SF_6) and trifluoromethane (CHF_3). If a fluorine-containing process gas is used in an etch reactor, there is the possibility of the production of PFCs by the plasma process since these chemicals are thermodynamically stable. Future restrictions of PFCs are possible, and may require that the process be optimized, or the effluent be treated to reduce the emission of PFCs.

Precautions

Maintenance

▸ **When performing maintenance on the reaction chamber or the chemical delivery system,**

1. Wear protective, cleanroom-approved clothing and gloves, safety glasses, and a full breathing apparatus whenever appropriate.
2. Clear the surrounding area of all personnel not wearing appropriate protective gear.
3. Perform a nitrogen purge before beginning work on the reaction chamber or any chemistry-carrying parts, unless specified otherwise. The main reaction chamber requires 120 pump-and-purge cycles of 30-second duration if no hydrogen bromide (HBr)

is used in the process and 240 cycles of 30-second duration if HBr is present. The type and duration of nitrogen purge needed with other parts of the gas delivery system will vary. Consult the maintenance procedures for details. The pump-and-purge process is vital to reducing toxic chemical concentrations.

4 Perform maintenance activities in a well-ventilated area. Air circulation helps to prevent excessive buildup of vapors due to the residual chemistry that may remain after the pump-and-purge process has been performed.

Unwanted Chemical Releases

Lam etchers are equipped with active features that enhance operator and service technician safety, and help to protect the environment and property against human error and component failure. The following features are used as protection against any unwanted chemical releases:

- Domino/2300 process modules have secondary containment on inlet gases.
- Gases are supplied at sub-atmospheric conditions, and the vacuum switch activates if the line pressure rises above 75 torr. A vacuum pressure interlock is triggered when vacuum is not present in the reaction chamber and cuts off flow of process gases and the RF supplied to the chamber.
- If the main reaction chamber is open, the tilt switch interlock inhibits process gas from being supplied to the chamber. This interlock effectively backs up the vacuum interlock in most process modules.
- A differential pressure switch interlock shuts off all gases being supplied to the system if the gas box exhaust flow is lost.
- A vacuum switch shuts off the supply of process gas to the reaction chamber if the integrity of the line supply gases from the gas box to the reaction chamber is broken.

Lam also recommends that the facility scrubber system remain operational in the event of a power failure.

Each process module has an independent exhaust port. Lam recommends that you have a dedicated vacuum pump for each process module. This will prevent cross-contamination of waste products from the process modules.

It is the responsibility of the customer to ensure that potentially hazardous mixtures of waste exhaust gases cannot occur in the exhaust handling system.

Lam recommends that you mount an area hazardous gas monitoring device in the vicinity of the system. The gas box interlock circuit has provisions for a dry contact interlock switch input from such a device allowing it to shut off all gas flow into the gas boxes.

It is the responsibility of the customer to provide exhaust systems which are compatible with exhaust chemistries noted in this manual.

Obtaining Environmental Effluent Information

For information on environment effluents from the baseline process, see your designated Lam contact person.

Obtaining Environmental Permit Information

For information on environmental permits for your system, see your designated Lam contact person.

Chemicals Used

Table 5–1 lists process chemicals commonly used in various Lam products.

Table 5–2 describes physical properties and health effects for humans if they are exposed for the various chemical used for process and maintenance in Lam products. Material safety data sheets are available from the suppliers of these chemicals and should be kept on hand.

GENERAL ALERT

Caution

Chemical Hazard: If alternate chemistries are used to support user processes, obtain, refer to, and keep on hand the material safety data sheets (MSDS) for those chemistries.

Table 5–1 .Chemical Uses

Process Modules	He	O_2	Ar	CF_4	CHF_3	C_2F_6	C_4F_8	CO	NF_3	N_2	HBr	HCl	Cl_2	BCl_3	SF_6	H_2O
HDD etch	X	X	X	X	X	X	X	X		X					X	
Poly etch	X	X	X	X		X			X	X	X	X	X	X	X	
Metal etch	X	X	X							X			X	X	X	
Photoresist strip		X								X						X

Table 5–2 .Chemical-Specific Hazard Summary

Chemical	CAS No.	Description	Health effects	ACGIH TLV[a] (ppm)	OSHA PEL[b] (ppm)
Acetone	67-64-1	Colorless, highly volatile, flammable liquid. Sweet/fruity odor	Irritant of the eyes and mucous membranes and at high concentrations a central nervous system depressant. Acetone is considered to be of low risk to health because few adverse effects have been reported despite widespread use for many years.[c] In animal studies, acetone has been found to increase the toxicity of other solvents. Contact can cause skin and eye irritation.	TWA: 750[d] STEL: 1000[e] C: N/A[f]	TWA: 1000 STEL: N/A C: N/A

Table 5–2 .Chemical-Specific Hazard Summary (continued)

Chemical	CAS No.	Description	Health effects	ACGIH TLV[a] (ppm)	OSHA PEL[b] (ppm)
Argon (Ar)	7440-37-1	Colorless, odorless, inert compressed gas	Inhalation of extremely high concentrations can cause headache and dizziness. Acts as a simple asphyxiant by displacing oxygen in air.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Boron Trichloride (BCl_3)	10294-34-5	Colorless, fuming liquid. Reacts with water and moist air to form hydrochloric and boric acids	Strong irritant of the eyes, mucous membranes, and skin as a result of its hydrolysis to hydrogen chloride.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Chlorine (Cl_2)	7782-50-5	Greenish-yellow gas with irritating, suffocating/sharp pungent (bleach) odor	Strong irritant of the eyes, mucous membranes, skin, and pulmonary tract. Mild mucous membranes irritation may occur at 0.2 to 16 ppm. Eye irritation occurs at 7 to 8 ppm, throat irritation at 15 ppm, and cough at 30 ppm. Other studies have shown that at least some subjects develop eye irritation, headache, and cough at concentrations as low as 1 to 2 ppm. In high concentrations, chlorine gas may irritate the skin, causing burning sensation, inflammation, blisters, or burns.[c]	TWA: 0.5 STEL: 1 C: N/A	TWA: N/A STEL: N/A C: 1

Table 5–2 .Chemical-Specific Hazard Summary (continued)

Chemical	CAS No.	Description	Health effects	ACGIH TLV[a] (ppm)	OSHA PEL[b] (ppm)
Fluorides (as F)	7782-41-4	Odorless white to dark crystal or other solid, varies by fluoride compound	Fluoride causes irritation of the eyes and respiratory tract. Absorption of excess amounts of fluoride over a long period of time results in increased radiographic density of bone.	TWA: 2.5 (mg/m^3) STEL: N/A C: N/A	TWA: 2.5 (mg/m^3) STEL: N/A C: N/A
Helium (He)	7440-59-7	Colorless, odorless, tasteless gas	Acts as a simple asphyxiant by displacing oxygen in air. Inhalation of extremely high concentrations can cause headache and dizziness.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Hexafluoro-ethane	76-16-4	Colorless, slight ethereal, tasteless gas	Inhalation of high concentrations can cause dizziness, disorientation, incoordination, or narcosis. May cause asphyxiation due to oxygen displacement.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Hydrogen Bromide (HBr)	10035-10-6	Colorless, corrosive, nonflammable gas with sharp, acrid odor	Irritant of the eyes, mucous membranes, and skin. There are no systemic effects reported from industrial exposure.[c]	TWA: N/A STEL: N/A C: 3	TWA: 3 STEL: N/A C: N/A
Hydrogen Chloride (HCl)	7647-01-0	Colorless fuming gas with sharp, irritating odor. Extremely corrosive	Strong irritant of the eyes, mucous membranes, and skin. The major effects of acute exposure are limited to the upper respiratory tract and are sufficiently severe to encourage a prompt withdrawal from a contaminated environment. Exposure of the gas to the skin can cause burns.	TWA: N/A STEL: N/A C: 5	TWA: N/A STEL: N/A C: 5

Table 5–2 .Chemical-Specific Hazard Summary (continued)

Chemical	CAS No.	Description	Health effects	ACGIH TLV[a] (ppm)	OSHA PEL[b] (ppm)
Hydrogen Fluoride (HF)	7664-39-3	Clear colorless vapor above boiling point (19.5°C), fuming liquid at lower temperatures. Corrosive, with sharp, irritating odor	Severe respiratory irritant. In solution it causes severe and painful burns of the skin and eyes. Fluorosis may be caused at levels significantly higher than the OSHA PEL.[g]	TWA: N/A STEL: N/A C: 3	TWA: 3 STEL: N/A C: N/A
Isopropyl Alcohol	67-63-0	Clear, colorless, flammable liquid/vapor	Irritant of the eyes and mucous membranes. Isopropyl alcohol is of low toxicity by any route, and the TLV is set to prevent eye, nose, and throat irritation.[g]	TWA: 983 STEL: 1230 C: N/A	TWA: 980 C: N/A
Nitrogen (N_2)	7727-37-0	Colorless, odorless, tasteless gas	Inhalation of extremely high concentrations can cause headache and dizziness. Acts as a simple asphyxiant by displacing oxygen in air.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Nitrogen Trifluoride (NF_3)	7783-54-2	Odorless at potentially dangerous levels.	Causes anoxia in animals due to the formation of methemoglobin and a potential fluorosis hazard may be associated with prolonged inhalation at the TLV. There are no reports of human intoxication. Nitrogen trifluoride provides odor warning properties at potentially dangerous levels.	TWA: 10 STEL: N/A C: N/A	TWA: 10 STEL: N/A C: N/A

