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# PURPOSE

This Standard establishes the minimum requirements for the safe use of installed and fixed gas systems including bulk, cylinder-supplied and sub-atmospheric systems, gas mixing units, gas filter units and the associated storage of gas sources at TI sites worldwide.

The following pressurized gases are excluded from this Standard: SCBA (Self-contained breathing apparatus), portable fire extinguishers, portable cart mounted oxygen/acetylene gas assemblies for cutting and welding, refrigeration systems, fuel gas systems and fuel gas containers (e.g., natural gas, propane) that have an odorous agent (mercaptan) in them and commercially available consumer products (e.g., cigarette lighters, spray paint).

# SCOPE

The provisions of this Standard apply to all TI employees, suppliers, vendors, and visitors at TI sites worldwide.

# reference documents

1.

## TI ESH Standard 00.00 TI ESH Standards Program Document

## TI ESH Standard 03.01C Hazard Communication and Chemical Labeling

## TI ESH **Standard** 03.01E Chemical Storage and Spill Control

## TI ESH Standard 05.01Egress and Evacuation

## TI ESH Standard ENV 05.01 [Air **Emissions** Management](https://sps01.itg.ti.com/sites/wwf/esh/standards/Knowledge_Bank/ENV05-01.doc)

## National Fire Protection Association (NFPA) 704 Standard System for the Identification of the Hazards of Materials for Emergency Response

## SEMI Standard S2 Environmental, Safety and Health Guidelines for Semiconductor Manufacturing Equipment

## SEMI Standard S8 Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment

## SEMI Standard S10Safety Guideline for Risk Assessment and Risk Evaluation Process

## 3.10 NFPA 318-2015 Standard for the Protection of Semiconductor Fabrication Facilities

# Definitions

[TI ESH Standards Glossary of Definitions](https://sps01.itg.ti.com/sites/wwf/esh/standards/Knowledge_Bank/00.01.xlsx)

# Requirements

## Documentation - Sites shall develop and maintain the following information:

### The identification of persons or organizations responsible for the site’s gas systems management;

### A description of each type of gas system used on site (i.e. corrosives, flammables, etc.);

### A list of all TI, local and national regulatory requirements under which each of the site’s gas systems were constructed; provisions for maintaining applicable regulations or site agreements made with the local Authority Having Jurisdiction (AHJ),

### Provisions to ensure the site shall conduct and document a hazard assessment and code review before the installation of a new hazardous gas system, when converting an existing gas system using one type of gas (e.g., chlorine) to use another gas (e.g., fluorine) or before making modifications (e.g., changes to piping, exhaust and/or life safety systems, etc.) to an existing hazardous gas system,

### Provisions to ensure that the installation, modification and/or conversion of hazard gas systems shall be designed, reviewed and installed by competent person(s) (i.e. design performed by, professional engineer or the gas system owner and reviewed by site ESH prior to installation),

### Documentation showing a list of leak detection equipment, location(s) of the sampling point(s), calibration intervals, inspection intervals, and the date of the last completed calibration, and

### Documentation of the current configuration (e.g. how the programming is designed), the minimum detection limits of each system (e.g. lower detectable limits of the monitors) and each action generated upon gas leak detection.

## Hazard Assessment

### A hazard assessment shall be conducted to evaluate the risk of the process and installation by a competent person(s). This assessment shall include, at a minimum, the following:

#### Consideration of physical and chemical properties and hazards of the gas system,

#### The location of the gas installation;

#### A documented review of the local/regulatory code requirements based on the hazard and the location;

#### A description of the required Personal Protective Equipment for service and maintenance activities, and;

#### An assessment of the entire system that evaluates the consequences of component failures and human errors and proposes recommendations on actions that would eliminate or at least reduce the risks to acceptable levels.

##### Note: Sites shall design and install hazardous gas systems such that a single failure shall not increase the risk (Example: no single component failure will, by itself, expose a person to the hazard).

Note: For additional information on how to conduct a Hazard Risk assessment, see SEMI S10 which provides a structure, guidelines, and checklists for conducting Hazard Assessments for equipment.

