

Tempress Safety Manual

Tempress[®] Systems Inc.
Safety manual
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Preface

This manual contains general safety information for TEMPRESS SYSTEMS INC. equipment. For specific safety information about your system, refer to your system manuals.

Operators must have a general knowledge of the technology involved in TEMPRESS SYSTEMS INC. systems. They should also understand safety practices outlined in this manual and all applicable cleanroom requirements.

Maintenance personnel must be experienced in the mechanical, electrical, pneumatic, and gas control systems for TEMPRESS SYSTEMS INC. equipment. They should be especially aware of the hazards of working with high-voltage equipment and reactant and non-reactant gases, and have a knowledge of the safety requirements involved.

Process engineers must understand diffusion and deposition processes. This includes the effect of gas flows, temperature, and pressure on diffusion and chemical vapor deposition.

Readership

All TEMPRESS SYSTEMS, INC. system users, including operators, maintenance personnel, and process engineers.

Systems, Assemblies and Software Covered

This manual is generic and applies to all TEMPRESS SYSTEMS INC. wafer processing equipment. No system-specific information is provided.

How this Manual is Organized

This manual is divided into six sections:

- | | |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Section 1 | <i>General Safety</i> Provides information about safety in the work area. |
| Section 2 | <i>Electrical Hazards</i> Explains what electrical hazards are, and how accidents can be avoided. |
| Section 3 | <i>Gas Hazards</i> Provides general information about hazards that are present during the operation and maintenance of a system. |
| Section 4 | <i>Process Gases/Vapors</i> Explains the characteristics and hazards of the gases used in TEMPRESS SYSTEMS INC. wafer processing equipment. |
| Section 5 | <i>Glossary</i> Explains terms used in the manual with which you may not be familiar. |

Revision History

This manual is a revision of the Tempress Systems Inc. "Safety and Responsibility Manual". It replaces earlier versions.

Original Language

This manual was originally written in English.

Notes, Cautions, Warnings and Danger

Cautions, warnings and danger boxes appear throughout this manual to attract your attention to a hazard.

TEMPRESS SYSTEMS INC. systems contain hazards that are potentially lethal. Read and understand the hazard messages before you perform any action or touch anything.

Examples are given below. The icon to the left of the box is related to the hazard type. An exclamation icon is used for generic hazards.

**Caution**

Cautions alert for a potentially hazardous situation that may result in minor or moderate injuries. Cautions can also alert for potential equipment and/or product damage.

**Warning**

Warning alert for conditions that may result in permanent and/or lethal injuries.

**Danger**

Danger message alert you to an imminently hazardous situation which, if not avoided, will result in death or serious injury. Danger messages are limited to the most extreme situations.

**Note**

Notes alert to pay attention to items or procedures of special importance.

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1 General safety

1.1 General

This manual contains information about the safety aspects of working with TEMPRESS SYSTEMS INC. systems.

Operators and maintenance personnel must understand the hazards associated with high voltages and reactive gases, and must apply safe practices when working with them.

Some of the hazards associated with working on semiconductor manufacturing equipment may include exposure to:

- Electrical circuits, including high voltage, high frequency or both.
- Toxic, corrosive and flammable gases and liquids.
- Moving parts.
- Heated parts
- Pressurized parts.

Maintenance personnel must understand the system interlocks for the particular system on which they are working.

1.2 Accidents and Prevention

Accidents result from committing one or more unsafe acts in combination with hazardous circumstances. Accident prevention consists of eliminating the hazardous circumstances whenever possible and not committing unsafe acts when the circumstances are unavoidably hazardous.

"I've been doing it this way for years, and nothing has happened to me yet," is a statement that means none of your unsafe acts have been committed in circumstances hazardous enough to cause an accident. It does not mean that the way of working is safe.

1.2.1 Unsafe Acts

There are two kinds of unsafe acts: things you should have done but did not do, and things you did do but should not have done. Either may cause injury or death to you or a co-worker.

Persons in charge should:

- Provide training in proper procedures.
- Give necessary instructions.
- Enforce safety rules.
- Allow adequate time, resources and personnel to perform the work.
- Provide adequate facilities, lighting, ventilation and housekeeping.
- Provide adequate safety equipment and proper tools.
- Monitor job progress.

Persons performing the work should:

- Follow instructions and safety rules.
- Use safety equipment provided.
- Use proper tools.
- Concentrate on the work.

Never:

- Take shortcuts because of haste or convenience.
- Bypass interlocks for convenience.
- Work when tired, ill or fatigued.
- Carry out heat treatment of wafers on H₂ or other inflammable, explosive gas atmospheres, without the by Tempress installed safety measures.

1.2.2 General Safety Precautions

The following are general safety precautions:

- A thorough knowledge about the English language and the subject terminology (jargon) is required.

- Before you start working, make sure that emergency aid is available in the area. The aid should be compatible with the nature of the hazard. The emergency aid should be at the nearest safe location.
- Personnel shall always remember that if they remove a unit or part from its normal location all Tempress safety measures would no longer exist, the person authorizing this act shall assume responsibility for ensuring suitable alternative safety precautions for other personnel.
- Never work alone in, or near, a possible hazardous environment. Work together with a partner (other engineer or operator). If your partner has to leave the area, stop working until he or she returns.
- It is important that there is always minimal one person in the cleanroom is who can ask (shout) for help (or medical assistance).
- If you are working with a partner on a task, do not assume that your partner has performed some action necessary to finish the task. Always ask him or check yourself before you proceed.
- Do not wear jewelry. Any jewelry, especially a ring, is hazardous to wear around equipment with moving parts. It can become trapped in the moving part and can cause severe injuries.
- All actions, other than the usual manipulations for operation are to be carried out under the supervision of a responsible person. This responsible person might have at his disposal personnel especially appointed.
- Use the correct tool (screwdriver, alignment tool, etc.) for the job.
- Secure the power switch in case more people are in the room you are working in, so they never can accidentally set power on the system and create a dangerous situation for maintenance engineers and other personnel.
- Turn off gases and power if there is a safety risk. Lock switches, valves, etc. in the "off" position, if possible (lockout). If not possible, attach a label to the switch and have someone stand guard until you finish.
- Operators have to know how to handle in case of calamity (see 1.4).
- Inspection and/or maintenance has to be done by trained and qualified personnel.
- When handling isolation materials, consult the relevant Material Safety Data Sheets (MSDS).
- In case of doubt about the safety measures, contact Amtech/Tempress Systems Inc.
- Any modification and/or unauthorized changes to the system will void any and/or all CE-certification according to the EU Directives. Tempress Systems Inc. cannot take any responsibility in such cases.
- The use of a logbook is recommendable.
- Local labor, safety, environmental and health standards are always mandatory.

1.3 Cleanroom Safety Precautions

1.3.1 Before You Enter the Cleanroom

If you are a visitor or new to the environment, check if there are local prescriptions available for cleanroom safety. Always follow the local safety guidelines and training get a training if possible. Make sure you can recognize the audible alarms and know what they mean and what you must do if you hear an alarm.

1.3.2 At the Work Location

Before you start work at your work location:

- Learn the location of the emergency exits in relation to the location at which you will be working.
- Know the location of the nearest telephone and make a list of telephone numbers you can call in case of emergency.
- Locate emergency aid facilities, like eyewashes, showers, etc. Make sure you understand how to use them.

1.3.3 At Work in the Cleanroom

When you are working in the cleanroom:

- Always close cupboard doors and be aware of loose equipment that may be hanging overhead. Such things may or may not be marked and can cause injury.
- Use extra caution when moving about the cleanroom - a cleanroom hood, safety glasses, or goggles drastically reduce your peripheral vision.
- Do not rely on your normal sense of smell - a cleanroom hood or face shield covers your nose, and raises the threshold detection value for all chemicals.
- Walk slowly and deliberately - cleanroom boots worn over shoes are slippery, and the more boots are worn, the more slippery they become. The cleanroom suit desensitizes all of your body. You are less likely to be aware of brushing against objects in the cleanroom.
- Allow yourself extra room around mechanical equipment - the loose fabric of cleanroom suits can easily become tangled in machinery.
- Cleanroom gloves make manual work more difficult. They make it harder to grip and manipulate a tool. They also insulate your hands from heat. If you accidentally touch something that is hot, the glove may melt before you feel the heat.
- Remember - Cleanroom suits protect the product, but do not protect the person wearing it.

1.4 Emergency Response

Emergency response is what you do between the time you notice an emergency and the time professionally trained personnel arrive. The recommendations here are guidelines only, and are not a substitute for professional help. All persons working in a facility should be trained in its emergency response plan and in emergency first aid.

1. Alert all personnel in the area and set off the necessary alarms.
2. Push the EMO (EMergency Off) switch on the TEMPRESS SYSTEMS INC. equipment.
3. Confine the problem, even if it is just by shutting the door behind you as you run out. *What else is done to confine a problem must be part of the emergency response plan because it will vary depending on the kind of emergency.*
4. Evacuate the area and administer the appropriate first aid to the victims.
5. Notify the proper emergency department.
6. Prevent staff and non-employees from re-entering the area until the emergency department has examined the area and has declared it safe.