Table 5–2 .Chemical-Specific Hazard Summary (continued)

Chemical	CAS No.	Description	Health effects	ACGIH TLV[a] (ppm)	OSHA PEL[b] (ppm)
Oxygen (O_2)	7782-44-7	Colorless, odorless, tasteless gas	Low oxygen levels (less than 16%) can lead to asphyxiation. Industrial exposures to high oxygen pressures are rare.[h] All cells can be damaged by high oxygen levels, particularly the respiratory and central nervous systems.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Sulfur Hexafluoride (SF_6)	2551-62-4	Colorless, odorless gas	Acts as a simple asphyxiant by displacement of oxygen. At extremely high levels it may mildly affect the nervous system.[c]	TWA: 1000 STEL: N/A C: N/A	TWA: 1000 STEL: N/A C: N/A
Tetrafluoro-methane (CF_4)	75-73-0	Colorless, odorless, tasteless gas	Inhalation of high concentrations can cause dizziness, disorientation, incoordination, narcosis, or vomiting. May cause asphyxiation due to oxygen displacement.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Trifluoro-methane (CHF_3)	75-46-7	Colorless, odorless, tasteless gas	Inhalation of high concentrations can cause dizziness, disorientation, incoordination, narcosis, or vomiting. May cause asphyxiation due to oxygen displacement.	TWA: N/A STEL: N/A C: N/A	TWA: N/A STEL: N/A C: N/A
Octafluoro-cyclobutane (C_4F_8)	115-25-3	Colorless, odorless gas	Acts as simple asphyxiant displacing air necessary for life. Causes rapid respiration, muscular incoordination, fatigue, dizziness, nausea, vomiting, unconsciousness and death.	TWA:S/A STEL: S/A C: N/A S/A= simple asphyxiant	TWA: S/A STEL: S/A C: N/A

Table 5–2 .Chemical-Specific Hazard Summary (continued)

Chemical	CAS No.	Description	Health effects	ACGIH TLV[a] (ppm)	OSHA PEL[b] (ppm)
Carbon Monoxide (CO)	630-08-0	Colorless, odorless gas	Causes headache, palpitations, dizziness, weakness, confusion and nausea. Continued exposure causes loss of consciousness and death.	TWA: 50 STEL: 400 C: N/A	TWA: 35 STEL: 400 C: N/A

a. ACGIH-TLVs are from 1994-95 ACHIH TLV Booklet

b. OSHA-PELs are Federal OSHA 29CFR 1910.1000, July 1, 1994

c. N.H. Proctor, J.P. Hughes: *Chemical Hazards of the Workplace*, 3rd edition, Lippincott, 1991.

d. TWA = 8-hour time-weighted average

e. STEL = 15-minute short-term exposure limit

f. C = Ceiling concentration

g. *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 6th edition, Cincinnati, Ohio, ACGIH, 1991

h. G.D. Clayton, F.E. Clayton: *Patty's Industrial Hygiene and Toxicology*, 4th edition, Wiley and Sons, 1994

6
Water Containment

Lam equipment uses water for cooling and in some applications for processing. No means of water leak detection or leak containment are provided as standard equipment. It is the responsibility of the end-user to detect any leakage in the water supply and shut off the water being supplied to the system.

7
Ultraviolet Radiation

The 2300 process modules produce a gas plasma in the reaction chamber which emits ultraviolet (UV) light. Prolonged exposure can cause skin burns or eye damage. All the view and instrument ports on the chamber are equipped with either plastic filters or metal enclosures which will block the UV light. Lam recommends the following:

- You should not operate the process module without the protective filters and enclosures installed.
- If, for maintenance purposes, you must operate the chamber with the protective filters or enclosures removed, wear protective eye wear and avoid prolonged exposure.

8
2300 Poly Process Module

This chapter provides safety information specific to the 2300 poly process module.

For system safety information or for safety information on any other process module for the system, see the remainder of this manual.

Domino/2300 process modules are operated from the transport module operator interface. For general system operating instructions, see the applicable operation manuals.

For transport module maintenance information, see the maintenance manual.

Interlocks

Process Module Interlocks

The hazardous functions of the process module are interlocked as shown in Table 8–1.

Table 8–1 .Process Module Interlocks

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP not inhibited	Turbo exhaust valve on
Chamber pressure sw true	H	H	H	H	F		
Foreline pressure sw true		H			F	F	F
Chamber vacuum sw true	H		H	H			
Gas ring sw closed				H			

Table 8–1 .Process Module Interlocks (continued)

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP not inhibited	Turbo exhaust valve on
HE/RF enclosure cover sw closed		H					
Helium maximum flow sw true		F					
Station X slot valve closed				H			
Coil enclosure down sw closed	H	H		H			
TCP RF connector sw closed	H						
TCP match scrubber sw closed	H			H			
TCP Match cover sw closed	H			H			
Lower match cover sw closed		H	H				
Lower match connector sw closed		H					
Roughing pump on				H			
Precharge manifold at vacuum				H			
No customer gas detect				H			
No customer interlock				H			

H = hardware human safety interlock

F = firmware equipment safety interlock

Describing the Interlocks

Enclosure Hardware Interlocks

The PM AC power distribution enclosure and PM DC power distribution enclosure are equipped with interlocks that disconnect AC power to the PM if they are activated. These interlocks are all in series in the 24 VAC interlock circuit.

Process Module Hardware and Firmware Interlocks

All hardware and firmware interlocks on the PM have redundant software interlocks also. The following table lists the various PM interlocks implemented in hardware and firmware (as well as software) and the process that they interlock.

Table 8–2 .PM Hardware and Interlocks

Interlock Switches/ DI ID#/ Conditions

		Chamber pressure sw true	Foreline pressure sw true	Chamber vacuum sw true	Gas Ring sw closed	He/RF enclosure cover sw closed	Helium maximum flow sw true	Station X slot valve closed	Coil Enclosure Down sw closed	TCP RF connector sw closed	TCP Match scrubber sw closed	TCP Match cover sw closed	Bias Match cover sw closed	Bias Match RF Connector sw closed	Precharge manifold at vacuum	No Customer gas detect	No Customer interlock
P&ID designation		CM2S1	CM3S1	PS1	SW1												
		node1	node1	node1	node1	node2	node2	node2	VIOP	VIOP	VIOP	VIOP	VIOP	VIOP	node3_	node3_	node3_
		DI0	DI2	DI3	DI6	DI2	DI3	DIA	DI03	DI04	DI05	DI02	DI17	DI18	DI2	DI6	DI7
	LED on board	CR1-A	CR1-B	CR1-C	CR1-D	CR2-B	CR2-C	CR2-D	CR3-A	CR3-B	CR3-C	CR3-D	CR4-A	CR4-B			
Enable the following function																	
TCP RF power on	(CR5-C)			K4					K5	K17	K21, K16	K20, K15					
Bias RF power on	(CR5-D)			K4		K7, K13	K18		K5				K10, K12	K11			
ESC power on	(CR5-A)			K4		K7, K13							K10, K12		H	H	H
Chamber Gas delivery valve on	(CR5-B)			K4	K3			K8	K5		K21, K16	K20, K15					
Pendulum valve open	(CR6-A)	U7/B	U7/D														
Turbo Exhaust valve on	(CR4-D)		U7/D														

Note: K =Hardware interlock, relay used on the board. U=Firmware interlock, opto-couples used on the board

LEDs Location (top of the board)

TM Slot Valve	He Max Flow Switch	He/RF Enclosure Cover Switch	Chamber ATM switch	Gas Ring Down Switch	Chamber Vacuum Switch	Foreline Vacuum Switch	Chamber Pressure Switch
CR2-D	CR2-C	CR2-B	CR2-A	CR1-D	CR1-C	CR1-B	CR1-A
TMP Exh Valve Open	Hardware Bypass ON	Bias RF Connector Switch	Bias Match Covers Switches	TCP Match Covers Switches	CP Match Scrubber Switch	TCP RF Connector Switch	Coil Enclosure Down Switch
CR4-D	CR4-C	CR4-B	CR4-A	CR3-D	CR3-C	CR3-B	CR3-A
Not used	Not used	Not used	Pendulum Valve Open	Bias RF Interlocks OK	TCP RF Interlocks OK	Chamber Gas Delivery OK	ESC High Voltage On
			CR6-A	CR5-D	CR5-C	CR5-B	CR5-A

DI Lights

Green=Switch is true

No light=Switch is not true

Node 3 (Gas Box) DS3	Node 1 (Chamber) DS1
Node 5 (VME) DS4	Node 2 (Lower Electrode) DS2

Node Connection Lights

Green=connected correctly

Red=not connected or connected wrong

Processes Which Are Interlocked

TCP RF Power On

Table 8–3 shows the hardware interlocks that disable TCP RF power unless they are satisfied.

Table 8–3 .TCP RF Power

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Coil Enclosure Down sw closed	VIOP_DI03
TCP RF connector sw closed	VIOP_DI04
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02

Ensure that the PM chamber is at vacuum, which means the pressure is lower than 75 Torr. Make sure that the coil enclosure is in the down position so that RF cannot be generated and expose personnel to dangerous RF. Ensure that the TCP RF generator is connected to the TCP Matching Network and the house supplied scrubber is operational so that the pressure differential between inside the coil enclosure and ambient pressure is met. Make sure that all of the covers are in place on the TCP enclosure.

Additionally, the RF generator has an internal temperature interlock. Make sure that this interlock is not tripped due to excessive heat.

Bias RF Power On

Table 8–4 shows the hardware interlocks that disable Bias RF power unless they are satisfied.