### Worldwide ESH approval of the assessment and system design shall be required before the installation of any new gas system and when modifying an existing system containing highly toxic gases (HTG) and toxic gases with poor warning properties (TGWPWPs),

### Replacement of components of a system (e.g. valves, sensor, controls, piping) with equivalent rated components shall not require an additional hazard assessment provided the risk assessment on the original system is still applicable,

### For new installations, installed after 3/29/06, sites shall consider in their hazard assessment the use of sub-atmospheric or similar safety delivery-type systems for hazardous gases. Where a sub-atmospheric delivery system is available but not selected for use, the Sites shall document why they chose a different delivery system.

### Sites shall maintain records of the following:

#### Drawings, diagrams and other records pertaining to each gas delivery system type,

#### Records which demonstrate that system installations and/or modifications meet the requirements of this Standard. Examples include gas detection monitor replacement, PLC replacement, piping repair due to damage or failure, changes made regarding the type of fittings used, etc., and

#### Copies of any hazard assessments or third party reviews performed on the system.

### Sites shall maintain a copy of gas delivery system records for the active life of the system.

## Written Procedures

### Sites shall, at a minimum, establish the following written procedures for managing gas systems:

#### Cylinder Handling and Storage,

#### Purging of systems,

#### Source cylinder change,

#### System and equipment periodic inspection,

#### Management of gas detection alarms,

#### System and equipment testing, maintenance, repair, and service,

#### Gas volume management to ensure storage area and cylinder in-use volumes remain within amounts allowed by regulation,

##### Note: Local regulations on maximum storage, area volumes or maximum building volumes shall be used to determine the maximum number of cylinders allowed.

#### Management of leaking hazardous gas sources, and

#### Emergency response plans; including steps for trouble-shooting of gas and cryogenic systems.

### Sites shall establish Standard Operating Procedures (SOP’s) for maintenance of gas leak detection equipment and response to alarms that include:

#### Protection of employees in the event a temporary override or bypass of leak detection is required,

Note: Overriding and bypassing leak detection on pyrophoric gas systems is not allowed.

#### Alternative means for entering a gas cabinet or ventilated enclosure in the absence of gas leak detection and/or exhaust,

#### A means of notifying authorized personnel who may enter an exhausted enclosure during gas leak detection down-time,

#### A means for providing alternative leak detection for ambient air monitoring for hazardous pressurized gases,

#### Response to loss of exhaust, loss of gas detection or monitor malfunction.

##### The site shall utilize TI ESH Standard 03.02 Appendix A *Gas Matrix* to define which gas supply system can have a delayed shut-off to allow response personnel time to verify that no additional hazards are present using one of the following methods:

##### Visual inspection of the area indicates no smoke or fire is detected,

##### Confirmation that no loss of exhaust has occurred, and

##### Confirmation that the concentration outside the exhausted enclosure is not greater than appropriate action levels or the concentration within the exhausted enclosure is below one half the level Immediately Dangerous to Life or Health (IDLH).

### Sites shall establish a process to ensure environmental personnel are notified of a gas leak, so that the environmental personnel can ensure compliance with TI ESH Standard ENV05.01 Air Emissions Management.

## Labeling**.**

### Gas systems shall be labeled in accordance with TI ESH Standard 03.01C*Hazard Communication and Chemical Labeling* and site local regulatory requirements.

## Hazardous Gas Rooms, Storage and Distribution Areas

### In addition to the requirements found in TI ESH Standard 03.01E *Chemical Storage and Spill Control*, the following shall be applicable to hazardous gas rooms:

#### Hazardous gas rooms shall be provided with a mechanical exhaust rate of not less than 1 cubic foot per square foot (CFM) (0.0283 cubic meters per minute) of floor area over the storage area;

#### A means for incident notification (such as hazardous production material (HPM) pull stations, incident alarm buttons, telephones, etc.) shall be provided outside each hazardous gas room. The travel distance to such a device shall not be more than 45.7 m (150 ft.);

#### Hazardous gas rooms inside a building and distribution areas external to a building shall be provided with a remotely located means for emergency shutdown; and

#### Access to hazardous gas rooms and areas containing hazardous gas systems external to the building shall be properly secured and limited to authorized personnel.