1.5 Working On a System

1.5.1 Lockout/Tagout

When equipment is being serviced, the controls, valves and breakers for that equipment must be controlled by the persons doing the maintenance. Ideally, the equipment is shut down and each person applies an individual lock and retains the key so that the equipment cannot be returned to service until all persons have removed their locks. A tag on each lock identifies the person or persons working on the equipment, the time the locks were applied, and the reason for the locks.

Use lockouts in the following circumstances:

- Electrical systems and circuits where a hazard of electrical shock exists. This prevents a person who is unaware of the maintenance activity from turning on the equipment.
- Repair and service of mechanical equipment, where moving parts would create a safety hazard for the maintenance person.
- Work on lines that carry hazardous substances, or that are under pressure.

If it is not possible to apply a lock, tag the controls, valves and breakers with a tape or tag that identifies the person or persons working on the equipment, the time the tag was applied and the reason for the tagout. The tag or tape should cover the controls so that it must be deliberately removed in order to activate the equipment. Ask someone to stand on permanent guard at the controls to prevent accidental activation.

In such cases, the equipment must be turned on only by the person working on the equipment, or clearance must be obtained from him before activation.

You should ensure the following:

- Do not have spare keys or use combination locks for lockouts. Only the person who placed the lock should be able to remove it.
- Educate all personnel about the locks and tags. They must be taught never to remove a tag or to use tagged-out equipment.
- If there are more personnel working on the system, do not return equipment to service until all the personnel listed on the lockout or tagout have verified its operation and authorized its return to service.

1.5.2 Working with Electrical Equipment

When you are working with electrical equipment:

- Always treat all circuits as if they were live until you have personally disconnected the power and locked or tagged-out the circuit.
- Keep your clothing, hands and feet dry at all times.
- Carefully inspect the insulation on the leads to your test equipment. The slightest break in the insulation may be dangerous.
- Use grounding straps to ensure that the equipment frame is at the same potential and tied to earth ground.
- Be wary of capacitors when making voltage or other circuit checks. They can maintain a charge for several hours after power is disconnected.
- Ensure that the shorting rods used to discharge capacitors are connected to the chassis ground, not earth ground. When the equipment is unplugged for servicing, the earth ground may be disconnected. A shorting bar tied to earth ground will not discharge the capacitors because there is no DC return path.
- Do not wear rings, watches, metal-rimmed glasses or any jewelry when working around electrical circuits. They are conductors and increase the chance of shock or electrocution. Pencils can conduct through the lead, so do not use them to point at or to push some item.
The coins and keys in your pockets can conduct electricity too.
- Do not troubleshoot when the primary power is turned on, unless it is absolutely necessary.
Remove the fuses, open the circuit breakers or disconnect the circuits from their source of power to protect yourself, the test equipment and the equipment under test. Lock-out and tag-out the breakers.

1.5.3 Lifting and Moving Parts of a System

Accidents can easily happen when a system is being installed or moved. Parts are often top-heavy and may topple over if lifted or nudged into position. Accidents have happened with gas cabinets, where the footprint is small and the cabinet is high and top-heavy.

To avoid potential hazards when lifting and moving parts of a system:

- Always use dedicated lifting tools (a forklift for example).
- Read the system maintenance and installation manual and follow the advice and observe all warnings.
- Do not use your foot or arm to support a heavy item for "just a moment" - something can slip!
- Only transport the system in an upright position.
- During movement, the furnace assembly is slightly unstable and should be considered top heavy.

Information about dangers from tipping a system over can often be found in the system manuals. An example is shown in Figure 1-1.

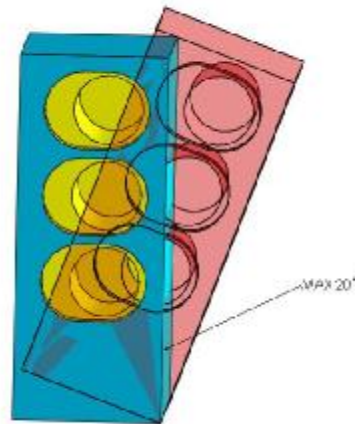


Figure 1-1 Example illustration showing tipping danger

1.5.4 N₂ Rich Environments

Some systems use an N₂ rich environment to prevent oxidation of wafers during wafer transfers. Although N₂ is not a harmful gas, it excludes the oxygen you need to breathe. Always observe safety warnings and advice on labels, and in the manuals, before you start work in an N₂ rich environment.

1.5.5 Hot Surfaces and Objects

Some parts of the system may be too hot to touch. You can burn your hand just as easily on a flange at 130°C as you can with boiling water. Before you touch something, consider whether it may be hot. If you see a warning label, follow the advice on the label.

1.5.6 Cycle Purging

Before the vacuum integrity of any part of the system (chambers, gas loops, etc.) is disturbed, that chamber or gas loop must be cycle purged. Cycle purging dilutes process gases to a safe level. The number of purge cycles required depends on the hazards the gas presents.

1.5.7 Pump Oil and Filter Precautions

The gases used in some of the TEMPRESS SYSTEMS INC. systems pass through the oil in the vacuum pump before they are exhausted to the outside or to a post-reaction gas handling system. The oil becomes contaminated with these gases.

- A gas may react with pump oil containing residues of a different gas.
- Oil contaminated with a toxic gas is also toxic. See the MSDS for the required protective equipment and disposal procedures.
- The oil is hot, and under pressure. Be careful when removing filters and fittings.
- Oil contaminated with acid should be handled as an acid.

1.5.8 Process By-products

Systems that process with toxic and reactive gases can contain remains of the gases and byproducts that were not fully reacted or exhausted. Before opening a system for maintenance, make sure you are aware potential hazards resulting from the use of process gases. Take appropriate measures to protect yourself from exposure.

Systems that use arsine for doping, for example, are extremely dangerous. Maintenance personnel working on these systems must receive special training and be equipped with special suits, gloves and full-face respirators. All removed parts must be treated as toxic chemical waste and handled accordingly.

1.5.9 Insulation Material and Fibrous Wool

In some heating elements supplied by TEMPRESS SYSTEMS INC., the element wire is embedded in a white material that looks like polystyrene foam. The material is a ceramic/aluminum silicate fibre combined with an inorganic binding material. When the material is disturbed, fibrous dust may be generated.

This dust can cause irritation to the skin, eyes and respiratory system. Studies on animals show that the fibrous dust may cause lung damage (fibrosis) and possibly cancerous tumors.



Warning

Modifications or other treatment to the ceramic fiber wool may not be done without special safety measures.

General Precautions

- Read the supplier MSDS and follow the advice and procedures they contain.
- Wear protective clothing and equipment appropriate for the hazard - this must include overalls, hat, dust mask (with a particulate air filter cartridge to DIN 3181 P3), goggles and gloves.
- Reduce underfoot debris - keep the work area clean.
- Use a vacuum cleaner with a HEPA filter.
- Work in a controlled and careful manner to avoid dust generation and dispersion.

Handling

- Never saw, cut or sand silicate fiber material.
- Double-bag, seal and label heating elements for transport.
- Treat heating elements and silicate fiber as chemical waste.
- Use boots and overall with full head coverage and full cloth exchange afterward is additionally compulsory. Contact lenses are NOT allowed to be worn.
- Always use vacuum cleaner with HEPA filter and large inlet piece must be available in all circumstances. In case generation of dust can be foreseen (e.g. during tube replacement or modifying materials) assistance must be present to remove dust instantly when generated.
- Waste containing refractory ceramic fibres must be packaged in thorough sealed plastic and can be disposed as non-classified industrial waste in case of no interfering local policy.

Reference

Documents:

- HAZARDS FROM THE USE OF REFRACTORY CERAMIC FIBRE (267_3v2.pdf)
- MSDS No 201 by Thermal Ceramics
- MSDS No M0114 by UNIFRAX

Dedicated tools:

- Dustmask DIN3181 P3
- Vacuumcleaner with HEPA filter

1.6 Seismic Events

Like any equipment in the semiconductor industry, Tempress Systems Inc. wafer processing systems are sensitive to severe vibration and changes in levelling. In the event of a seismic event, like an earth quake or earth tremor, the system should be checked and re-qualified before use of the system is resumed.

Always follow local procedures for system inspection and re-qualification after a seismic event.

1.7 System caution and Warning Labels



Indicates that there is a danger that you could jam (or pinch) your hands between two objects. Catching your hand in a door that is closing, or an elevator that is closing are examples.



The system contains heavy objects. Use proper lifting tools or proper lifting techniques to avoid straining your muscles or injuring your back.



Hazardous chemicals are present.



Hot surfaces inside. Touching the surfaces can cause skin burns.



Indicates that there is a danger that you could experience an electric shock if the component remains under electric power.

This label is attached to the outside of the power cabinet and furnace covers.



Indicates that there is a danger that you could damage your eyes if the heating element remains under electric power when the insulation and clamps are removed.

2 Electrical Hazards

The TEMPRESS SYSTEMS INC. equipment may contain circuits using 115/230/400/440/480 V AC 1 - phase or 3-phase 50/60 Hz, power circuits using 5 to 24V DC. Any of these circuits can be a potential source of an electric shock and may cause electrocution if they are short-circuited.

2.1 Principle Causes of Shock or Electrocution

Read the following unsafe acts to prevent that you, or someone else, receive a shock or being electrocuted:

- Failure to follow procedures and pay no attention to detail.
- Failure to shut off equipment and lock-out power.
- Violation of lockout and tagout by using equipment that has been tagged as defective or out of service.
- Lack of final inspection before reconnecting power: someone could be working on another section of the circuit you energize.