Table 8–4 .Bias RF Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2

Table 8–4 .Bias RF Power On (continued)

Interlock state	Hardware
Helium maximum flow sw true	node2_DI3
Coil Enclosure Down sw closed	VIOP_DI03
Bias Match cover sw closed	VIOP_DI17
Bias Match RF Connector sw closed	VIOP_DI18

ESC Power On

Table 8–5 shows the hardware interlocks that disable ESC power unless they are satisfied:

Table 8–5 .ESC Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2
Bias Match cover sw closed	VIOP_DI17

The vacuum switch prevents you from operating the ESC when the chamber is at atmosphere and opened, exposing personnel to dangerous voltages. The covers on the He/RF enclosure and the bias match prevent exposure to RF radiation.

Chamber Gas Delivery

Table 8–6 shows the hardware interlocks that disable delivery of process gas from the gas box to the reaction chamber unless they are satisfied:

Table 8–6 .Chamber Gas Delivery

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Gas Ring sw closed	node1_DI6
Station X slot valve closed	node2_DIA
Coil Enclosure Down sw closed	VIOP_DI03

Table 8–6 .Chamber Gas Delivery (continued)

Interlock state	Hardware
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02
Precharge manifold at vacuum	node3_DI2
No Customer gas detect	node3_DI6
No Customer interlock	node3_DI7

The precharge manifold vacuum switch is located inside of the gas box. The two customer specific I/Os are available for you to connect external switches to the process modules to act as interlocks.

Pendulum Valve Open

Table 8–7 shows the firmware interlocks that do not allow the pendulum valve to open unless they are satisfied:

Table 8–7 .Pendulum Valve Open

Interlock state	Hardware
Chamber pressure sw true	node1_DI0
Foreline pressure sw true	node1_DI2

The chamber pressure switch prevents the pendulum valve from opening if the chamber pressure is greater than 500 mtorr. This prevents damage to the turbo pump. The pendulum valve is additionally interlocked to the foreline pressure switch which monitors pressure in the foreline and is a measure of how well the roughing pump is pumping.

Turbo Exhaust Valve Open

Table 8–8 shows the firmware interlock that does not allow the turbo exhaust valve to open unless it is satisfied:

Table 8–8 .Turbo Exhaust Open

Interlock state	Hardware
Foreline pressure sw true	node1_DI2

Opening the foreline exhaust valve at a pressure above 750 mtorr could damage the turbo pump. The foreline pressure switch measures pressure in the foreline and prevents this from happening.

PM Heater Power Interlock

The AC/DC power distribution enclosure provides contactor K1 to interrupt AC power to the system heaters. This contactor is enabled by a combination RTD over-temperature sensors, the temperature monitor board (TMB) of the Anafaze™ temperature controller, and ground fault interrupter (GFI) T1. All over-temperature sensors for all controlled heaters, and the GFI sensor must be safe to enable AC power to heaters.

Thermal Interlock

The foreline manifold heaters are temperature regulated 208 VAC heaters, which employ bi-metallic over-temperature switches set at 100 degrees Celsius to disconnect heater power in the event of a thermal runaway.

Wafer Transfer Slot Valve Interlock

The wafer transfer slot valve is interlocked. This interlock helps to isolate gases in the reaction chamber. Signals are sent from the PM to the TM, so that the TM does not open the slot valve when the PM is at atmosphere and the TM is at vacuum.

Gas Box Hardware Interlocks

To protect personnel from exposing to toxic gases, the interlock circuitry must rely only on the dual compliant electro-mechanical devices.

Table 8–9 shows the gas panel functional interlocks.

Table 8–9 .Gas Box Hardware Interlocks

		Inputs							
		Chamber delivery valve ok contact closure from PM interlock board	Roughing Pump ok contact Closure from PM interlock board	Precharge Manifold at VAC	Chamber Delivery at VAC	Differential pressure SW ok	N2 Purge Supply	Customer Gas Detect	Customer Interlock SW ok
				PSH2	PSH3	PSH8	PSH9	IS20	IS21
				DI2	DI3	DI4	DI5	DI6	DI7
SOVNo.	*Enable following function*								
SOV1	N2 Primary valve on						X	X	X
SOV2	Vacuum Primary valve on		X	X				X	X
SOV3	Gas Manifold Purge valve on						X	X	X
SOV4	Gas Manifold Precharge valve on		X	X				X	X
SOV5	Chamber gas delivery valve on	X	X	X				X	X
SOV7	Chamber slow vent						X	X	X
SOV8	Chamber wafer transfer						X	X	X
SOV9	Chamber N2 valve on						X	X	X
SOV10-80	All gas primary valve on				X	X		X	X
SOV12-82	All gas secondary valve on				X	X		X	X

SOVx refers to the shutoff valve in the gas box.

SOV1 Nitrogen Primary Valve On

Table 8–10 shows the following interlocks that prevent the opening of the nitrogen primary valve unless they are true.

Table 8–1 0 .SOV1

Interlock	Number	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	S20
Customer Interlock SW ok	DI7	IS21

Interlocked unless opening by the pressurer switch for the nitrogen purge supply (PSH9). Additionally, the customer has the option of adding up to two external interlocks of their choice. The system ships with these two I/Os jumpered short.

SOV2 Vacuum Primary Valve On

Table 8–11 shows the following interlocks that prevent the opening of the vacuum primary valve unless they are true.

Table 8–1 1 .SOV2

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board		
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV3 Gas Manifold Purge valve on

Table 8–12 shows the following interlocks that prevent the opening of the gas manifold purge valve unless they are true.

Table 8–1 2 .SOV3

Interlocks	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Interlocked unless opening by the pressure switch for the nitrogen purge supply (PSH9). Additionally, the customer has the option of adding up to two external interlocks of their choice. The system ships with these two I/Os jumpered “short”.

SOV4 Gas Manifold Precharge Valve On

Table 8–13 shows the following interlocks that prevent the opening of the gas manifold precharge valve unless they are true.

Table 8–1 3 .SOV4

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board	-	-
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV5 Chamber Gas Delivery Valve On X

Table 8–14 shows the following interlocks that prevent the opening of the chamber gas delivery valve unless they are true.

Table 8–1 4 .SOV5

Interlock	Hardware	Switch
Chamber delivery valve ok contact closure from PM interlock board.		
Roughing Pump ok contact Closure from PM interlock board		
Precharge Manifold @ VAC	DI2	PSH2
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV7 Chamber Slow Vent

Table 8–15 shows the following interlocks that prevent the opening of the chamber slow vent valve unless they are true.

Table 8–1 5 .SOV7

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV8 Chamber Wafer Transfer

Table 8–16 shows the following interlocks that prevent the opening of the chamber wafer transfer valve unless they are true.

Table 8–1 6 .SOV8

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV9 Chamber N2 Valve On

Table 8–17 shows the following interlocks that prevent the opening of the chamber N2 valve unless they are true.

Table 8–1 7 .SOV9

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV10-80 All Gas Primary Valve On

Table 8–18 shows the following interlocks that prevent the opening of the all gas primary valve unless they are true.

Table 8–1 8 .SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Gas is prevented from going to the PM from the gas box if the chamber is not vacuum as read through vacuum switch (PSH3) and if the differential pressure switch (PSH8) in the coil enclosure is not true.

SOV12-82 All Gas Secondary Valve On

Table 8–19 shows the following interlocks that prevent the opening of the all gas secondary valve unless they are true.

Table 8–1 9 .SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

RF Energy

RF energy is produced by the poly etch process module. Table 8–20 shows the power requirements for various applications of the poly etch process module.

Table 8–2 0 .Poly Etch Power Requirements

Process	Process gas	Generator frequency (upper/lower)	Generator power (typical)
Polysilicon Oxide Breakthrough Step	CF_4 or Cl_2	13.56 MHz 13.56 MHz	250-350 50-250
Polysilicon Main Etch Step	Cl_2, HBr, O_2	13.56 MHz 13.56 MHz	150-450 100-250
Polysilicon Overetch Step	HBR, He, O_2	13.56 MHz 13.56 MHz	150-350 100-250
Tungsten Silicide Main and Overetch Steps	Cl_2, O_2	13.56 MHz 13.56 MHz	200-300 100-200
Nitride Bulk Etch Step	CF_4, HBr	13.56 MHz 13.56 MHz	500-700 50-200
Nitride Endpoint and Overetch Steps	SF_6, HBr	13.56 MHz 13.56 MHz	500-700 0-100
Plasma Clean Step 1	SF_6, Cl_2	13.56 MHz	600-800 0
Plasma Clean Step 2	SF_6, O_2	13.56 MHz	600-800 0

Chemicals

Chemicals Used During Maintenance

The following chemicals are used during each wet clean of the 2300 poly process module:

Isopropyl alcohol (IPA) (3 to 6 ounces)

Hydrogen peroxide solution (6 percent H_2O_2 with DI H_2O) (30 ounces)

Chemicals Used During Etch Process

The poly etch process module is capable of three types of plasma etch processes: polysilicon, tungsten silicide and nitride. All the three etch processes produce different exhaust effluents.

Polysilicon Etch

Etching polysilicon is based upon the following chemical reaction:

$$Si + 2\ Cl_2 \rightarrow SiCl_4$$

Actual plasma etch processes, however, are more complex than this, because there are more chemical species involved in the etch. For example, other gases such as hydrogen bromide (HBr) are routinely added to the process and wafers contain other compounds including nitrogen (N), silicon (Si), oxygen (O), and photoresist. It is difficult to exactly calculate or even measure the effluent of a plasma reactor, but the major products can be readily predicted from a calculation of the thermodynamically most stable products.