### The main entry doors to gas rooms shall be posted with the following information:

#### Identification of the general hazard categories of the materials in the room (examples: flammable gas, toxic gas, oxidizing gas, acid gas),

#### A complete chemical list using the name from the Safety Data Sheet (SDS) (Example: Use the name “hydrogen chloride” rather than the symbol “HCl”),

#### Chemical hazard classification information (e.g. NFPA 704 Diamond),

#### Authorized Personnel Only, and

#### Emergency contact number(s).

### The main entry to hazardous gas systems external to the building shall be posted with the following information:

#### Identification of the general hazard categories of the materials in the area (examples: flammable gas, toxic gas, oxidizing gas, acid gas),

#### A complete chemical list using the name from the Safety Data Sheet (SDS) (Example: Use the name “hydrogen” rather than the symbol “H2”),

#### Chemical hazard classification information (e.g. NFPA 704 Diamond),

#### Authorized Personnel Only, and

#### Emergency contact number(s).

### Gas rooms that contain cylinders and/or equipment containing hazardous gases shall have two exit doors equipped with panic hardware. The exits shall be placed a distance apart (measured in a straight line between exit doors) at least one-half of the length of the maximum overall diagonal dimension of the room.

#### The exit doors must open in the direction of travel from the room and have automatic closing devices,

#### Rooms containing cylinders of hazardous gases shall be locked at all times, except when work or cylinder transfer is in progress, and

#### The site shall ensure that emergency responders have access to these rooms.

### Only compatible hazardous gases and their associated purge gases may be stored in or dispensed from the same hazardous gas room.

Note: Gases and gas mixtures that have multiple hazards must be separated according to their hazards (See Appendix B *Separation of Hazardous Production Materials (HPMs*)).

### Hazardous gas rooms supplied with make-up air from heating or air conditioning systems shall be provided with a manual means to shutoff the source of air from outside the room or area.

#### Make-up air shall not be obtained from another chemical or gas room, and

#### Make-up air that is obtained through simple back-draft dampers from the surrounding area shall be equipped with an automatic fire damper (Example: fusible link),

### Access and Egress, Working Clearances within the Gas Storage/Use location

#### Exit pathways from hazardous gas areas/rooms shall be in accordance with TI ESH Standard 05.01 Egress and Evacuations,

#### A minimum clearance of 1m (3ft) shall be maintained in front of all gas cylinder cabinets and ventilated enclosures, and

#### An approach aisle of 1 m (3 ft.) width shall be maintained for gas cabinet access.

## Gas Cabinet Installation and Connection

### Access openings to gas cabinets and ventilated enclosures shall be self-closing.

### Gas cabinet doors shall be capable of opening to at least a 90 degree angle.

### Gas cylinders shall be stored single-depth within a cabinet.

### Gas cabinets containing gas cylinders equipped with manual valves shall be designed so that they can be operated through the limited-access opening (e.g., window) with the cabinet door(s) closed and securely latched.

### Gas cylinder cabinets shall be designed and constructed to address the hazards and compatibilities of the gas. Specifications for purchase of all gas cylinder cabinets shall meet applicable requirements of SEMI S2 and SEMI S8.

#### Where more than one pyrophoric gas cylinder is stored in a gas cylinder cabinet, the cabinet shall be provided with a ¼” (6mm) steel plate between pyrophoric gas cylinders and manifolds for the prevention of fire impingement, and

#### Air inlets for gas cylinder cabinets shall be provided with adequate clearance to allow necessary airflow.

### Pyrophoric Gas Cylinder Cabinets

#### Air inlets shall be provided in a manner to create uniform flow across the gas cylinder fittings and gas plumbing,

#### If the pyrophoric gas is ducted to a combustible main exhaust duct it shall be provided with fire protection downstream from the combustible duct connection, and

#### If the pyrophoric gas is also a highly toxic gas or highly toxic gas mixture, the gas cabinet exhaust duct shall be made entirely of ferrous metal and tie into an exhaust main duct or sub-main duct. Both the exhaust discharge duct to and the abatement system shall be labeled to indicate that it contains a highly toxic, pyrophoric gas.

### The design of piping and other system components shall account for thermal expansion and contraction, seismic movement, vibration and other factors unique to the installation.

#### Gas cabinets shall be installed at the same level as the floor or be equipped with a ramp for access.

#### Exception: Ramps are not required where gas cylinder lifting devices are provided.

#### Compressed gas cylinders shall be connected by means of a connection assembly (pig-tail) to reduce strain on the source container or fittings during cylinder connection or disconnection.