Some hazardous conditions that may contribute to shock or electrocution are:

- Improper grounding of equipment.
- Improper tools.
- Equipment improperly installed or maintained.
- Modifications to original installation; for example, bypassed safety interlocks and overloaded circuits.

2.2 Current and effect

Current under 15 mA AC (<75 mA DC) is allowed on human body, although the sensation may be unpleasant or painful, the victim can escape the current.

Current of 15 – 20 mA AC (50 – 75 mA DC) is dangerous. It may cause severe muscle contraction and can paralyze the muscle needed for breathing.

Currents above 20 mA AC (> 75 mA DC) is very dangerous. It can cause uncontrollably heart muscle quivers instead of pumping blood. Currents above 20 mA can cause severe burns and nerve damage.

2.3 Energized Circuit Precautions

When it is necessary to work on an energized circuit, take the following precautions:

- Check the equipment with a voltmeter (make sure it is calibrated) to detect potential shock hazards.
- Treat low voltage systems with the same respect as high voltage systems. Current kills, not voltage.
- To minimize the possibility of shorting out a circuit through your body, keep one hand free at all times. Keep your free hand behind you, or preferably, in your pocket: keeping your hand in your pocket prevents the instinct to use that hand on the circuit).
- Never work on energized electrical systems unless there is an observer who can rescue you in case of emergency. Your helper is not an observer, because the helper is also at risk.
- Make sure you have completed all recommended safety courses.
- Always use tools with non-conductive handles.
- Use tools appropriate for the circuit. High voltage circuits require special tools.
- Never work in insufficient lighted areas.

Do not wear any jewelry during maintenance or any activity to the furnace system this may hinder you to act quickly in case of an emergency.

3 Gas Hazards

This section contains gas hazard information for operators and engineers working with the Tempress Systems Inc. systems. The information is of a general nature, and is concerned with the hazards applicable to operating and maintaining the system.

Observe all applicable federal, state and local codes for storage, use and disposal of the Gases used in your facility.

3.1 Gas handling and Storage

For safety purposes all materials packaged in cylinders should be treated like gases, although some, TEOS for example, are actually volatile liquids.

Handling compressed or liquefied gases is more hazardous than handling liquid and solid materials:

- Many gases are colorless and odorless; there is no warning of their presence.
- Internal pressure can cause gas cylinders to rupture violently if the cylinders are heated or damaged.
- Escaped gases are difficult to confine.
- The auto-ignition temperature of many flammable gases is low.
- Liquefied gases become very cold if they escape from their cylinder and evaporate. They can cause frostbite. Others, like liquid nitrogen, exist only at super-cold temperatures.
- Spills of liquid gas spread faster and farther than ordinary liquids.
- If the bottle falls over and the valve ruptures, the bottle can travel at high speed, much like a rocket out of control. Never leave a gas bottle standing - always attach it to a wall.

3.1.1 Cylinder Receipt and Content Identification

On receipt, each cylinder must have stenciled or adhesive labels identifying the contents, a DOT transport label, and a protective cap over the valve. If the labels are not clearly legible, mark the cylinder as "contents unknown" and return it to the supplier.

NEVER remove the labels. Do not remove the protective cap until the cylinder is secured to a wall, bench or cylinder stand and is ready to use.



Warning

There is no uniform color code among manufacturers. Do not rely on the color of the cylinder to identify the gas.

3.1.2 Storage

Gases must be stored in a manner that protects the cylinders, and persons working with the cylinders, from harm. Consideration must be given to the possibility of reactions between gases in case of a leak.

- Gas storage areas must be well-ventilated, dry, and fire-resistant, and away from sources of ignition or heat.
- Outdoor storage may be acceptable if the cylinders are protected from moisture and high heat (>125°F/51.6°C). All applicable storage regulations must be followed for each gas.
- A gas must be properly separated from any other gas or chemicals with which the gas may react. Oxidizing gases (Oxygen and acid gases like Nitrogen Trifluoride) must be separated from flammable or alkaline gases because they combine violently.
- Access to the area should be controlled.
- The cylinders must be secured so that they cannot fall over or strike each other.
- Full and empty cylinders should not be stored together. If an empty cylinder is mistakenly connected to a pressurized system, material sucked back into the empty cylinder may react violently with the gas residue.

3.1.3 Handling or Moving Cylinders

Handle cylinders with care:

- Do not drag, roll, or slide cylinders. Use a hand truck or cart with restraints.
- Do not use the protective cap as a handle.

- Do not drop cylinders or permit them to strike each other.
- Do not remove the protective cap until the cylinder is secured to a wall, bench or cylinder stand and ready for connecting.

3.1.4 Using Gases

3.1.4.1 Preparation

- Learn about the gases you will be using before you start using them; know the specific hazards, special requirements and specific first aid for inhalation and skin contact for each of the gases.
- Know where the emergency eyewash, shower and breathing equipment are located.
- Make sure that emergency aid is always available. The aid should be compatible with the nature of the hazard. The emergency aid should be at the nearest safe location.
- If the possibility of a large leak of toxic gases exists, for example when the cylinders are being installed or removed, the emergency aid must be in an area safe from contamination. This may be a person outside the work area, or may be a person in protective gear inside the area.
- Never work alone in or near a hazardous environment. Work together with a partner (other engineer or operator). If your partner has to leave the area, stop working until he or she returns.
- Make sure all necessary protective and emergency equipment is present and in working order before you bring in a cylinder.
- Read and follow the instructions for installing and adjusting regulators.
- Avoid heat treatment of product on H₂ or other inflammable, explosive gas-atmospheres.

3.1.4.2 Safe Clothing

- Do not wear contact lenses. Contact lenses may trap chemicals under the lens, against the eye. They do not protect the eye against splashes and may make exposure to gases more irritating.
- Do not wear jewelry. Rings, watches and other jewelry are hazardous to wear around hazardous chemicals. If the chemical is spilled (vapor or liquid) on the skin, it can become concentrated under the jewelry and cause more severe burns. The jewelry also prevents thorough washing.

3.1.4.3 Work Practices

- Do not remove the protective cap until the cylinder is secured to a wall, bench or cylinder stand and ready for connecting.
- Never tamper with the safety devices in the valves.
- Do not interchange regulator equipment between gases that are not compatible.
- Adapters, to allow regulators to be used on cylinders of a different thread type, should not be used.
- Over-tightening may cause leaks. Follow the manufacturer's instructions for installing and tightening gas fittings, valves and regulators.
- Never attempt to repair any safety device or regulator.
- Never lubricate a regulator.
- Never force a regulator to fit.
- When corrosive gases are used, the cylinder valve stem should be worked at intervals to prevent it from freezing open.
- Cylinders should be considered "empty" while they still have slight positive pressure, to prevent suckback and contamination of the cylinder. Empty cylinders should be closed, the protective cap re-installed, tagged as empty, removed promptly and treated with the same precautions as filled cylinders. If cylinders are returned to the supplier with the valve open, the interior will become contaminated with atmospheric air, moisture and possible foreign material.
- Only cylinders that are in use should be in the work area. Do not store spare cylinders in the work area.

3.1.4.4 Disposal of Leaking Cylinders

Disposal of gases is a complex problem and must be carried out only by personnel who are familiar with the gas involved and the disposal procedures. Contact your gas supplier for current procedures.

**Danger**

If you are uncertain of the identity of the gas in a leaking cylinder, evacuate the area immediately. Do not attempt disposal until the gas has been positively identified and the appropriate disposal method can be used.

**Danger**

Do not attempt to identify the gas by its smell or flammability.

**Danger**

Do not attempt to locate leaks with a gas lighter or flame. Use an appropriate leak detector.

4 Process Gases/Vapors

This section contains gas hazard information for operators and engineers working with the TEMPRESS SYSTEMS INC. systems. The information is of a general nature, and is concerned with the hazards applicable to operating and maintaining the system.

Observe all applicable federal, state and local codes for storage, use and disposal of the gases used in your facility.

4.1 Introduction

The descriptions for each gas in this section are obtained from a number of sources. Typically, a description incorporates information from various gas suppliers, supplemented with information from governmental bodies like the OSHA.