For polysilicon etch using a baseline chlorine (Cl_2) and HBr, the most common effluent component is hyrocloric acid (HCl). Chlorine (Cl_2) utilization is complete, and not detected in the effluent. HBr and bromine (Br_2) were also detected in the effluent in smaller concentrations.

For the baseline carbon tetrafluoride (CF_4) oxide breakthrough step on polysilicon, CF_4 utilization is very low, at about 10 percent. Emissions are primarily perfluorocarbons (PFCs), with small quantities of silicon tetrafluoride (SiF_4) and carbon difluoride (COF_2). For the basline process, the utilization efficiency of the CF_4 was 13.6 percent, while the production efficiency of the Trifluoromethane (CFH_3) and hexafluoroethane (C_2F_6) were 16.3 percent and 5.4 percent, respectively.

For the baseline nitride bulk etch step using CF_4 and HBr chemistry, the utilization efficiency of the CF_4 is 34.2 percent, while the production efficiency of the CFH_3 is 12.7 percent and the C_2F_6 is 1.6 percent.

For the baseline nitride endpoint and overetch steps using SF_6 and HBr chemistry, the utilization efficiency of the SF_6 is 83.6 percent.

For the baseline chlorine/sulfur hexafluoride (Cl_2/SF_6) plasma clean, Cl_2 utilization is low, and is thus detected in the effluent. SF_6 utilization is 53.0 percent. There is evidence of sulfuryl fluoride (SO_2F_2) and thionyl fluoride (SOF_2) detected in the effluent as well.

For the baseline sulfur hexafluoride/oxygen (SF_6/O_2) plasma clean, there is low fluorine consumption, and thus high emission levels of SOF_2 and SO_2F_2, and possibly SOF_2. SF_6 utilization effieciency is 68.3 percent.

The baseline process for polysilicon, oxide breakthrough step main, and overetch steps is:

BT step: 15mtorr, 200 sccm CF_4 for 10 seconds
ME step: 10mtorr, 100 sccm CL_2 300 sccm HBr
OE step: 60mtorr, 400 sccm He, 200 sccm HBr, 4 sccm O_2

Baseline process for tungsten silicide main and overetch steps is:

4mtorr, 180 sccm CL_2, 4 sccm O_2

Baseline process for nitride bulk, endpoint and overetch steps is:

BE step: 20mtorr, 150 sccm CF_4 50 sccm HBr
EP step: 15mtorr, 50 sccm SF_6 100 sccm HBr
OE step: 30mtorr, 50 sccm SF_6 100 sccm HBr

9
2300 Poly PM Industrial Hygiene Report

This chapter lists the industrial hygiene test results of the 2300 poly PM on the Domino platform.

Chemical Exposure Testing

Test Parameters and Procedures

The following test equipment and test criteria were employed during testing of the 2300 process module on the Domino platform.

Table 9–1 .Test Equipment andTest Criteria

Parameter/chemical	Test procedure/analytical method	Exposure limit / (TLV)
RF Induced electric and Magnetic Fields	Narda Industrial Compliance Meter for Electromagnetic Energy Model 8511	4.89 mW/cm_2 electric 54.3 mW/cm_2 magnetic. (Instantaneous) Calculated from ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)
UV Radiation	International Light Direct Reading Meter Model No. IL1400A Meter	10 μW/cm_2 for five minute exposure period From Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)
Bromine (Br_2)	NIOSH method 6011, iron chromatography silver membrane filter	Ppm Time Weighed Average TWA) for 8 hour exposure period From Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)

Table 9–1 .Test Equipment andTest Criteria (continued)

Parameter/chemical	Test procedure/analytical method	Exposure limit / (TLV)
Carbon Monoxide (CO)	Direct Reading Monitor	25 ppm TWA for 8 hour exposure period From Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)
Carbon Tetrachloride (CCl_4)	OSHA method 7, GC/FID charcoal tube	5 ppm for 8 hour exposure period From Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)
Chlorine (Cl_2)	Direct Reading Monitor And NIOSH method 6011, ION chromatography silver membrane filter	0.5 ppm TWA for 8 hour exposure period 1 ppm (STEL) for instantaneous exposure period. From Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)
Hydrochloric Acid (HCl)	NIOSH method 7903, ION chromatography silica gel tubes for acids	5 ppm Ceiling for instantaneous exposure period.
Hydrofluoric Acid (HF)	NIOSH method 7903, ION chromatography silica gel tubes for acids	3 ppm Ceiling for instantaneous exposure period
Hydrogen Bromide (HBr)	MDA TLD-1 Toxic Gas Meter And NIOSH method 7903, ION chromatography silica gel tubes for acids	3 ppm Ceiling for instantaneous exposure period
Hydrogen Peroxide (H_2O_2)	OSHA method ID126SG differential pulse polarography	1 ppm TWA for 8 hour exposure period
Isopropyl Alcohol (IPA)	OSHA method 7, GC/FID charcoal tube	500 ppm STEL for 15 minute exposure period From Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (1999)

Table 9–1 .Test Equipment andTest Criteria (continued)

Parameter/chemical	Test procedure/analytical method	Exposure limit / (TLV)
Argon (Ar)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 0
Octafluorocyclobutane (C4F8)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 0
Hexafluoropropylene (C3F6)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 0
Oxygen (gaseous)(O2)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 0
Hexafluoroethane (C2F6)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 2
Carbon Tetrafluoride(CF4)	)Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 1
Trifluoromethane (CHF3)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 1
Sulfur Hexafluoride (SF6)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 1
Octafluorocyclobutane (C4F8)	(Inert gas) Non-toxic gas Do not need to sample	NFPA Code Health = 1
Nitrogen (N2) (Inert gas)	Non-toxic gas Do not need to sample	NFPA Code Health = 0
Noise (Sound Level Readings)	OSHA Quest Sound Level Meter	80 dBA

Test Results

The 2300 process recipe used during engineering evaluation was:

- Nitride: 10 mT/800Wt/70Wb/8 O_2/50 HBr/100CF_4/8T He/30
- Silicon: 10mT/900Wt/120Wb/35 Cl_2/8 O_2/150 HBr/8T He/30

The SEMI S2-0200 evaluation of the 2300 process module includes the industrial hygiene assessment of the potential for exposure to process chemistries including Cl_2, Br_2, HCl, HBr, HF, CCl_4; and the maintenance chemicals used during a chamber clean: IPA, and H_2O_2. Industrial hygiene data was recorded during the initial opening (post process) and subsequent opening and cleaning of the reaction chamber performed by an equipment technician. All equipment panels and protective covers were in place during the industrial hygiene measurements unless otherwise noted. Local exhaust at the process module was not utilized during the monitoring.

The process module that was sampled had processed 4,200 wafers for an engineering evaluation. The *2300 Poly Process Module Maintenance* Manual recommends a chamber clean each quarter. Prior to opening the chamber, a standard clean recipe consisting of 125 sccm of SF_6 for 135 seconds, then O_2 for 200 seconds. Then 30 pump/purge cycles were performed. At the time of evaluation, no recommended number of pump/purge cycles had been established. The *2300 Poly Process Module Maintenance* Manual recommends 50 to 100 pump/purge cycles if Cl_2 or HBr is in use.

Three real-time industrial hygiene air-sampling instruments were used to measure the identified analyses. Carbon monoxide was measured using an Interscan 1000 series, Model 1146 (SN 28257). The lower sensitivity for CO of the detector was 2 ppm. An Interscan Model 1340 (SN 215041) was used to measure Cl_2. The lower sensitivity was 0.1 ppm for $C1_2$. A Zellweger Analytics MDA TLD-1 (SN 104781) was utilized to detect HBr. The lower limit of detection for HBr using the MDA is 0.3 ppm. The TLD was operated with a freshly opened, freezer stored Chemcassete QC cartridge (Part No. 705505-0, SN900474), appropriate for HBr.

Industrial hygiene air samples were collected using SKC constant-flow air sampling pumps with inline collection media (see references to specific analyses). The pumps are UL-listed as intrinsically safe apparatus for use in Class I, II, and II, Division 1 Hazardous Locations. Start and end times were measured for each sample to determine the duration of sampling. Sample pump train flow rates were determined from pump calibration data. Sample pumps were calibrated using a BIOS Dry Cell Calibrator (Model DC-1B, Rev. 2.06E, SN B2951) equipped with a BIOS standard calibration cell (Model DC-1SC, Rev. E, SN S2854). The standard calibration cell is rated for sample pump flows of 10 to 9,999 milliliters per minute. The BIOS Dry Cell is an NIST-traceable primary standard.

The pumps were operated for at least five minutes to allow them to come to operating temperature, and for flow to stabilize. The flow rate for each pump was adjusted and set, and then calibrated using a representative sampling train (for example, sorbent tube, impinger with fluid, Tygon tubing, needle valve, and so forth.) that remains with the pump from pre-test calibration through testing and post-test calibration. During pre-test calibration, the flow through each sample pump/sample train is measured three times. At post-test calibration, the flow through each sample pump/sample train is again measured three times. Each pump is checked to verify that the average flow rate for pre-test and post-test calibrations differed by no more than 5 percent. For purposes of sample analysis, the flow rate was determined as the arithmetic average of the six calibration measurements (that is, three pre-test and three post-test calibrations). A *Sample Pump Calibration Log* is completed in the field to document the calibration.