#### Cylinder connections shall be made using the appropriate fitting for the gas type and pressure.

#### Cabinets for small cylinders (Examples: Sub-atmospheric gas system (SAG) bottles, Uptime bottles, or lecture cylinders) shall be equipped with shelves or brackets that raise the cylinder valve to a level which allows for ergonomically correct maintenance.

## Gas Cylinders

### Gas cylinders shall be properly maintained and labeled.

### Hazardous gas cylinders shall be inspected in accordance with manufactures recommendations or at a minimum every five (5) years.

### Exception: Gas cylinders used as fire protection agents shall be inspected at intervals as prescribed by appropriate local fire protection regulations.

### Gas cylinders, whether in storage or “online” (in use) shall be provided with structural support and fixed to that support to prevent them from tipping over.

### Cylinders that are online (in use) in areas with seismic activity shall be secured using a rigid method. Chaining to secure an active cylinder is not allowed.

### Gas cylinders of pyrophoric, flammable, or combustible gas shall be individually secured with a non-combustible securing restraint.

### Gas cylinders in storage (not connected to piping or plumbing) shall have the cylinder outlet cap and a protective shipping cap (i.e. “dust cap”) in place.

### When a gas cylinder contains a Restricted Flow Orifice (RFO) the gas cylinder shall be marked to indicate the size of the RFO installed.

## Manufacturing/AT Equipment Gas Boxes

### Equipment exhaust ventilation shall be designed to meet the requirements of the SEMI S2 section on Exhaust Ventilation and to prevent exposures to potentially hazardous chemicals.

### Equipment exhaust parameters and relevant test information should be reviewed to determine the duct velocity, volumetric flow rate, capture velocity and face velocity. This information shall be used to establish the installation of exhaust to an equipment gas box.

## Gas Leak Detection

### All gas supply and storage systems, gas detection systems and any required safety controls for such systems shall meet the requirements of TI ESH Standard 03.02 Appendix A Gas Matrix for the specific gas.

### All samples discharged from the leak detector must be discharged into the appropriate exhaust stream.

### Components (Example: valves) shall be equipped with a lock out capable device in accordance with TI ESH Standard 06.11 *Lock Out Tag Out*.

### Gas cabinets and ventilated enclosures shall immediately shut-off the gas supply upon activation of a shutdown actuator (Example: Emergency Off (EMO) or shut-down signal from controls).

### Gas Leak Detection Controls

#### Controls specified in this sub-section shall be tested for functionality during installation and following any maintenance activity that may have affected the safety-related control components.

#### Controls, upon failure, shall alarm at a continuously monitored location (Example: Programmable Logic Controller (PLC) failure).

#### Software-based alarm and activation circuits used for safety control shall meet the requirements of the SEMI S2 section on Fail-to-safe Equipment Control Systems (FECS).

#### If redundant detection of HTG or TGWPWPs from separate VMB’s or exhausted enclosures occurs, automatic gas shut-down shall occur at the next upstream valve from where the detection occurred.

#### Determining Leak Detector

##### Identify all gases to be supplied through the gas cabinet, cylinder cabinet or other exhausted enclosure,

##### Utilize the TI ESH Standard 03.02 Appendix A *Gas Matrix* to determine what gases must be monitored,

##### Identify the TI Occupational Exposure Limit (TI OEL), the short term exposure limit (STEL) and if any ceiling exists for exposure (Ceiling) for each gas,

##### Determine the gas monitor capabilities for each gas,

##### Determine which gas has the lowest allowable exposure limit,

##### Determine which monitor can detect the gas of concern, and

##### Determine if you need any additional monitoring.

### Leak Detection Equipment Calibration

#### Sites shall maintain gas leak detection equipment calibration records for a period of one year. Calibration records shall include the following:

#### Procedures for calibration,

#### Calibration results, and

#### Identification of the person performing the calibration.

### Gas Leak Detection Records Retention

#### Records showing non-zero levels of detection shall be retained per the TI Record retention policy for Industrial Hygiene exposure records. The records shall include the following:

##### Resolution of the alarm, including cause and corrective action;

##### Dates and times of alarms and restoration, and;

##### Location of the alarm with how the alarm is configured (set points) and programed.

#### Zero-detection records shall be assumed unless a documented detection level is recorded.

## Exhaust Systems

### Exhaust systems shall be sized and constructed to properly remove gas related hazards from the working environment or manufacturing equipment.