Each description of a gas in this section starts with the gas name and chemical formula. The remaining information follows the format below:

| | |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Other names this gas may be called, if any. |
| Uses | The use of this gas in Tempress Systems Inc. wafer processing equipment. |
| Description | The description may include the color, toxicity, odor and flammability of the gas at room temperature and atmospheric pressure. The gas is identified as a compressed or a liquid gas, because the hazards of each kind are different. |
| Thresholds | Threshold limit values are concentrations to which a person can be safely exposed without ill effect. They are guidelines only; they may differ from country to country, and they are subject to change in the light of new medical evidence. STEL, IDLH, TLV-TWA, PEL, Ceiling LC50. |
| Toxicity | The basic toxic effects of inhalation or skin and eye contact are explained. Threshold limit values and toxicity of various concentrations of the gas are given. |
| Specific First Aid | If a gas requires first aid procedures, they are given here. |
| Handling and Storage Precautions | Any characteristic of the gas that makes it especially hazardous will be mentioned. Refer to the MSDS for specific information on the protective clothing and breathing apparatus required. |

4.2 Ammonia (NH₃)

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|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Not available. |
| Description | Ammonia is a colorless gas with a pungent, highly-irritating odor. It is lighter than air and is flammable at high concentrations and temperatures, but does not ignite easily. Ammonia is alkaline, corrosive and toxic. It is shipped as a liquefied gas. |
| Uses | Ammonia is used in silicon nitride processes as a source of nitrogen. It is also used for direct nitridation of silicon. |
| Thresholds | Odor threshold is 5 ppm STEL is 35 ppm (OSHA, ACGIH) IDLH is 500 ppm (OSHA) |
| Toxicity | <p>Ammonia is irritant at low concentrations and lethal at high concentrations. Because concentrations of 5 ppm are detectable by odor, and concentrations of 100 to 400 ppm are irritating, it is unlikely that anyone would unknowingly become over-exposed.</p> <ul style="list-style-type: none"> • Breathing concentrations of 400 to 700 ppm causes severe respiratory and eye irritation. • Exposure to concentrations of ammonia above 700 ppm can cause injury to the eyes, including severe irritation, hemorrhage, and swollen lids. If not treated immediately by washing with water, partial or total loss of sight may result. • Inhaling 1700 ppm causes immediate violent coughing and bronchial spasms; less than a half hour of exposure may be fatal. • Inhaling 5000 ppm (0.5%) is fatal almost immediately due to pulmonary edema and asphyxia. <p>Liquid ammonia produces severe chemical burns on contact, and can cause frostbite.</p> |
| Specific First Aid | <p><u>Skin</u> Flush with water for at least 15 minutes.</p> <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 15 minutes. Separate eyelids with fingers for better washing.</p> <p><u>Inhalation</u> Move victim to fresh air and seek immediate medical attention. In all cases, seek immediate medical attention.</p> |
| Handling and Storage Precautions | In addition to the general precautions detailed in Section 4, ammonia requires following all toxic and flammable gas precautions, and requires the use of corrosion-resistant regulators and flow meters. |

4.3 Argon (Ar)

| | |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Not available. |
| Description | Argon is an inert, colorless, odorless and tasteless gas, shipped as a compressed gas. |
| Uses | Not available. |
| Thresholds | Not available. |
| Toxicity | Argon is non-toxic but can act as an asphyxiant by displacing the oxygen necessary to support life. Mild oxygen deficiency may produce dizziness, nausea and vomiting. Oxygen deficiency may cause death because of errors in judgment or mental confusion. Loss of consciousness may occur without warning. |
| Specific First Aid | Move victim to fresh air, and put head below lungs to enable the Ar to escape |
| Handling and Storage Precautions | Argon requires the precautions necessary for any compressed gas. |

4.4 Arsine (AsH₃)

| | |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Arsenic trihydride, Arsenic hydride, Hydrogen arsenide, Arsenous hydride. |
| Description | Arsine is a colorless gas with a garlic-like odor. It is flammable in air and is extremely toxic. It is a strong reducing agent and reacts violently with oxidizing agents such as fluorine, chlorine, nitric acid and nitrogen trichloride. |
| Uses | Polysilicon dopant. Used for gas phase doping (diffusion processes). |
| Thresholds | Odor threshold is 0.5 to 1 ppm. TLV-TWA 0.05 ppm (OSHA, ACGIH) PEL is 0.05 ppm (OSHA). STEL is 0.0006 ppm (NIOSH) IDLH is 5 ppm (NIOSH) |
| Toxicity | <p>Arsine is extremely toxic. It is a powerful systemic toxin with a strong affinity for the hemoglobin in the blood, causing hemolysis. Inhalation of arsine can cause the breakdown of red blood cells and hemoglobin, impairment of kidney function and damage to the liver and heart. Arsine can be absorbed via the skin.</p> <p>In low concentrations symptoms may be delayed for several hours. Symptoms may include: headache, malaise, weakness, dizziness, breathing difficult, abdominal pain, nausea, edema and coma.</p> <p>Because the odor threshold is 0.5 -1 ppm and the permissible exposure limit is 0.05 ppm, arsine does not have adequate warning properties to avoid overexposure.</p> |
| Specific First Aid | <p>Skin Flush with water for at least 20 minutes and seek immediate medical attention.</p> <p>Eyes Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 20 minutes. Separate eyelids with fingers for better washing. Seek immediate medical attention.</p> <p>Inhalation Move victim to fresh air and seek immediate medical attention.</p> <p>In all cases, seek immediate medical attention.</p> |
| Handling and Storage Precautions | Refer to supplier MSDS. |



Danger

AsH₃ and all AsH₃ process by-products are extremely toxic. All personnel working with a system in which AsH₃ is used must receive special training to ensure safety. Maintenance personnel must be aware of the hazards involved when performing maintenance on system that runs an AsH₃ process (and an AsH₃) anneal, and must be appropriately equipped and trained. Full-face respirators and special suits and gloves must be worn. All removed parts

4.5 Boron Tribromide (BBr₃)

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|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Boron Bromide, Tribromoborane. |
| Description | Boron Tribromide is a colorless, non-flammable, fuming liquid with a pungent odor. Although boron tribromide is non-flammable and does not support combustion, it decomposes when heated, emitting hot bromine and vapors which are very harmful. Hydrobromic acid can form in moist environments and react with metals to liberate hydrogen, a flammable gas. Boron Tribromide reacts violently with water. |
| Uses | Liquid boron source used for p-type diffusion doping. It is an industry standard gas used in a broad range of applications from lightly-doped bipolar memory base regions to heavily-doped PMOS microprocessors and isolation diffusions. |
| Thresholds | TLV is 1 ppm (OSHA) STEL is 3 ppm (OSHA) Ceiling is 1 ppm (NIOSH) |
| Toxicity | Over-exposure can cause severe burns to skin and eyes. Severe irritation of the respiratory tract upon inhalation along with coughing, nose bleeds, abdominal pain and diarrhea, and measles-like eruptions on the torso and extremities. |
| Specific First Aid | <p><u>Skin</u> Blot with dry absorbent to remove excess material and then flush with running water for 15 minutes. Seek medical attention.</p> <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for 3 to 5 minutes. Separate eyelids with fingers for better washing.</p> <p><u>Inhalation</u> Remove to fresh air. Administer artificial respiration or oxygen if needed. Seek medical attention. Hold for medical observation for 24 hours in case pulmonary edema develops.</p> |
| Handling and Storage Precautions | Avoid heating, contact with water, steam or moist air. |

4.6 Diborane (B₂H₆)

| | |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Boroethane, Boron Hydride, Diboron hexahydride |
| Description | Diborane is a colorless, flammable, toxic gas with a sickly-sweet odor like burned chocolate. Undiluted diborane is shipped as a compressed gas in cylinders containing 5 pounds of Diborane, refrigerated in dry ice. Because of its instability, no more than 0.100 kg (0.22 lb.) per cylinder is shipped, pressurized with a diluent gas such as hydrogen, argon, nitrogen or helium. |
| Uses | Diborane is used as a doping gas for "P" type silicon. |
| Thresholds | PEL-TWA is 0.1 ppm (OSHA) TLV-TWA is 0.1 ppm (ACGIH) The LC50 in humans by inhalation is 159 ppm/15 minutes. |
| Toxicity | Diborane is a toxic gas comparable to phosphine, chlorine, fluorine, and arsine. Inhaling even small amounts of diborane may cause headache, nausea, weakness, tremors, convulsions, tightness of chest, coughing, breathing problems, pulmonary edema, or hemorrhage. Immediately evacuate the area as soon as you smell diborane because inhaling diborane temporarily deadens the sense of smell. If the odor disappears, it may be because you cannot smell the gas any more, and not because the gas has disappeared. |
| Specific First Aid | <u>Inhalation</u> Move victim to fresh air and seek immediate medical attention. In all cases, seek immediate medical attention. |
| Handling and Storage Precautions | Diborane is flammable in concentrations of 0.9 to 98%, in air. The auto-ignition temperature of Diborane is 38-52°C (100-125°F). |



Danger

Diborane reacts violently with water at room temperature. The heat of the reaction can cause diborane to spontaneously ignite. Do not use water to dilute a diborane spill or to extinguish a diborane fire. Use foam or CO₂.