Samples for H_2O_2 analysis were sent to Wisconsin Occupational Health Laboratory of Madison, Wisconsin. All other sample media were to submit toAT Labs of Boardman, Ohio for analysis. Both labs are American Industrial Hygiene Association (AIHA)-accredited industrial hygiene laboratories.

The following health hazard data was obtained for the 2300 process module. Table 9–2 presents real time monitoring data.

Table 9–2 .Industrial Hygiene Direct Reading Survey Results

Area / Sample description (sampling period 10:05 – 10:20 am)	Result ppm		Reference standards ACGIH TLV/ 25% Ppm	Reference standardsOS HA PEL/25% Ppm
1. At edge of chamber during chamber crack.	HBr	<0.3	C 3/C0.75	3/0.75
	Cl_2	0.2	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/12.5
2. At edge of open chamber.	HBr	<0.3	C 3 C/0.75	3/0.75
	Cl_2	0.15	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/12.5
3. Technician breathing zone upon chamber open.	HBr	<0.3	C 3/0.75	3/0.75
	Cl_2	0.1	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/125

Table 9–2 .Industrial Hygiene Direct Reading Survey Results (continued)

Area / Sample description (sampling period 10:05 – 10:20 am)	Result ppm		Reference standards ACGIH TLV/ 25% Ppm	Reference standardsOSHA PEL/25% Ppm
4. Technician breathing zone during removal of upper focus ring and hot ring.	HBr	Not measured	C 3/0.75	3/0.75
	Cl_2	0.1	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/125
5. Technician breathing zone during measurement of deposits on chamber.	HBr	<0.3	C 3/0.75	3/0.75
	Cl_2	0.1	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/1.25
6. Near chamber as cleaning begun.	HBr	<0.3	C 3/0.75	3/0.75
	Cl_2	<0.1	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/1.25
7. Technician breathing zone, during removal of liner.	HBr	<0.3	C 3/0.75	3/0.75
	Cl_2	<0.1	0.5/0.125	C1/C0.25
	CO	4	25/6.25	50/1.25
8. Technician breathing zone, as cleaning continued.	HBr	<0.3	C 3/0.75	3/0.75
	Cl_2	Not measured	0.5/0.125	C1/C0.25
	CO	< 2	25/6.25	50/1.25
9. Near chamber lip while cleaning with IPA.	CO	Not measured	25/6.25	50/1.25

<u>**Notes:**</u>ACGIH – American Conference of Governmental Industrial Hygienists

TLV – Threshold Limit Value

OSHA – Occupational Safety & Health Administration

PEL – Permissible Exposure Limit

ppm – parts per million

C – ceiling value

< denotes “less than” the detection limit indicated.

Ultra-Violet Radiation

The SEMI S2-0200 evaluation of the 2300 process module on the Domino platform includes the industrial hygiene evaluation of the potential for exposure to UV light. Measurements were recorded during normal operation of the process module under the SP1 recipe.

UV was measured using an International Light 1400A Radiometer survey meter (SN 3034) with a SEL 240 probe (SN 4438). Measurements were recorded throughout the normal recipe or cycling of wafers (see Table 9–3). Readings in microwatts per centimeter cubed (mW/cm^3) were recorded at a two-inch distance from the quartz glass viewport.

Table 9–3 .UV Light Survey Results

Area/Description	Reading ($\mu W/cm^2$)	ACGIH Effective Irradiance 5 min. exposure limit $\mu W/cm^2$
Left viewport, at face.	0.02	ACGIH = 10
Left viewport, at 2 inches distance.	< 0.01	ACGIH = 10
Right viewport, at face.	0.02	ACGIH = 10
Right viewport, at 2 inches distance.	< 0.01	ACGIH = 10

Note ACGIH – American Conference of Governmental Industrial Hygienists.

< Denotes "less than" the detection limit indicated.

Radio Frequency

The SEMI S2-0200 evaluation of the 2300 process module on the Domino platform includes the industrial hygiene evaluation of the potential for exposure to non-ionizing RF radiation. Measurements were recorded during normal operation of the process module (see Table 9–4). All panels, mesh screens, and protective covers were in place during the measurements.

RF was measured using a Narda Industrial Compliance Meter for Electromagnetic Energy, Model 8511. The Narda meter was set for a range that included the 13.56 MHz frequency being generated by the system. Maximum process recipe operation is 900 watts under the SP1 recipe for the 13.56 MHz power supply. Power levels are directly related to the desired process and specific recipe. Measurements were taken continuously throughout the process cycle two inches from the measurement area and included cables, power source, viewport and lower / upper match areas.

Table 9–4 .Non-Ionizing Survey Results, 13.56 MHz, 900W

Area/description	Field (mW/cm^2)	Readings	ACGIH / OSHA[a] reference standards (6 min. exposure = mW/cm^2)	
TCP: At generator top At cable exit Along cable At connection to match	E Field	<0.01	4.89 mW/cm^2	**OSHA** = 10 mW/cm^2
	H Field	<0.01	54.3 mW/cm^2	
Bias: At generator top At cable exit Along cable At coil on floor Along cable left side At connection to match	E Field	<0.01	4.89 mW/cm^2	**OSHA** = 10 mW/cm^2
	H Field	<0.01	54.3 mW/cm^2	
At power source top and cable connection	E Field	<0.01	4.98 mW/cm^2	**OSHA** = 10 mW/cm^2
	H Field	<0.01	54.3 mW/cm^2	
TCP and Bias Match: Left side, Right side, Front and Back	E Field	<0.01	4.89 mW/cm^2	**OSHA** = 10 mW/cm^2
	H Field	<0.01	54.3 mW/cm^2	

a. These values also meet the SEMATECH Application Guide guidance limits for uncontrolled environments, specifically 0.98 mW/cm^2 for electric field strength

Noise

The following health hazard data was obtained for the 2300 process module, measuring noise (using a Quest Sound Level Meter): Model 2400, Serial Number JN7110028.

The SEMI S2-0200 evaluation of the 2300 process module includes the industrial hygiene review for potential exposure to elevated noise levels during operation of the system. No additional engineering controls such as noise reduction materials were utilized. The survey (see Table 9–5) was performed by initially recording background noise levels followed by measurements recorded adjacent to the equipment in both the operator and technician work areas during normal system operation under recipe SPC_Ox_ER Cl_2 50. The transporter side of the system was considered the backside of the system.

Table 9–5 .Industrial Hygiene Noise Measurement Results

Location/Description	Result DBA	ACGIH TLV dBA
General Area Background, about 15-20 feet from system.	76 – 78	80
Left side, one foot from system, about 50 inches above floor level.	78	80
Front, 6 inches from system, about 60 inches above floor level.	76	80
Right side, 6 inches from system, about 60 inches above floor level.	76	80
Backside, 3 inches from system, about 60 inches above floor level.	76	80

10
2300 Metal Process Module

This chapter provides safety information specific to the 2300 metal process module.

For system safety information or for safety information on any other process module for the system, refer to the remainder of this manual.

Domino/2300 process modules are operated from the transport module operator interface. For general system operating instructions, see the *2300 Metal Operation* manual.

For transport module maintenance information, see the *Domino Transport Module Maintenance* manual.

Interlocks

Process Module Interlocks

The hazardous functions of the process module are interlocked as shown in Table 10–1.

Table 10–1 .Process Module Interlocks

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP Not inhibited	Turbo exhaust valve on
Chamber pressure sw true	H	H	H	H	F		
Foreline pressure sw true		H			F	F	F
Chamber vacuum sw true	H		H	H			
Gas ring sw closed				H			

Table 10–1 .Process Module Interlocks (continued)

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP Not inhibited	Turbo exhaust valve on
HE/RF enclosure cover sw closed		H					
Helium maximum flow sw true		F					
Station X slot valve closed				H			
Coil enclosure down sw closed	H	H		H			
TCP RF connector sw closed	H						
TCP match scrubber sw closed	H			H			
TCP Match cover sw closed	H			H			
Lower match cover sw closed		H	H				
Lower match connector sw closed		H					
Roughing pump on				H			
Precharge manifold at vacuum				H			
No customer gas detect				H			
No customer interlock				H			

H = hardware human safety interlock

F = firmware equipment safety interlock

Describing the Interlocks

Enclosure Hardware Interlocks

The following enclosures are equipped with interlocks that disconnect AC power to the PM if activated. These interlocks are all in series in the 24 VAC interlock circuit.

- The cover for the AC power distribution enclosure
- The cover for the DC power distribution enclosure

Process Module Hardware and Firmware Interlocks

All hardware and firmware interlocks on the PM have redundant software interlocks also. The following table lists the various PM interlocks implemented in hardware and firmware (as well as software) and the process that they interlock.