### Exhaust systems shall direct the hazardous gas effluent to the appropriate abatement system for treatment. Incompatible effluents shall be segregated to prevent reactions within the ducts and exhaust system (e.g., VOC, acids, bases [ammonia]). See TI ESH Standard 03.02 Gas Systems Appendix C Exhaust Chemistry Selection Guide.

Note: Minimum airflow cooling calculation can be determined using 1.42 cubic meters (50 cubic feet) per liter (at maximum flow rate) of pyrophoric gas. If a burn tube is used see Appendix D *Burn Tube Design* and Appendix E Burn tube Exhaust Flow Calculator. This system must be installed as shown in the design (straight pipe with no bends)

### Exhaust at all points of the system except the stack discharge shall be designed and operated at negative pressure to the surrounding area.

### Exhaust systems shall operate continuously and shall be supported by emergency power or legally required standby power.

Note: For additional information see NFPA 69, NFPA 70, NFPA 91, and NFPA 110.

### Exhaust Ducts and Components

#### Exhaust ducts shall be sized and constructed to properly remove a gas leak from a gas cabinet or ventilated enclosure. See TI ESH Standard 03.02 Appendix A Gas Matrix for specific exhaust requirements.

#### Exhaust duct materials shall be rated for compatibility as required.

#### Exhaust duct materials shall be rated for fire protection as follows:

##### Process exhaust lines containing pyrophorics shall be provided with a minimum of 6 meters (20 feet) of ferrous metal duct to ensure cooling of the exhaust effluent to less than 66 degrees C (150 degrees F) before discharge to a non-ferrous duct,

##### Exhaust ducts that may potentially convey flammable gas shall be constructed of ferrous metal for a minimum of 3 meters (10 feet) from any gas cabinet or ventilated enclosure,

##### Exhaust ducts constructed of combustible material that are greater than 254 mm (10-inches) in diameter that convey flammable vapors shall be provided with fire sprinklers.

Note:Engineering controls shall be used to maintain concentrations below 20% of the Lower Explosive Limit (LEL).

#### Each exhaust line connecting a gas cabinet or ventilated enclosure shall be provided with a damper secured at the appropriate position to meet the engineering designed flow rate.

#### For new installations or modifications, dampers for exhaust of hazardous gases shall have minimum-position blocking devices to prevent restricting the flow below the required velocity or volume.

### Exhaust Monitoring, Indicators, and Controls

#### Exhaust systems shall be monitored to ensure that the main fans are producing adequate exhaust for system requirements.

#### Exhaust monitoring points shall be located upstream of the first damper.

#### Exhaust monitoring devices shall not be equipped with adjustment devices (e.g. knob, lever) but shall require use of a tool to make setting changes.

#### In exhaust systems where a hazard (e.g., pyrophoric byproducts) can result from exhaust failure or inadequate exhaust the process exhaust shall be provided with a sensor to monitor for low/no flow conditions.

### Exhaust Abatement (Treatment) Systems

#### Abatement systems shall be provided for gas cabinets, ventilated enclosures, vent lines and process exhaust when dilution alone will not prevent releases to the environment above one-half (½) the IDLH .

#### If the abatement system is an incinerator, a ferrous metal exhaust duct is required at the exit of the incineration chamber.

#### Point-Of-Use (POU) abatement systems for hazardous gases shall send an alarm to a continually monitored location when the abatement device has failed or exhaust has been diverted (bypassed) around the abatement device.

#### Pyrophoric process abatement systems shall meet the following criteria:

##### It shall be designed to handle the highest level of pyrophoric gas flow from all process systems and vent lines that are connected to the abatement device,

###### Note: Multiple process or purge vent lines may be routed to a common abatement device provided the calculations indicate the capacity is adequate under maximum flow conditions.

##### It shall be interlocked to prevent process gas flow unless the abatement device is functioning properly or equipped with a safe bypass around the abatement device (i.e. by-pass to a secondary abatement device which is interlocked to the process gas flow).