4.7 Dichlorosilane (SiH₂Cl₂)

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| Synonyms | DCS |
| Description | Dichlorosilane is in the silicon chloride chemical family. It is a colorless gas with an odor. It is shipped as a liquid, but its boiling point is 8.3°C (46.9°F), and its vapor pressure at 20°C (68°F) is only 1.65 bar (24 psia). It is often received as a compressed gas. |
| Uses | Dichlorosilane is used in LPCVD nitride processes as a silicon source. Also used in high-temperature oxidation (HTO) |
| Thresholds | Breathing dichlorosilane may be fatal. No exposure limit has been established. |
| Toxicity | <p>On contact with air, dichlorosilane decomposes into HCl. Because of this, it is extremely irritating to the respiratory tract, eyes and skin. Depending on intensity and duration of exposure, effects may vary from mild irritation to severe destruction of tissues.</p> <p>Symptoms of exposure may include burning sensations, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting. Penetration of Dichlorosilane into the lower bronchial tract may produce bronchitis, chemical pneumonitis and pulmonary edema, and may be fatal.</p> <p>Contact of dichlorosilane with the eyes will cause pain, tearing, inflammation and swelling of tissue. Eye exposure to high concentrations of dichlorosilane may result in ulceration of the conjunctiva and cornea and destruction of all ocular tissues (i.e., complete physical destruction of the eye).</p> <p>Contact with the skin will cause severe burns. Shock symptoms may occur and include sweating, rapid pulse, paleness and collapse.</p> |
| Specific First Aid | <p>Skin Skin contact should be treated by immediately flushing the skin with large quantities of water for at least 15 minutes. Remove contaminated clothing as quickly as possible. Cover the affected area with a sterile dressing or clean sheeting and transport for medical care. Do not apply greases or ointments. Control shock if present.</p> <p>Eyes Remove contact lenses. Treat eye exposure by immediate and prolonged flushing of the eyes with water. Separate eyelids with fingers for better washing. Obtain medical attention at once.</p> <p>Inhalation Remove the victim to fresh air. Exposure to minor concentrations for a brief period should require no additional first aid. If breathing has stopped or is impaired, administer artificial respiration and then give supplemental oxygen. Keep the victim warm and quiet. Use positional drainage to assure that the victim does not inhale vomited material, and assure that no mucus is obstructing the airway. Seek medical attention at once.</p> |

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| Handling and Storage Precautions | <p>Dichlorosilane requires the precautions necessary for any compressed gas. Do not use or store near any possible ignition source or near water, and do not expose cylinders to temperatures over 125°F (52°C). Do not allow water to enter a cylinder. Use only in dry equipment. Evacuate the system and purge with an inert gas before introducing dichlorosilane.</p> <p>Do not handle dichlorosilane unless you are wearing heavy rubber gloves, safety shoes and a face shield. A safety shower and eye bath should be nearby. Use only in a well-ventilated area, preferably with a forced ventilation hood.</p> <p>In the presence of water, dichlorosilane will hydrolyze to form hydrogen chloride, which attacks steel. The reaction between steel and hydrogen chloride also releases flammable hydrogen gas. Dichlorosilane may be stored in mild steel in the complete absence of water. In the presence of even trace amounts of water, however, dichlorosilane becomes extremely corrosive. It hydrolyzes rapidly, producing silica, silicon oxyhydride, and hydrogen chloride.</p> <p>Spills of dichlorosilane can be neutralized or absorbed in soda ash or expanded vermiculite. Contact with a small amount of water will usually cause a fire. Leaking cylinders will be evidenced by the formation of dense white fumes in air. Do not use a flame to detect a leak in a cylinder. Small leaks can be detected with ammonium hydroxide. Dichlorosilane has a boiling point of 46.9°F (8.3°C) and an auto-ignition point of 212°F (100°C).</p> <p>When dichlorosilane burns, it produces hydrogen chloride, chlorine, and finely divided silica. The chlorine decomposes steel, making a fire from a dichlorosilane leak in steel especially hazardous. Small fires can be extinguished with dry powder or CO₂. Large fires are best controlled with water.</p> <p>Water causes dichlorosilane to decompose, and this hydrolysis proceeds faster than burning, which helps to extinguish the fire and more quickly dissipate spills.</p> <p>At high temperatures, dichlorosilane decomposes to form silicon and hydrogen chloride. These gases may react to form SiCl₂, SiHCl₃, SiCl₄, and/or H₂. Avoid mixing dichlorosilane with any oxidizing agents.</p> <p>Ground and bond all lines and equipment. Do not use around sparking motors or other non-explosion-proof equipment or other ignition sources. As an extra precaution, containers of dichlorosilane may be blanketed with an inert gas.</p> <p>Do not attempt to dispose of waste or surplus dichlorosilane. Return unused quantities to the supplier for proper disposal.</p> <p>Contact with dichlorosilane may cause packing material to become brittle.</p> |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

4.8 Disilane (Si₂H₆)

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|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Silicon Hexahydride, Disilicane. |
| Description | Disilane is a colorless gas, spontaneously combustible in air. It is shipped as a compressed gas. Disilane explodes violently on contact with sulfur hexafluoride. |
| Uses | Disilane is used as a silicon source. |
| Thresholds | No threshold limit value has been established for disilane. A suggested limit is 5 ppm for silane, which may form when disilane decomposes. |
| Toxicity | Symptoms of inhalation of disilane are not well defined. Inhalation of concentrations as low as one molar percent may cause disilane to react with basic solutions in the body, forming silicates and hydrogen. Hydrolysis in body tissues can form silicic acid. Skin burns from ignited disilane are similar to other thermal burns. |
| Specific First Aid | Prompt medical attention is required for all cases of exposure to disilane. Move the victim to an uncontaminated area. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. All treatment should be symptomatic and supportive. Skin burns should be treated as any thermal burn. |
| Handling and Storage Precautions | Use and store only in well-ventilated areas away from all possible ignition sources. Disilane requires the precautions necessary for any compressed gas. Disilane is pyrophoric, and leaks will almost always ignite in air. Burning disilane produces silicon dioxide. Concentrations of less than one molar percent are non-flammable. All higher disilane concentrations should be considered highly flammable. Earth-ground and bond all lines. Electrical equipment should be non-sparking and explosion proof. |

4.9 Germanium Tetrahydride (GeH₄)

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|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Germane, Monogermane, Germonomethane, Germanium tetrahydride, UN 2192, MGI10400. |
| Description | Germanium tetrahydride is a flammable and toxic gas with a pungent odor that is not detectable by some people. It is shipped as a compressed gas. Germane is reactive with oxidizers and halogens. |
| Uses | Used for Ge doping in Si deposition processes and deposition of epitaxial SiGe or a-SiGe. |
| Thresholds | Odor threshold: not available TLV-TWA is 0.2 ppm (ACGIH) TLV-TWA is 0.2 ppm, 0.63 mg/m ³ (OSHA) |
| Toxicity | Germane tetrahydride is an irritant to eyes and skin, and is potentially lethal if inhaled. Symptoms of short-term exposure include: nausea, vomiting, diarrhea, difficulty breathing, headache, dizziness, lung congestion, blood disorders, kidney damage, liver damage and death. Germane tetrahydride is a hemolytic agent. Secondary renal and neurological damage has been observed. |
| Specific First Aid | <p>Eyes Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains (at least 15-20 minutes). Seek medical attention.</p> <p>Skin Remove contaminated clothing, jewelry and shoes immediately while flushing with water. Continue flushing with water for at least 15 minutes. Seek medical attention.</p> <p>Ingestion Ingestion of a hazardous gas is not likely. Seek medical attention.</p> <p>Inhalation Remove the victim to fresh air. If breathing has stopped or is impaired, administer artificial respiration and then give supplemental oxygen. If victim has no pulse, administer CPR. Keep the victim warm and quiet. Seek medical attention at once.</p> |
| Handling and Storage Precautions | Avoid temperatures above 50°C (122°F), sources of ignition and exposure to air. Germane requires the precautions necessary for any compressed gas. |

4.10 Helium (He)

| | |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Not available. |
| Description | Helium is a colorless, odorless, tasteless and inert gas. It is shipped as a compressed gas. |
| Uses | Helium is used to detect leaks in vacuum lines and valves. It may be used as a carrier gas or a diluent. |
| Thresholds | Not available. |
| Toxicity | Helium is non-toxic, but could asphyxiate by displacing oxygen. Mild oxygen deficiency may produce dizziness, nausea and vomiting. Oxygen deficiency may cause death because of errors in judgment or mental confusion. Loss of consciousness may occur without warning. |
| Specific First Aid | <u>Inhalation</u> Move victim to fresh air, and put head below lungs to enable the He to escape. |
| Handling and Storage Precautions | Helium requires the precautions necessary for any compressed gas. |

4.11 Hydrogen (H₂)

| | |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Not available. |
| Description | Hydrogen is a colorless, odorless and flammable gas, shipped as a compressed gas. |
| Uses | Hydrogen is combined with oxygen and burned to perform wet oxidation processes. Hydrogen is also used in anneal processes, and sintering and bake processes to remove native oxide. |
| Thresholds | Not available. |
| Toxicity | Hydrogen is non-toxic, but could act as an asphyxiant by displacing oxygen. Mild oxygen deficiency may produce dizziness, nausea and vomiting. Oxygen deficiency may cause death because of errors in judgment or mental confusion. Loss of consciousness may occur without warning. |
| Specific First Aid | <u>Inhalation</u> Move victim to fresh air. |
| Handling and Storage Precautions | Hydrogen is extremely flammable. See the MSDS for specific precautions about explosion-proof equipment and grounding. |