Table 10–2 .PM Hardware and Interlocks

		Interlock Switches/ DI ID#/ Conditions															
		Chamber pressure sw true	**Foreline pressure sw true**	**Chamber vacuum sw true**	**Gas Ring sw closed**	**He/RF enclosure cover sw closed**	**Helium maximum flow sw true**	**Station X slot valve closed**	**Coil Enclosure Down sw closed**	**TCP RF connector sw closed**	**TCP Match scrubber sw closed**	**TCP Match cover sw closed**	**Bias Match cover sw closed**	**Bias Match RF Connector sw closed**	**Precharge manifold at vacuum**	**No Customer gas detect**	**No Customer interlock**
P&ID designation		CM2S1	CM3S1	PS1	SW1												
		node1	node1	node1	node1	node2	node2	node2	VIOP	VIOP	VIOP	VIOP	VIOP	VIOP	node3_	node3_	node3_
		DI0	DI2	DI3	DI6	DI2	DI3	DIA	DI03	DI04	DI05	DI02	DI17	DI18	DI2	DI6	DI7
	LED on board	CR1-A	CR1-B	CR1-C	CR1-D	CR2-B	CR2-C	CR2-D	CR3-A	CR3-B	CR3-C	CR3-D	CR4-A	CR4-B			
Enable the following function																	
TCP RF power on	(CR5-C)			K4					K5	K17	K21, K16	K20, K15					
Bias RF power on	(CR5-D)			K4		K7, K13	K18		K5				K10, K12	K11			
ESC power on	(CR5-A)			K4		K7, K13							K10, K12		H	H	H
Chamber Gas delivery valve on	(CR5-B)			K4	K3			K8	K5		K21, K16	K20, K15					
Pendulum valve open	(CR6-A)	U7/B	U7/D														
Turbo Exhaust valve on	(CR4-D)		U7/D														

Note: K =Hardware interlock, relay used on the board. U=Firmware interlock, opto-couples used on the board

LEDs Location (top of the board)

TM Slot Valve	He Max Flow Switch	He/RF Enclosure Cover Switch	Chamber ATM switch	Gas Ring Down Switch	Chamber Vacuum Switch	Foreline Vacuum Switch	Chamber Pressure Switch
CR2-D	CR2-C	CR2-B	CR2-A	CR1-D	CR1-C	CR1-B	CR1-A
TMP Exh Valve Open	Hardware Bypass ON	Bias RF Connector Switch	Bias Match Covers Switches	TCP Match Covers Switches	CP Match Scrubber Switch	TCP RF Connector Switch	Coil Enclosure Down Switch
CR4-D	CR4-C	CR4-B	CR4-A	CR3-D	CR3-C	CR3-B	CR3-A
Not used	Not used	Not used	Pendulum Valve Open	Bias RF Interlocks OK	TCP RF Interlocks OK	Chamber Gas Delivery OK	ESC High Voltage On
			CR6-A	CR5-D	CR5-C	CR5-B	CR5-A

DI Lights

Green=Switch is true

No light=Switch is not true

Node 3 (Gas Box) DS3	Node 1 (Chamber) DS1
Node 5 (VME) DS4	Node 2 (Lower Electrode) DS2

Node Connection Lights

Green=connected correctly

Red=not connected or connected wrong

Processes Which Are Interlocked

TCP RF Power On

Table 10–3 shows the hardware interlocks that disable TCP RF power unless they are satisfied.

Table 10–3 .TCP RF Power

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Coil Enclosure Down sw closed	VIOP_DI03
TCP RF connector sw closed	VIOP_DI04
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02

Ensure that the PM chamber is at vacuum, which means the pressure is lower than 75 Torr. Make sure that the coil enclosure is in the down position so that RF cannot be generated and expose personnel to dangerous RF. Ensure that the TCP RF generator is connected to the TCP Matching Network and the house supplied scrubber is operational so that the pressure differential between inside the coil enclosure and ambient pressure is met. Make sure that all of the covers are in place on the TCP enclosure.

Additionally, the RF generator has an internal temperature interlock. Ensure that the interlock does not trip due to excessive heat.

Bias RF Power On

Table 10–4 shows the hardware interlocks that disable Bias RF power unless they are satisfied.

Table 10–4 .Bias RF Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2

Table 10–4 .Bias RF Power On (continued)

Interlock state	Hardware
Helium maximum flow sw true	node2_DI3
Coil Enclosure Down sw closed	VIOP_DI03
Bias Match cover sw closed	VIOP_DI17
Bias Match RF Connector sw closed	VIOP_DI18

ESC Power On

Table 10–5 shows the hardware interlocks that disable ESC power unless they are satisfied:

Table 10–5 .ESC Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2
Bias Match cover sw closed	VIOP_DI17

The vacuum switch prevents you from operating the ESC when the chamber is at atmosphere, opened, and exposes personnel to dangerous voltages. The covers on the He/RF enclosure and the bias match prevent exposure to RF radiation.

Chamber Gas Delivery

Table 10–6 shows the hardware interlocks that disable delivery of process gas from the gas box to the reacion chamber unless they are satisfied:

Table 10–6 .Chamber Gas Delivery

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Gas Ring sw closed	node1_DI6
Station X slot valve closed	node2_DIA
Coil Enclosure Down sw closed	VIOP_DI03

Table 10–6 .Chamber Gas Delivery (continued)

Interlock state	Hardware
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02
Precharge manifold at vacuum	node3_DI2
No Customer gas detect	node3_DI6
No Customer interlock	node3_DI7

The precharge manifold vacuum switch is located inside of the gas box. The two customer specific I/Os are available for the customer's use to connect external switches to the process modules to act as interlocks.

Pendulum Valve Open

Table 10–7 shows the firmware interlocks that do not allow the pendulum valve to open unless they are satisfied:

Table 10–7 .Pendulum Valve Open

Interlock state	Hardware
Chamber pressure sw true	node1_DI0
Foreline pressure sw true	node1_DI2

The chamber pressure switch prevents you from opening the pendulum valve if the chamber pressure is greater than 500 mtorr. This prevents damage to the turbo pump. The pendulum valve is additionally interlocked to the foreline pressure switch which monitors pressure in the foreline and is a measure of how well the roughing pump is pumping.

Turbo Exhaust Valve Open

Table 10–8 shows the firmware interlock that does not allow the turbo exhaust valve to open unless it is satisfied:

Table 10–8 .Turbo Exhaust Open

Interlock state	Hardware
Foreline pressure sw true	node1_DI2

Opening the foreline exhaust valve at a pressure above 750 mtorr could damage the turbo pump. The foreline pressure switch measures pressure in the foreline and prevents this from happening.

PM Heater Power Interlock

The AC/DC power distribution enclosure provides contactor K1 to interrupt AC power to the system heaters. This contactor is enabled by a combination RTD over-temperature sensors, the temperature monitor board (TMB) of the Anafaze temperature controller, and ground fault interrupter (GFI) T1. All over-temperature sensors for all controlled heaters, and GFI sensor must be safe to enable AC power to heaters.

Thermal Interlock

The foreline manifold heaters are temperature regulated 208 VAC heaters, which employ bi-metallic over-temperature switches set at 100 degrees Celsius to disconnect heater power in the event of a thermal runaway.

Wafer Transfer Slot Valve Interlock

The wafer transfer slot valve is interlocked. This interlock helps to isolate gases in the reaction chamber. Signals are sent from the PM to the TM, so that the TM does not open the slot valve when the PM is at atmosphere and the TM is at vacuum.

Gas Box Hardware Interlocks

To protect personnel from exposing to toxic gases, the interlock circuitry must rely only on the dual compliant electro-mechanical devices.

Table 10–9 shows the gas panel functional interlocks.

Table 10–9 .Gas Box Hardware Interlocks

		Inputs							
		Chamber delivery valve ok contact closure from PM interlock board	Roughing Pump ok contact Closure from PM interlock board	Precharge Manifold at VAC	Chamber Delivery at VAC	Differentia l pressure SW ok	N2 Purge Supply	Customer Gas Detect	Customer Interlock SW ok
				PSH2	PSH3	PSH8	PSH9	IS20	IS21
				DI2	DI3	DI4	DI5	DI6	DI7
SOVNo.	*Enable following function*								
SOV1	N2 Primary valve on						X	X	X
SOV2	Vacuum Primary valve on		X	X				X	X
SOV3	Gas Manifold Purge valve on						X	X	X
SOV4	Gas Manifold Precharge valve on		X	X				X	X
SOV5	Chamber gas delivery valve on	X	X	X				X	X
SOV7	Chamber slow vent						X	X	X
SOV8	Chamber wafer transfer						X	X	X
SOV9	Chamber N2 valve on						X	X	X
SOV10-80	All gas primary valve on				X	X		X	X
SOV12-82	All gas secondary valve on				X	X		X	X

SOVx refers to the shutoff valve in the gas box.

SOV1 Nitrogen Primary Valve On

Table 10–10 shows the following interlocks that prevent the opening of the nitrogen primary valve unless they are true.

Table 10–1 0 .SOV1

Interlock	Number	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	S20
Customer Interlock SW ok	DI7	IS21

Interlocked unless opening by the pressure switch nitrogen purge supply (PSH9). Additionally, the customer has the option of adding up to two external interlocks of their choice. The system ships with these two I/Os jumpered short.

SOV2 Vacuum Primary Valve On

Table 10–11 shows the following interlocks that prevent the opening of the vacuum primary valve unless they are true.

Table 10–1 1 .SOV2

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board		
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV3 Gas Manifold Purge valve on

Table 10–12 shows the following interlocks that prevent the opening of the gas manifold purge primary valve unless they are true.

Table 10–1 2 .SOV3

Interlocks	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

These valves are interlocked unless opening by the pressure switch for the nitrogen purge supply (PSH9). Additionally, the customer has the option of adding up to two external interlocks of their choice. The system ships with these two I/Os jumpered “short”.

SOV4 Gas Manifold Precharge Valve On

Table 10–13 shows the following interlocks that prevent the opening of the gas manifold precharge valve unless they are true.

Table 10–1 3 .SOV4

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board	-	-
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV5 Chamber Gas Delivery Valve On X

Table 10–14 shows the following interlocks that prevent the opening of the chamber gas delivery valve unless they are true.