##### The exhaust flow shall be monitored and, at a minimum, shall be maintained at the calculated flow rate required to ensure full combustion of the maximum flow of pyrophoric gases. A drop in exhaust flow shall result in the following actions:

##### Automatic shutdown of the pyrophoric gas source,

##### Alarm to a continuously monitored location, and

##### Automatically place the process equipment in a safe-state.

#### A burn tube can be used as a backup or an alternate to a pyrophoric abatement system. If used, the burn tube shall meet the following:

##### The tube shall be a minimum length of 6 meters (20 feet), a minimum diameter of 4 inches (10 cm) and shall be constructed of Schedule 5 stainless steel pipe.

See TI ESH Standard 03.02 – Appendix D *Burn-Tube Design*, Drawings 1 & 2 for installation of a burn tube.

##### Exhaust flow shall be monitored and, at a minimum, shall be maintained at the calculated flow rate required to ensure full combustion of the maximum flow of pyrophoric gas.

See TI ESH Standard 03.02 – Appendix D *Burn Tube Design* for the burn tube exhaust flow calculator.

##### Loss of exhaust flow shall initiate an alarm at a continually monitored location and at the process equipment affected and shall result in automatically placing the process equipment in a safe-state, and

##### For new installations, the air injector shall be located no less than 8 feet (2.5 meters) from the ground.

## Ventilated Enclosure Design

### Only compatible gases shall be installed or plumbed in any individual ventilated enclosure;

### Access openings (working windows), where provided, shall be sized as small as possible for safe handling,

### Penetrations in ventilated enclosures, except for designed air inlets, shall be sealed.

## Piping and Distribution Systems

### Hazardous gas piping systems shall be:

#### Constructed of welded, seamless, stainless-steel tubing, and

#### Orbital or heliarc welded in locations outside exhausted enclosures.

### Supply and vent line tubing and piping components (examples: valves, gauges, gaskets) shall be compatible with the gas chemistry and the expected working pressures.

### Piping components (valves, pneumatics)

#### Valves shall be selected for compatibility and pressure requirements.

#### Distribution systems downstream of a regulator shall be designed to withstand pressures generated in the event of failure of the regulator.

#### Distribution systems equipped with automatic control systems shall be designed to achieve a safe-state condition when a failure occurs or when activated.

#### Pneumatic valve air lines shall be constructed of material which will melt in a fire.

### Mechanical connections (examples: gauges and valves) for hazardous gas systems shall be located within ventilated enclosures.

### Pressure relief shall be provided on plumbing systems to ensure that the pressure cannot exceed 110% of the design criteria for the lowest pressure-rated component in the affected portion of the system.

#### Non-hazardous pressure relief and vent lines shall discharge to a safe location.

#### Hazardous gas pressure relief and vent lines shall be directed to an appropriate treatment (abatement) system.

### Gas Cabinet vent lines shall not be designed to vent to the gas cabinet enclosure.

#### Vent lines from hazardous gas plumbing shall be welded stainless steel tubing with no mechanical fittings outside of a ventilated enclosure.

#### Gas cabinet and valve manifold box (VMB) vent lines containing pyrophorics shall not discharge to a non-ferrous pipe or duct.

## Purge Gas and Testing

### Purge gas sources, whether single cylinders or from a bulk system, shall NOT be connected to and used for purging incompatible gases.

### Backflow prevention or check valves shall be provided when the backflow of hazardous materials could create a hazardous condition or cause the unauthorized discharge of hazardous materials.

### A bulk (house) purge source may be used as long as the purge line pressure is within 95% (95 percent) of the gas line pressure.

### Automatic gas purge controls (required for HTG&TGWPWPs and pyrophoric gases) shall:

#### Provide the operator notice when the purge is complete,

#### For automatic gas panel systems, initiate an alarm when they fail to accomplish the minimum number of purge cycles. The number of purge cycles shall be at least two (2) times the number required to dilute the process gas to one-quarter (1/4) TI OEL.

#### Prevent opening of the hazardous source gas cylinder until the purge is accomplished.

#### If failure to achieve minimum vacuum levels and refill pressure levels occurs, shall initiate an alarm, abort the purge cycle and prevent gas pressurization from the process gas source until purge can be completed.

#### Where Pyrophoric Gas is used:

##### Auto purge gas cabinets or systems must be programmed with the number of cycle purges to ensure lines are adequately purged of pyrophoric gases and air prior to maintenance or service.

#####  A documented procedure shall be established to ensure adequate manual purges are conducted prior to opening the gas line.