4.12 Hydrogen Chloride (HCl)

| | |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Anhydrous Hydrochloric Acid. |
| Description | Colorless gas at normal temperature and pressure; pungent suffocating odor; white fumes in moist air. Highly corrosive. Hydrogen Chloride is non-combustible, but contact with metals produces hydrogen gas which is explosive. |
| Uses | Used in oxidation processes for gettering (removal of metal combinations) and as an etchant for quartz cleaning. The source for HCl is either gas, or by the combustion of TCA or Trans-LC. |
| Thresholds | Odor threshold is 0.77 ppm TLV is 5 ppm (ACGIH) PEL is 5 ppm (OSHA) |
| Toxicity | <p><u>Eye Contact</u> Exposure causes immediate pain and irritation with excess tear production and closure of the eye lids. The severity of injury depends on the concentration and duration of contact and may range from slight excess redness and irritation of the conjunctiva to total corneal opacification and blindness.</p> <p><u>Skin Contact</u> May cause severe irritation, chemical burns with ulceration and scarring of the skin. Repeated exposure of skin to vapors may result in dermatitis.</p> <p><u>Inhalation</u> 5 ppm irritating to the upper respiratory tract; 50-100 ppm intolerable. Inhalation of concentrations greater than 50 ppm causes choking, coughing, burning of the throat and severe irritation of the respiratory tract.</p> <p><u>Ingestion</u> Highly toxic. May cause chemical burns of the mouth, throat, esophagus and stomach with severe abdominal pain, nausea, diarrhea, vomiting, dizziness, weakness and collapse.</p> |
| Specific First Aid | <p><u>Eyes</u> Remove contact lenses. Immediately flush eyes thoroughly with water for at least 15 minutes. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly. Seek medical attention.</p> <p><u>Skin</u> Immediately flush skin with plenty of water while removing contaminated clothing and shoes. Discard clothing and shoes.</p> <p><u>Inhalation</u> Remove to fresh air. Perform CPR if not breathing. Give oxygen if breathing is difficult. Keep patient warm; seek medical attention.</p> <p><u>Ingestion</u> Rinse mouth with water. Give 2 glasses of water. Do not induce vomiting. Seek medical attention.</p> |
| Handling and Storage Precautions | Non-flammable, toxic, corrosive gas. Container may rupture due to heat of fire. No part of a container should be subject to a temperature higher than 52°C (125°F). Contact with most metals, in the presence of moisture, produces flammable Hydrogen. Store and use with adequate ventilation at all times. Close valve when not in use and when empty. |

4.13 Isopropyl Alcohol (C(3)H(8)O)

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|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Isopropanol, 2-propanol, propan-2-ol, sec-propyl alcohol, dimethylcarbinol, isohol, petrohol, pro, IPA |
| Description | Isopropyl alcohol is a flammable, colorless liquid with an odor resembling alcohol. The odor threshold concentration of isopropyl alcohol has been reported as 22 ppm. |
| Uses | Cleaning. |
| Thresholds | REL-TWA is 400 ppm (NIOSH) STEL is 500 ppm (NIOSH) TLV is 400 ppm (ACGIH) |
| Toxicity | Isopropyl alcohol is an irritant of the eyes and mucous membranes. In tests, exposure to 400 ppm for 3 to 5 minutes resulted in mild irritation of the eyes, nose and throat. At 800 ppm these effects were intensified. An oral dose of 25 ml in 100 ml water produced hypotension, facial flushing, bradycardia and dizziness. Prolonged skin contact can cause skin sensitivity and eczema. |
| Specific First Aid | <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 15 minutes. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly. Seek medical attention.</p> <p><u>Skin</u> Flush with water for at least 15 minutes. Wash with soap and water after flushing.</p> <p><u>Ingestion</u> Seek medical attention.</p> <p><u>Inhalation</u> Remove victim to fresh air. Seek medical attention.</p> |
| Handling and Storage Precautions | Isopropyl alcohol should be stored in a cool dry, well-ventilated area in tightly sealed containers. Containers should be stored separately from strong oxidizers like acetaldehyde, chlorine, acids, and isocyanates. |

4.14 Nitric Oxide (NO)

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|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Nitrogen monoxide. |
| Description | Nitric oxide is a colorless, odorless, highly-toxic acid gas. It turns reddish-brown in air through oxidation. It is shipped as a compressed gas. |
| Uses | Used for the nitridation of oxide, or direct nitridation/oxidation of silicon. |
| Thresholds | TLV is 25 ppm. |
| Toxicity | <p>Nitric oxide is especially dangerous because it causes delayed pulmonary edema, and it is not very irritating to the respiratory tract until concentrations above the toxic level are reached. Typically the victim has little discomfort during and immediately after exposure, but becomes cyanotic several hours later. This is followed by increasing difficulty in breathing and a variety of symptoms. Untreated cases may be fatal.</p> <ul style="list-style-type: none"> • As little as 25 ppm, breathed for an 8-hour period, can cause respiratory problems that appear 5 to 48 hours after the exposure. At this concentration, there is little discomfort during exposure. • Breathing 100-150 ppm for 30 - 60 minutes may cause pulmonary edema after a delay of several hours. • A few breaths at concentrations of 200-700 ppm can produce fatal pulmonary edema after a lapse of 5-8 hours. |
| Specific First Aid | <p>All persons suspected of exposure to nitric oxide should be treated, because prompt treatment during the early stages can minimize the damage to the lungs.</p> <ol style="list-style-type: none"> 1. Terminate the exposure immediately. 2. Carry the victim, do not let him/her walk, to fresh air. Instruct the victim to breathe as hard and fast as possible. Hyperventilation may occur, which may cause breathing to stop. 3. If there is any difficulty in breathing, give oxygen by any means that provides high concentrations. 4. If breathing stops, perform CPR. Avoid inhaling air exhaled by the victim. If you have given artificial respiration to a nitric oxide victim, you should also seek medical treatment for exposure to nitric oxide. |
| Handling and Storage Precautions | At room temperature, nitric oxide reacts with atmospheric oxygen to form nitrogen dioxide, a reddish-brown toxic gas. Reddish fumes near a nitric oxide tank indicate a nitric oxide leak. Nitrogen dioxide requires additional precautions because of its toxicity. See the supplier MSDS for details. |

4.15 Nitrogen (N₂)

| | |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | None. |
| Description | Nitrogen is a colorless, odorless, non-toxic and non-flammable gas. Nitrogen is shipped as a compressed gas, or as a liquefied gas to facilities where large quantities of nitrogen are used. |
| Uses | Nitrogen is commonly used to dilute toxic gases to acceptable levels. Nitrogen is also used as a purge gas. |
| Thresholds | Not available. |
| Toxicity | <p>Nitrogen is non-toxic but acts as an asphyxiant by displacing oxygen necessary for sustaining life.</p> <p>Mild oxygen deficiency may produce dizziness, nausea and vomiting. Oxygen deficiency may cause death because of errors in judgment or mental confusion. Loss of consciousness may occur without warning.</p> <p>Liquid nitrogen is -196°C (-320°F) or lower. Contact with it or with uninsulated pipes containing it will immediately freeze human flesh, causing severe damage. The vapors from liquid nitrogen may also cause frostbite.</p> |
| Specific First Aid | <p><u>Inhalation</u> Move victim to fresh air.</p> |
| Handling and Storage Precautions | <p>Compressed nitrogen has no special requirements other than the normal handling as a compressed gas.</p> <p>Metals exposed to liquid nitrogen become brittle and may shatter.</p> <p>Liquid nitrogen will absorb oxygen from the air. This is hazardous when a spill occurs in an enclosed space. As the oxygen is absorbed, the available oxygen level quickly decreases to levels that cannot support life. The evaporating nitrogen further diminishes the available oxygen by displacing room air. Unconsciousness and death could occur in a few minutes.</p> <p>Liquid nitrogen heavily contaminated with oxygen can explode.</p> |

4.16 Nitrous Oxide (N₂O)

| | |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | Laughing gas |
| Description | Nitrous oxide is a colorless, non-flammable and non-toxic gas with a slightly sweet taste and odor. It is shipped in cylinders as a liquefied gas. |
| Uses | Nitrous oxide is used as an oxygen source in oxide and oxynitride processes. |
| Thresholds | REL-TWA is 25 ppm (NIOSH) TLV-TWA is 50 ppm (ACGIH) |
| Toxicity | Nitrous oxide is non-toxic and non-irritating. It is a weak anesthetic when inhaled in high concentrations mixed with air or oxygen. Inhaled without oxygen, it can cause asphyxia. Inhaling small amounts often produces a type of hysteria (thus its common name of "laughing gas"). This could be dangerous in a work area because the victim's responses are not appropriate to the situation. Contact with liquid nitrous oxide can cause frostbite. |
| Specific First Aid | <u>Inhalation</u> Move victim to fresh air. |
| Handling and Storage Precautions | Nitrous oxide requires the precautions necessary for any liquefied gas. |

4.17 Oxygen (O₂)

| | |
|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Synonyms | None. |
| Description | Oxygen is a colorless, odorless and tasteless gas. It is shipped as a compressed gas, or as a liquid at -183°C (-297°F). |
| Uses | Oxygen is combined with hydrogen and burned in wet oxidation processes. |
| Thresholds | Not available. |
| Toxicity | When pure oxygen is breathed for 5 hours symptoms of toxicity will appear. Symptoms vary with exposure, duration and pressure. They include nausea, dizziness, bronchial irritation, hypothermia, increased depth of respiration, pulmonary discomfort or injury, peripheral vasoconstriction, blurred or complete or loss of vision, fainting, convulsions and death. Contact with liquid oxygen can cause frostbite. |
| Specific First Aid | <u>Inhalation</u> Mild symptoms disappear when the victim is removed to a normal concentration of oxygen. |
| Handling and Storage Precautions | Oxygen is not flammable, but flammable materials may burst into flames spontaneously in the presence of high concentrations of oxygen. Cylinders of oxygen should not be stored near cylinders of flammable gases. Never store combustible materials in the vicinity of oxygen cylinders. Never permit oil, grease, or other readily combustible substances to come in contact with oxygen cylinders. Never lubricate valves, regulators, gauges, or fittings with oil or any other combustible substances. |