Table 10–1 4 .SOV5

Interlock	Hardware	Switch
Chamber delivery valve ok contact closure from PM interlock board.		
Roughing Pump ok contact Closure from PM interlock board		
Precharge Manifold @ VAC	DI2	PSH2
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV7 Chamber Slow Vent

Table 10–15 shows the following interlocks that prevent the opening of the chamber slow vent valve unless they are true.

Table 10–1 5 .SOV7

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV8 Chamber Wafer Transfer

Table 10–16 shows the following interlocks that prevent the opening of the chamber wafer transfer valve unless they are true.

Table 10–1 6 .SOV8

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV9 Chamber N2 Valve On

Table 10–17 shows the following interlocks that prevent the opening of the chamber N2 valve unless they are true.

Table 10–1 7 .SOV9

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV10-80 All Gas Primary Valve On

Table 10–18 shows the following interlocks that prevent the opening of the all gas primary valve unless they are true.

Table 10–1 8 .SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Gas is prevented from going to the PM from the gas box if the chamber is not vacuum as read through vacuum switch (PSH3) and if the differential pressure switch (PSH8) in the coil enclosure is not true.

SOV12-82 All Gas Secondary Valve On

Table 10–19 shows the following interlocks that prevent the opening of the all gas secondary valve unless they are true.

Table 10–1 9 .SOV12-82

Interlock	**Hardware**	**Switch**
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

RF Energy

To be supplied.

Chemicals

Chemicals Used During Maintenance

To be supplied.

Chemicals Used During Etch Process

To be supplied.

11
2300 Metal PM Industrial Hygiene Report

This chapter lists the industrial hygiene test results of the 2300 metal PM on the Domino platform.

Chemical Exposure Testing

To be supplied.

Ultra-Violet Radiation

To be supplied.

Radio Frequency

To be supplied.

Noise

To be supplied.

12
2300 Strip Process Module

This chapter provides safety information specific to the 2300 strip process module.

For system safety information or for safety information on any other process module for the system, refer to the remainder of this manual.

Domino/2300 process modules are operated from the transport module operator interface. For general system operating instructions, see the *2300 Strip Operation* manual.

For transport module maintenance information, see the *Domino Transport Module Maintenance* Manual.

Interlocks

Process Module Interlocks

The hazardous functions of the process module are interlocked as shown in Table 12–1.

Table 12–1 .Process Module Interlocks

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP Not inhibited	Turbo exhaust valve on
Chamber pressure sw true	H	H	H	H	F		
Foreline pressure sw true		H			F	F	F
Chamber vacuum sw true	H		H	H			
Gas ring sw closed				H			

Table 12–1 .Process Module Interlocks (continued)

Table functions	Top RF power on	Lower RF power on	ESC power on	Chamber gas delivery valve on	Pendulum valve open	TMP Not inhibited	Turbo exhaust valve on
HE/RF enclosure cover sw closed		H					
Helium maximum flow sw true		F					
Station X slot valve closed				H			
Coil enclosure down sw closed	H	H		H			
TCP RF connector sw closed	H						
TCP match scrubber sw closed	H			H			
TCP Match cover sw closed	H			H			
Lower match cover sw closed		H	H				
Lower match connector sw closed		H					
Roughing pump on				H			
Precharge manifold at vacuum				H			
No customer gas detect				H			
No customer interlock				H			

H = hardware human safety interlock

F = firmware equipment safety interlock

Describing the Interlocks

Enclosure Hardware Interlocks

The following enclosures are equipped with interlocks that disconnect AC power to the PM if activated. These interlocks are all in series in the 24 VAC interlock circuit.

- The cover for the AC power distribution enclosure
- The cover for the DC power distribution enclosure

Process Module Hardware and Firmware Interlocks

All hardware and firmware interlocks on the PM have redundant software interlocks also. The following table lists the various PM interlocks implemented in hardware and firmware (as well as software) and the process that they interlock.

Table 12–2 .PM Hardware and Interlocks

		Interlock Switches/ DI ID#/ Conditions															
		Chamber pressure sw true	Foreline pressure sw true	Chamber vacuum sw true	Gas Ring sw closed	He/RF enclosure cover sw closed	Helium maximum flow sw true	Station X slot valve closed	Coil Enclosure Down sw closed	TCP RF connector sw closed	TCP Match scrubber sw closed	TCP Match cover sw closed	Bias Match cover sw closed	Bias Match RF Connector sw closed	Precharge manifold at vacuum	No Customer gas detect	No Customer interlock
P&ID designation		CM2S1	CM3S1	PS1	SW1												
		node1	node1	node1	node1	node2	node2	node2	VIOP	VIOP	VIOP	VIOP	VIOP	VIOP	node3_	node3_	node3_
		DI0	DI2	DI3	DI6	DI2	DI3	DIA	DI03	DI04	DI05	DI02	DI17	DI18	DI2	DI6	DI7
	LED on board	CR1-A	CR1-B	CR1-C	CR1-D	CR2-B	CR2-C	CR2-D	CR3-A	CR3-B	CR3-C	CR3-D	CR4-A	CR4-B			
Enable the following function																	
TCP RF power on	(CR5-C)			K4					K5	K17	K21, K16	K20, K15					
Bias RF power on	(CR5-D)			K4		K7, K13	K18		K5				K10, K12	K11			
ESC power on	(CR5-A)			K4		K7, K13							K10, K12		H	H	H
Chamber Gas delivery valve on	(CR5-B)			K4	K3			K8	K5		K21, K16	K20, K15					
Pendulum valve open	(CR6-A)	U7/B	U7/D														
Turbo Exhaust valve on	(CR4-D)		U7/D														

Note: K =Hardware interlock, relay used on the board. U=Firmware interlock, opto-couples used on the board

LEDs Location (top of the board)

TM Slot Valve	He Max Flow Switch	He/RF Enclosure Cover Switch	Chamber ATM switch	Gas Ring Down Switch	Chamber Vacuum Switch	Foreline Vacuum Switch	Chamber Pressure Switch
CR2-D	CR2-C	CR2-B	CR2-A	CR1-D	CR1-C	CR1-B	CR1-A
TMP Exh Valve Open	Hardware Bypass ON	Bias RF Connector Switch	Bias Match Covers Switches	TCP Match Covers Switches	CP Match Scrubber Switch	TCP RF Connector Switch	Coil Enclosure Down Switch
CR4-D	CR4-C	CR4-B	CR4-A	CR3-D	CR3-C	CR3-B	CR3-A
Not used	Not used	Not used	Pendulum Valve Open	Bias RF Interlocks OK	TCP RF Interlocks OK	Chamber Gas Delivery OK	ESC High Voltage On
			CR6-A	CR5-D	CR5-C	CR5-B	CR5-A

DI Lights

Green=Switch is true

No light=Switch is not true

Node 3 (Gas Box) DS3	Node 1 (Chamber) DS1
Node 5 (VME) DS4	Node 2 (Lower Electrode) DS2

Node Connection Lights

Green=connected correctly

Red=not connected or connected wrong

Processes Which Are Interlocked

TCP RF Power On

Table 12–3 shows the hardware interlocks that disable TCP RF power unless they are satisfied.

Table 12–3 .TCP RF Power

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Coil Enclosure Down sw closed	VIOP_DI03
TCP RF connector sw closed	VIOP_DI04
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02

Ensure that the PM chamber is at vacuum, which means the pressure is lower than 75 Torr. Make sure that the coil enclosure is in the down position so that RF cannot be generated and expose personnel to dangerous RF. Ensure that the TCP RF generator is connected to the TCP Matching Network and the house supplied scrubber is operational so that the pressure differential between inside the coil enclosure and ambient pressure is met. Make sure that all of the covers are in place on the TCP enclosure.

Additionally, the RF generator has an internal temperature interlock. Ensure that the interlock does not trip due to excessive heat.

Bias RF Power On

Table 12–4 shows the hardware interlocks that disable Bias RF power unless they are satisfied.

Table 12–4 .Bias RF Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2

Table 12–4 .Bias RF Power On (continued)

Interlock state	Hardware
Helium maximum flow sw true	node2_DI3
Coil Enclosure Down sw closed	VIOP_DI03
Bias Match cover sw closed	VIOP_DI17
Bias Match RF Connector sw closed	VIOP_DI18

ESC Power On

Table 12–5 shows the hardware interlocks that disable ESC power unless they are satisfied:

Table 12–5 .ESC Power On

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
He/RF enclosure cover sw closed	node2_DI2
Bias Match cover sw closed	VIOP_DI17

The vacuum switch prevents you from operating the ESC when the chamber is at atmosphere, opened, and exposes personnel to dangerous voltages. The covers on the He/RF enclosure and the bias match prevent exposure to RF radiation.

Chamber Gas Delivery

Table 12–6 shows the hardware interlocks that disable delivery of process gas from the gas box to the reacion chamber unless they are satisfied:

Table 12–6 .Chamber Gas Delivery

Interlock state	Hardware
Chamber Vacuum sw True	node1_DI3
Gas Ring sw closed	node1_DI6
Station X slot valve closed	node2_DIA
Coil Enclosure Down sw closed	VIOP_DI03

Table 12–6 .Chamber Gas Delivery (continued)

Interlock state	Hardware
TCP Match scrubber sw closed	VIOP_DI05
TCP Match cover sw closed	VIOP_DI02
Precharge manifold at vacuum	node3_DI2
No Customer gas detect	node3_DI6
No Customer interlock	node3_DI7

The precharge manifold vacuum switch is located inside of the gas box. The two customer specific I/Os are available for the customer's use to connect external switches to the process modules to act as interlocks.