### Leak and Pressure Testing Requirements

#### Assembled piping and components for hazardous gas systems shall be leak tested before introducing the process gas as follows:

##### Pressure testing (example: testing with helium, nitrogen or other inert gas) for silane and other hazardous gases shall reach at least a minimum of 95% (95 percent) of the designed operating pressure of the portion of the gas system being tested or to no more than the maximum rated pressure of any component within the system.

##### Where pressure relief valves are designed into the system, the test pressure shall be at least 0.35 bar (5 psig) less than the designed pressure relief setting, and

##### When pressure testing a new section installed on an existing system that is separated by a single isolation valve, the test pressure shall be no more than 95% (percent) of the operating pressure to prevent leak-by of test gas past the valve.

##### If a local code exists for pressure testing, testing shall be performed in accordance with the local code if it is more stringent.

#### Sub-atmospheric gas systems (SAG) shall be tested via inboard-leakage prior to introducing a hazardous gas. Inboard leak testing shall be performed using a system such as a “helium leak checker”.

### Hazardous Gas Panels

#### Panels and controls for HTG&TGWPWP and pyrophoric gases shall be constructed to interface with automatic shut off valves including panel valves and cylinder valves.

#### Each hazardous gas plumbing panel operating above 103 kPa (15 psig) shall be provided with a pneumatic shutoff valve.

#### A manual process line isolation valve and disconnect fitting shall be provided on each process line supplied from a gas panel.

#### Hazardous gas panels shall be provided with an inert gas purge mechanism of sufficient capacity to remove process gas from the panel and all integrated components.

##### Note: Vacuum pumps shall not be used for purging flammable or pyrophoric gas unless the pump and controls are reviewed by a competent person and approved for such use.

### Gas Pressure and Regulation

#### Gas pressure regulation shall be maintained at a pressure adequate to maintain a differential between the high pressure side and the low-pressure side during full flow by all use points - but not higher than end-use points can tolerate.

## Manufacturing and Support Equipment

### Manufacturing equipment purchased after September 1, 2006 that uses hazardous gases shall:

#### Meet the exhaust and EMO requirements of SEMI S2 and SEMI S6.

#### Be designed to default to a safe-state upon safety system failure.

##### Where applicable, Nationally Recognized Testing Laboratory (NRTL) approved devices (or their national equivalent Approved Testing Laboratory (ATL)) shall be used to activate safety circuits. If NRTL components are not available, reliable redundant non-NRTL devices may be used with approval from ESH Department.

### Support Equipment (e.g., pumps, gas generators, POU abatement)

#### The process equipment or the site control system shall be capable of monitoring pump purge flows and provide controls as follows:

##### Failure or inadequate purge flows shall shutdown (via interlock) the hazardous source gas to the process module or chamber served by the pump, and

##### Minimum purge flow volumes or times shall be ensured (via interlock) before the hazardous gas flow can be initiated.

#### Vacuum pumps for HTG&TGWPWP shall be equipped with an exhausted enclosure to control potential gas leaks.

##### The exhausted enclosure shall house all mechanical exhaust line fittings unless separate enclosures are provided, and

##### The exhausted enclosure shall be provided with gas leak detection.

#### Vacuum pumps which may contain pyrophoric gases shall be equipped with the following:

##### A nitrogen purge of sufficient volume and flow to purge all pyrophoric gases from the pump through the abatement device and to the exhaust system after equipment shutdown, and

##### Interlocks to prevent start-up of the pyrophoric gas in any of the following circumstances:

###### Vacuum pump is not operating,

###### Vacuum is lost, or

###### Vacuum pump purge fails or is inadequate.

## Gas Leak Detection

### Gas leak detection equipment shall be installed as required by TI ESH Standard 03.02 Appendix A *Gas Matrix*.

#### Required gas leak detection shall be functional before a hazardous gas is activated to any affected equipment.

1. If gas leak detection equipment is installed it must be functional (i.e., calibrated and maintained). If not required per local code or TI ESH Standard 03.02 Appendix A *Gas Matrix* and the site does not choose to keep it functional it must be removed.

#### Ambient gas leak detection shall be provided for HTG&TGWPWPs when mechanical connections are located outside exhausted enclosures.