4.18 Phosphine (PH₃)

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| Synonyms | Hydrogen Phosphide, Phosphorus hydride, Phosphorous trihydride, Phosphorated hydrogen. |
| Description | <p>Phosphine is a colorless, flammable and toxic gas with an odor of decaying fish. It is shipped as a liquefied gas in steel cylinders. Phosphine is extremely explosive and flammable. It may ignite spontaneously on contact with air.</p> <p>Phosphine burns readily in air and explodes on contact with oxygen. It is a strong reducing agent. It reacts spontaneously with chlorine, releasing HCl, a colorless, irritating, and toxic gas. Phosphine begins to decompose into phosphorous and hydrogen at about 375°C.</p> |
| Uses | Phosphine is used as a doping gas for "N" type silicon. Also used for gas phase doping and diffusion (deposition of P doped oxide followed by diffusion - alternative for POC13). |
| Thresholds | <p>Odor threshold (garlic or fishy smell) is 1.4 - 2.8 ppm PEL is 0.3 ppm (OSHA) STEL is 1 ppm (OSHA) IDLH is 200 ppm (OSHA)</p> <p>A concentration of 2000 ppm is lethal in a few minutes.</p> |
| Toxicity | <p>Phosphine is a highly toxic gas. It apparently acts on the central nervous system and the blood. Some of the symptoms exhibited by phosphine poisoning are weakness, nausea, vomiting, loss of appetite and great thirst. Convulsions, paralysis and coma may follow.</p> <p>Severe exposure can cause pulmonary edema, which may have a delayed onset of 72 hours or more after exposure. The majority of deaths are cardiovascular in origin and occur within 12 to 24 hours after exposure.</p> <p>Chronic phosphorus poisoning may result from the decomposition of phosphine in the human body.</p> <p>Liquid phosphine is toxic. Contact with liquid phosphine can also cause frostbite.</p> |
| Specific First Aid | <p><u>Skin</u> Brush all visible particles (solid phosphides) from hair and skin. Remove and double-bag clothing while flushing exposed skin with water. Seek immediate medical attention.</p> <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly. Seek immediate medical attention.</p> <p><u>Inhalation</u> Remove to fresh air. Administer artificial respiration or oxygen if needed. Seek medical attention. Hold for medical observation for 24 hours in case pulmonary edema develops.</p> |
| Handling and Storage Precautions | Phosphine is doubly hazardous because of its high toxicity and flammability. |

4.19 Phosphorus Oxychloride (POCl₃)

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| Synonyms | Phosphoryl Chloride, Phosphoric Trichloride, Trichlorophosphorous oxide |
| Description | Phosphorus oxychloride is a colorless, clear, fuming liquid with a pungent odor. It is not flammable, but is highly corrosive on contact. It hydrolyzes very rapidly with the liberation of heat yielding hydrochloric and phosphoric acid. |
| Uses | A liquid phosphorus source, mostly contained in a bubbler, used for n-type diffusion doping. The Cl ₂ liberated during POCl ₃ oxidation acts as a getter for metal ions resulting in a cleaner process. |
| Thresholds | TLV-TWA is 0.1 ppm (ACGIH) STEL is 0.5 ppm (OSHA) |
| Toxicity | Vapors are very irritating to mucous membranes and lungs. Liquid can cause severe burns to skin and eyes. Phosphorus oxychloride is harmful if inhaled and may cause delayed lung injury. May be fatal if swallowed. |
| Specific First Aid | <p><u>Skin</u> Flush with water for at least 15 minutes. Remove contaminated clothing while flushing.</p> <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for 15 minutes. Separate eyelids with fingers for better washing.</p> <p><u>Inhalation</u> Move victim to fresh air and seek immediate medical attention.</p> <p>In all cases, seek immediate medical attention.</p> |
| Handling and Storage Precautions | <p>Closed containers exposed to heat may explode.</p> <p>Reacts violently with water producing highly toxic fumes.</p> |

4.20 Silane (SiH₄)

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| Synonyms | Silicon Tetrahydride. |
| Description | <p>Silane is a colorless gas with a repulsive odor. It is spontaneously flammable in air. It is shipped as a compressed gas.</p> <p>Mixtures down to 1.0% silane in hydrogen and/or nitrogen have been spontaneously flammable when mixed with air. Decomposition of silane into silicon and hydrogen begins at about 400°C (752°F) and proceeds rapidly at temperatures above 600°C (1112°F). When silane burns in air, it produces a power-like substance (SiO₂).</p> |
| Uses | Silane is used as the silicon source in polysilicon and silicon nitride processes. It is also used to produce fluorine doped oxides (low-K). |
| Thresholds | Not available. |
| Toxicity | Little is known about the toxicity of silane except that breathing it may cause headache and nausea. The hazards associated with silane come from its spontaneous flammability in air. |
| Specific First Aid | Not available. |
| Handling and Storage Precautions | <ul style="list-style-type: none"> • Venting silane mixtures of any concentration should be done as for pure silane. Preferably, they should be burned. • Piping and process equipment must be pressure checked above working pressure and must be leak tight. • Evacuate piping and systems, and purge with a gas that does not react with silane before introducing silane. • Silane is a strong reducing agent. • Halogenation reactions with chlorine or bromine are explosively violent at room temperature. Be very cautious about using silane in systems with halogenated compounds. Even a trace of free halogen can be violently explosive with silane. • Silane is stable in the presence of neutral or acid water. In the presence of base (OH⁻), even traces provided by glass vessels, silane is rapidly hydrolyzed to hydrated silica. • Silane should not be the first gas introduced into the reaction chamber; it should always follow the nitrogen source so that it has something with which to react. • Do not condense silane (-110° C or less). Serious accidents have occurred with liquid and solid silane. Cold traps on vacuum pumps could become contaminated with liquid silane and explode when opened. • Vent with carrier gas to outdoors (no hoods) through pipe small enough to insure no back diffusion. Stainless steel or iron pipe is preferred. • Remove back plates on rotometer and pressure gauge covers to prevent possible build-up of silane in these devices. • Pressure regulators must have metal diaphragms to allow complete evacuation. |

4.21 TEOS (Tetraethylorthosilicate) (C₂H₅O)₄Si

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| Synonyms | Ethyl Silicate, Silicic Acid Tetraethyl Ester, Tetraethyl Silicate. |
| Description | TEOS is a colorless, flammable liquid with a faint alcohol odor. It is shipped as a liquid, usually in quartz ampules. |
| Uses | TEOS is used as a silicon source for oxide processes. It is usually contained in a bubbler. |
| Thresholds | TLV is 10 ppm. |
| Toxicity | TEOS may cause respiratory, skin, eye and mucous membrane irritation. Vapor contact with the eyes may cause severe irritation with redness, pain and blurred vision. Contact with skin may cause redness, pain and burns. Inhalation may cause mucous membrane irritation. Inhalation of concentrations greater than 100 ppm may have a narcotic effect (i.e., may cause central nervous system depression). Chronic over-exposure may affect kidneys, liver and lungs. |



Danger

TEOS reacts with water, releasing toxic and flammable vapors. Do not breathe the mist or vapors generated while washing exposed areas.

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| Specific First Aid | <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 15 minutes. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly.</p> <p><u>Skin</u> Flush with water for at least 15 minutes. Seek immediate medical attention.</p> <p><u>Inhalation</u> Remove victim to fresh air. Seek immediate medical attention.</p> |
| Handling and Storage Precautions | Store in a cool, dry, well-ventilated place away from all sources of ignition. Avoid contact with water, oxidizers, acids and alkalis. |

4.22 TMB (Trimethyl borate)((CH₃O)₃B)

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| Synonyms | Boric Acid, Trimethyl Ester, Methyl borate |
| Description | TMB is a clear, flammable liquid with a faint odor, shipped as liquid in a quartz ampule. |
| Uses | TMB is used as a source of boron for doping "P" type silicon, and in the deposition of P doped oxides. |
| Thresholds | Not available. |
| Toxicity | TMB irritates skin, eyes and mucous membranes. There is no data on its toxicity when vapors are inhaled. The effects of chronic exposure are not known. |
| Specific First Aid | <p><u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 15 minutes. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly.</p> <p><u>Skin</u> Flush with water for at least 15 minutes. Seek immediate medical attention.</p> <p><u>Inhalation</u> Remove victim to fresh air. Seek immediate medical attention.</p> |
| Handling and Storage Precautions | Store in a cool, dry, well-ventilated place away from all sources of ignition. Avoid contact with water and oxidizers. |

**Danger**

DO not use water to extinguish a TMB fire. Use foam or CO₂.
 TMB reacts violently with water, releasing heat and toxic boron gas. The heat of the reaction could cause the TMB to explode.

**Danger**

TMB reacts violently with water, releasing heat and toxic boron gas. Avoid breathing the mist or vapors generated while you wash affected areas.