Pendulum Valve Open

Table 12–7 shows the firmware interlocks that do not allow the pendulum valve to open unless they are satisfied:

Table 12–7 .Pendulum Valve Open

Interlock state	Hardware
Chamber pressure sw true	node1_DI0
Foreline pressure sw true	node1_DI2

The chamber pressure switch prevents you from opening the pendulum valve if the chamber pressure is greater than 500 mtorr. This prevents damage to the turbo pump. The pendulum valve is additionally interlocked to the foreline pressure switch which monitors pressure in the foreline and is a measure of how well the roughing pump is pumping.

Turbo Exhaust Valve Open

Table 12–8 shows the firmware interlock that does not allow the turbo exhaust valve to open unless it is satisfied:

Table 12–8 .Turbo Exhaust Open

Interlock state	Hardware
Foreline pressure sw true	node1_DI2

Opening the foreline exhaust valve at a pressure above 750 mtorr could damage the turbo pump. The foreline pressure switch measures pressure in the foreline and prevents this from happening.

PM Heater Power Interlock

The AC/DC power distribution enclosure provides contactor K1 to interrupt AC power to the system heaters. This contactor is enabled by a combination RTD over-temperature sensors, the temperature monitor board (TMB) of the Anafaze temperature controller, and ground fault interrupter (GFI) T1. All over-temperature sensors for all controlled heaters, and GFI sensor must be safe to enable AC power to heaters.

Thermal Interlock

The foreline manifold heaters are temperature regulated 208 VAC heaters, which employ bi-metallic over-temperature switches set at 100 degrees Celsius to disconnect heater power in the event of a thermal runaway.

Wafer Transfer Slot Valve Interlock

The wafer transfer slot valve is interlocked. This interlock helps to isolate gases in the reaction chamber. Signals are sent from the PM to the TM, so that the TM does not open the slot valve when the PM is at atmosphere and the TM is at vacuum.

Gas Box Hardware Interlocks

To protect personnel from exposing to toxic gases, the interlock circuitry must rely only on the dual compliant electro-mechanical devices.

Table 12–9 shows the gas panel functional interlocks.

Table 12–9 .Gas Box Hardware Interlocks

		Inputs							
		Chamber delivery valve ok contact closure from PM interlock board	Roughing Pump ok contact Closure from PM interlock board	Precharge Manifold at VAC	Chamber Delivery at VAC	Differential pressure SW ok	N2 Purge Supply	Customer Gas Detect	Customer Interlock SW ok
				PSH2	PSH3	PSH8	PSH9	IS20	IS21
				DI2	DI3	DI4	DI5	DI6	DI7
SOVNo.	*Enable following function*								
SOV1	N2 Primary valve on						X	X	X
SOV2	Vacuum Primary valve on		X	X				X	X
SOV3	Gas Manifold Purge valve on						X	X	X
SOV4	Gas Manifold Precharge valve on		X	X				X	X
SOV5	Chamber gas delivery valve on	X	X	X				X	X
SOV7	Chamber slow vent						X	X	X
SOV8	Chamber wafer transfer						X	X	X
SOV9	Chamber N2 valve on						X	X	X
SOV10-80	All gas primary valve on				X	X		X	X
SOV12-82	All gas secondary valve on				X	X		X	X

SOVx refers to the shutoff valve in the gas box.

SOV1 Nitrogen Primary Valve On

Table 12–10 shows the following interlocks that prevent the opening of the nitrogen primary valve unless they are true.

Table 12–1 0 .SOV1

Interlock	Number	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	S20
Customer Interlock SW ok	DI7	IS21

Interlocked unless opening by the pressure switch for the nitrogen purge supply (PSH9). Additionally, the customer has the option of adding up to two external interlocks of their choice. The system ships with these two I/Os jumpered short.

SOV2 Vacuum Primary Valve On

Table 12–11 shows the following interlocks that prevent the opening of the vacuum primary valve unless they are true.

Table 12–1 1 .SOV2

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board		
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV3 Gas Manifold Purge valve on

Table 12–12 shows the following interlocks that prevent the opening of the gas manifold purge primary valve unless they are true.

Table 12–1 2 .SOV3

Interlocks	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

These valves are interlocked unless opening by the pressure switch for the nitrogen purge supply (PSH9). Additionally, the customer has the option of adding up to two external interlocks of their choice. The system ships with these two I/Os jumpered “short”.

SOV4 Gas Manifold Precharge Valve On

Table 12–13 shows the following interlocks that prevent the opening of the gas manifold precharge valve unless they are true.

Table 12–1 3 .SOV4

Interlock	Hardware	Switch
Roughing Pump ok contact Closure from PM interlock board	-	-
Precharge Manifold @ VAC	DI2	PSH2
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV5 Chamber Gas Delivery Valve On X

Table 12–14 shows the following interlocks that prevent the opening of the chamber gas delivery valve unless they are true.

Table 12–1 4 .SOV5

Interlock	Hardware	Switch
Chamber delivery valve ok contact closure from PM interlock board.		
Roughing Pump ok contact Closure from PM interlock board		
Precharge Manifold @ VAC	DI2	PSH2
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV7 Chamber Slow Vent

Table 12–15 shows the following interlocks that prevent the opening of the chamber slow vent valve unless they are true.

Table 12–1 5 .SOV7

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV8 Chamber Wafer Transfer

Table 12–16 shows the following interlocks that prevent the opening of the chamber wafer transfer valve unless they are true.

Table 12–1 6 .SOV8

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV9 Chamber N2 Valve On

Table 12–17 shows the following interlocks that prevent the opening of the chamber N2 valve unless they are true.

Table 12–1 7 .SOV9

Interlock	Hardware	Switch
N2 Purge Supply	DI5	PSH9
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

SOV10-80 All Gas Primary Valve On

Table 12–18 shows the following interlocks that prevent the opening of the all gas primary valve unless they are true.

Table 12–1 8 .SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

Gas is prevented from going to the PM from the gas box if the chamber is not vacuum as read through vacuum switch (PSH3) and if the differential pressure switch (PSH8) in the coil enclosure is not true.

SOV12-82 All Gas Secondary Valve On

Table 12–19 shows the following interlocks that prevent the opening of the all gas secondary valve unless they are true.

Table 12–1 9 .SOV12-82

Interlock	Hardware	Switch
Chamber Delivery @ VAC	DI3	PSH3
Differential pressure SW ok	DI3	PSH8
Customer Gas Detect	DI6	IS20
Customer Interlock SW ok	DI7	IS21

RF Energy

To be supplied.

Chemicals

Chemicals Used During Maintenance

To be supplied.

Chemicals Used During Etch Process

To be supplied.

13
2300 Strip PM Industrial Hygiene Report

This chapter lists the industrial hygiene test results of the 2300 strip PM on the Domino platform.

Chemical Exposure Testing

To be supplied.

Ultra-Violet Radiation

To be supplied.

Radio Frequency

To be supplied.

Noise

To be supplied.

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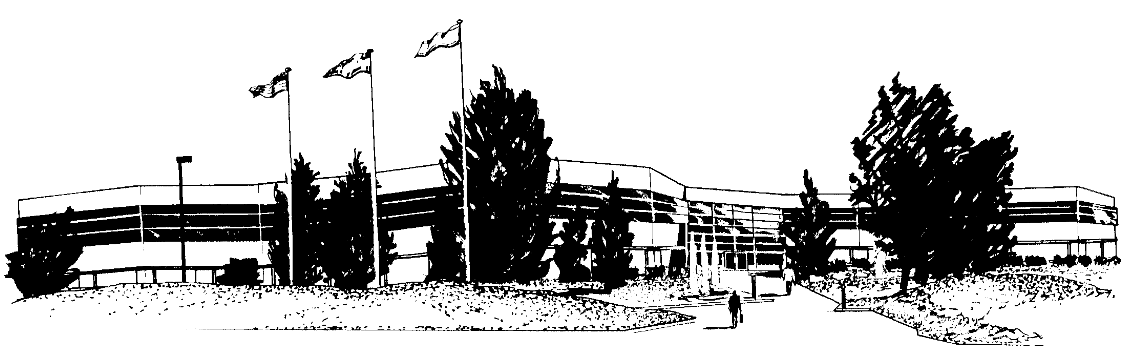

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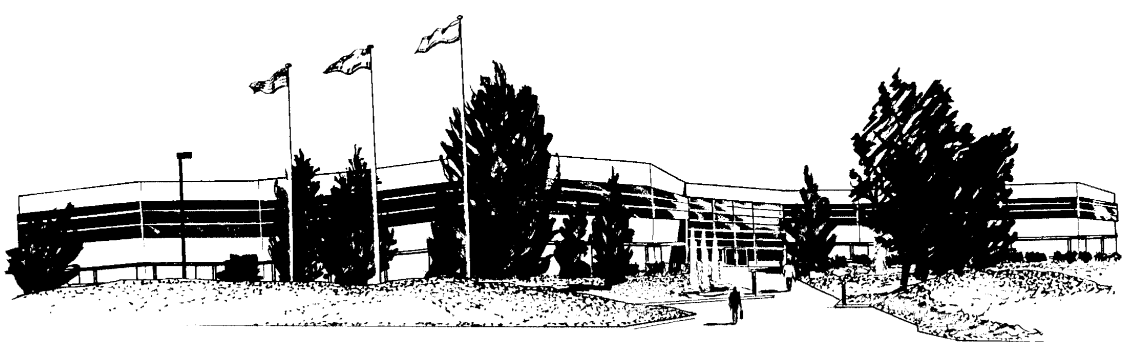

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