4.23 TMPi (Trimethyl phosphite) ((CH₃O)₃P)

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| Synonyms | Phosphoric Acid, Trimethyl Ester. |
| Description | TMP is a colorless, flammable liquid with a pungent odor. |
| Uses | TMP is used as a source of phosphorus for doping "N" type silicon, and in the deposition of P doped oxides. |
| Thresholds | TLV is 2 ppm. |
| Toxicity | TMP is irritating to the skin, eyes and mucous membranes. It may cause respiratory irritation with coughing, choking and congestion. Chronic exposure may cause dermatitis and affect the liver. Exposure of a pregnant woman to TMP may cause fetal death and/or birth defects in her unborn child. |
| Specific First Aid | <u>Eyes</u> Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 15 minutes. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly. Seek immediate medical attention. <u>Skin</u> Flush with water for at least 15 minutes. Seek immediate medical attention. <u>Inhalation</u> Remove victim to fresh air. Seek immediate medical attention. |
| Handling and Storage Precautions | TMP must not be stored near oxygen, oxidizing agents or peroxides. TMP has a flash point of 28°C (82°F). |

**Danger**

DO not use water to extinguish a TMPi fire. Use foam or CO₂. TMPi reacts violently with water, releasing toxic phosphorus oxides and carbon monoxide. The heat of the reaction could cause the TMP to explode.

**Danger**

TMP reacts violently with water, releasing toxic phosphorus oxides and carbon monoxide. Avoid breathing mist or vapours generated while you wash affected areas.

4.24 Trans 1,2-Dichloroethylene (C₂H₂Cl₂)

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| Synonyms | DCE, Trans-acetylene dichloride, trans-dichloroethylene, Trans-LC® (Trans Liquid Chlorine). |
| Description | Clear, colorless liquid with a pleasant odor. |
| Uses | Trans 1,2-Dichloroethylene is an ozone-safe liquid chlorine source for use in silicon oxidation (gettering) and tube cleaning. It can be used as a direct replacement for TCA. When the temperature is too low, or not enough oxygen is present to support combustion, phosgene (mustard gas) may be produced. |
| Thresholds | Odor threshold is 0.08 ppm TLV is 200 ppm. (Schumacher) |
| Toxicity | Harmful if swallowed, inhaled, or absorbed through skin. Vapor or mist is irritating to eyes, mucous membranes, and respiratory tract. Causes skin irritation. Prolonged contact can cause narcotic effect. |
| Specific First Aid | <p>Eyes Remove contact lenses. Flush the eyes with water or an eye flush solution for at least 15 minutes. The eyelids should be held open and away from the eyeball to ensure that all surfaces are flushed thoroughly. Seek immediate medical attention.</p> <p>Skin Flush with water for at least 15 minutes. Seek immediate medical attention.</p> <p>Ingestion Seek immediate medical attention.</p> <p>Inhalation Remove victim to fresh air. Seek immediate medical attention.</p> |
| Handling and Storage Precautions | Light, air and moisture sensitive. Store in closed container in a cool dry place. Can decompose to give hydrogen chloride gas, carbon monoxide, carbon dioxide and phosgene gas. |

5 Glossary

| Term | Explanation |
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| ACGIH | American Conference of Governmental Industrial Hygienists. A non-governmental association that annually publishes a list of Threshold Limit Values (TLVs) in the U.S. |
| Acid gas | A gas that is acid in its reactions, or that dissolves in water to produce an acid (pH <7.0) solution. Acid gases may be neutralized, in case of a leak, by a solution of a base such as sodium hydroxide. |
| Acute exposure | Short term exposure, usually to elevated levels of a substance. |
| Alkaline gas | A gas that is alkaline in its reaction, or that dissolves in water to form an alkaline (pH >7.0) solution. Alkaline gases may be neutralized, in case of a leak, by a dilute solution of an acid such as sulfuric acid. |
| Anaphylactic shock | Hypersensitivity resulting from exposure to an irritant. |
| Anoxia | Symptoms produced by oxygen deficiency, which may include dizziness, loss of coordination, nausea, unconsciousness and death. |
| ANSI | American National Standards Institute. ANSI, is a private, non-profit membership organization representing over 1,000 public and private organizations, businesses and government agencies. They seek to develop technical, political and policy consensus among various groups. |
| Asphyxia | Unconsciousness or death caused by lack of oxygen. Permanent brain damage may occur if the oxygen deprivation is severe or prolonged. |
| Auto-ignition | The temperature at which a gas spontaneously ignites. |
| CAS | Chemical Abstracts Service. A CAS registry number uniquely identifies a chemical substance. |
| Chronic | Long term or repeated exposure, usually to low levels of a substance. |
| Corrosive gas | A gas capable of chemically destroying other materials over time. |
| CPR | Cardiopulmonary Resuscitation; artificial respiration combined with forcibly compressing the chest to induce blood circulation. |
| Cyanotic | A symptom of severe oxygen deprivation. The victim will have blue-tinged lips, fingernails and earlobes. |
| Flammable | A substance that will burn. Reacts with oxygen to produce heat. |
| Flash point | The lowest temperature at which the vapor of a combustible liquid can be made to momentarily ignite in air. |
| Frostbite | Tissue damage due to contact with cold substances. Frostbite may cause severe tissue damage similar to burns. |
| Hot Work | Work carried out on systems that are powered on. |
| Hypotension | Abnormally or excessively low pressure of arterial blood or intra-ocular fluid |
| IDLH | Immediately Dangerous to Life or Health. A concentration of airborne contaminants that represents the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects. |
| Inhalation | Inhalation is the drawing of air or other substances (fumes, mist, vapor, dust, etc.) into the lungs. Inhalation is another word for "breathing". |

| Term | Explanation |
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| Inert gas | A gas which does not react with other chemicals. |
| Irritant | A substance that causes reddening, swelling and pain on contact. |
| ISO LC50 or LD50 | International Standards Organization. (Lethal concentration, 50% or Lethal dose, 50%; used interchangeably). The concentration of a specific gas that, when inhaled for a specified period of time, results in death to 50% of the exposed subjects. |
| Lethal | Deadly; capable of killing an exposed person. |
| MAK | Maximale Arbeitsplatzkonzentrationen. German occupational exposure limit value, roughly equivalent to the U.S. TLV. |
| mg/kg | Milligrams per kilogram of body weight. |
| mg/M ³ | Milligrams per square meter. |
| MSDS | Material Safety Data Sheet. Gives detailed information about the safety aspects concerning a particular gas or vapor. Supplied by the gas manufacturer. |
| Mucous membrane | The lining of the mouth, throat, nose, lungs and intestines. |
| Narcosis | Chemical alterations to brain functioning tending to produce sleep or unconsciousness. |
| NIOSH | National Institute for Occupational Safety and Health. |
| Non-toxic | Not likely to cause damage to body functions. Inert and non-toxic gases can, however, cause asphyxia. |
| OSHA | Occupational Safety and Health Administration. Body in the U.S. that advises on safety and health issues in the workplace. |
| Oxidizing agent | A chemical that removes electrons from other substances in a reaction. Oxidizers can react violently with reducing agents and flammable materials. |
| PEL | Permitted Exposure Limit. The amount of exposure below which there is no apparent immediate effect to health. Averaged over an eight-hour shift. |
| PPB | Parts per billion; (10 ⁹) the standard used to measure very small gas concentrations. |
| ppm | Parts per million; (10 ⁶) the standard used to measure gas concentrations. |
| Pulmonary edema | Congestion and swelling of the lung tissue in response to inhaling a toxic or irritating substance. Can be fatal if not detected and treated promptly. |
| Pyrophoric | A material that will spontaneously ignite in air. An example pyrophoric gas is Silane. |
| Reducing agent | A chemical that adds electrons to other substances in a reaction. Reducing agents can react violently with oxidizing agents and halogens or halogen compounds. |
| REL | Recommended exposure limit. |
| RF | Radio Frequency. Electromagnetic energy with frequencies ranging from 3 kHz to 300 GHz. |
| RF Generator | Device that creates high-voltage, high-frequency energy. Used in ASM plasma systems. |
| Shock | A serious after-effect of injuries or emotional distress. Symptoms include cold, clammy skin, nausea, chills and rapid shallow breathing. Not the same as electric shock. |
| Spontaneous ignition | Bursting into flames without an external ignition source such as a spark. See pyrophoric. |

| Term | Explanation |
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| Stable | Does not react quickly with other chemicals and does not tend to spontaneously decay into other chemicals. |
| STEL | Short Term Exposure Limit. STELs are expressed as airborne concentrations of substances averaged over a period of 15 minutes. STELs are recommended for those substances only when there is evidence either from human or animal studies that adverse health effects can be caused by high short time exposure. Exposure above the TLV up to the STEL should not occur more than four times per work day, and there should be at least 60 minutes between successive exposures. |
| Subcutaneous | Under the skin. |
| Threshold limit Value (TLV) | A guideline value "based on the best available information". The concentration of a chemical to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effects. It is based on an eight-hour shift and 40 hours per week. Note the TLV does not separate safe from dangerous - it is a guideline only. |
| Toxic | Capable of causing damage to body functions. This damage may be temporary, permanently disabling, or fatal. |
| TWA | Time-Weighted Average. An average concentration over a period of time. The TLV is a time-weighted average - based on five eight-hour shifts a week. |
| VAC | Volts, alternating current. |
| VDC | Volts, direct current. |
| Ventricular fibrillation | Irregular and uncoordinated contraction of the muscle fibers of the ventricles, the lower chambers of the heart. Since ventricular fibrillation completely prevents the heart functioning as a pump, it quickly brings death unless emergency measures restore the circulation of oxygenated blood throughout the body. |