### Within gas cabinets and ventilated enclosures, gas leak detection shall be provided as follows:

#### In the exhaust duct (or enclosure) downstream of all potential leak points,

#### Upstream of the first damper for all gas cabinets and exhausted enclosures,

#### If the gas cabinet or ventilated enclosure contains a gas that has multiple hazards, detection shall be based upon the gas that presents the greatest risk (Example: For 50%hydrogen/50% phosphine use, sites should monitor for phosphine because it presents the greatest risk at low levels).

### Sample analysis for any single detection point shall be completed within 60 seconds from sample pick-up to completed analysis unless otherwise defined in this Standard.

### Gas leak detection systems shall be supplied from emergency electrical power.

1. Emergency electrical power is not required for gas leak detection systems if loss of electrical power results in automatic and immediate shutoff of the gas supply at the gas leak detection system’s point of failure and the system sends a “trouble” alarm to a monitored location.

### Ventilation discharge from gas leak detection systems shall not be discharged to the ambient air (e.g. breathing zone).

### Gas leak detection systems shall be calibrated according to the manufacturer’s recommendations:

#### If calibration is performed on-site using a hazardous gas, special protection measures shall be in place to ensure that persons who are in the area during calibration are not exposed.

#### All calibration gases should be approved through the TI ESH Standard 03.01A Chemical and Material Screening process.

### Only qualified personnel shall perform installation, maintenance and calibration of equipment.

### Gas leak detection alarms shall initiate an appropriate response as defined by the site written standard operating procedures required (See Section 5.3.2 above).

### Sites shall ensure personnel are trained to understand what the audible Gas Leak Detection alarms represent and what actions are required upon activation or sites shall provide labels at the source that indicate what actions are required upon activation of an alarm.

## Fire Protection Systems

### Fire detection, suppression and other protective measures (e.g., fire barriers) shall be provided for protection of oxidizer, pyrophoric, and flammable systems where the hazard assessment identifies a risk to the gases that are stored and/or distributed in areas external to the building.

### Fire Protection, when required, shall meet the following requirements:

#### Sprinkler heads shall be rated at a temperature that ensures they will activate before the frangible disks or fusible plugs in the cylinder valve(s) open.

#### Exception: Cylinders without rupture discs or plugs shall be in a gas cabinet with a sprinkler rated at 80 degrees C (175 degrees F).

#### Fire protection sprinklers, when installed, shall be protected from corrosion when corrosive gases are present.

### For pyrophoric gas installations, Ultraviolet/Infrared (UV/IR) detection will be provided for mechanical fittings located outside of an exhausted enclosure (e.g. exterior gas installations).

### When installed, UV/IR detection systems shall:

#### Be supplied from an emergency power source,

#### Be designed to detect fires involving the burning of the specific pyrophoric,

#### Activate local audible and visual alarms,

#### Activate alarms at continuously monitored location, and

#### Shut down the gas at the source.

## Hazardous Gas Generating Equipment

### Equipment installations shall be designed, installed and maintained in accordance with the manufacturer’s recommendations and local site hazard assessment.

### Equipment generating hazardous gases, when inside buildings, shall be located inside an exhausted enclosure or assembly.

### Ozone generators shall be interlocked to automatically shutdown when:

#### The process using generated ozone is shutdown, and

#### When a gas leak detection occurs as defined in TI ESH Standard 03.02 Appendix A.

## Training and Documentation

### Only trained individuals shall be authorized to perform gas system and gas leak detection design, calibration, maintenance, repair and service functions.

### Training shall be based on the specific job duties the individual is expected to perform and shall include at a minimum the following:

#### Hazards associated with tasks they are required to perform,

#### Hazards of the systems they are required to operate, maintain or service,

#### Emergency shut-down and response procedures, and

#### Required personal protective equipment (PPE).

### Training may include documented job experience.

### Verification of job training and/or job experience shall be maintained as required.

### Awareness training shall be provided for persons who need to know the meaning of an alarm and their response.

# STANDARD Approval

This standard has been approved by David Thomas, TI Vice President.

# Revision history

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rev#** | **Date** | **Nature of Revision** | **Author/Editor** | **Approver** |
| A | 3/29/06 | Creation of standard | M. Alton/Larry Porter | K. Meissner |
| B | 2010 | Copy from 2010 | M. Alton  | K. Meissner |
| C | 2016 | Standard Update:- Reorganize sections- Provide guidance on how to select proper monitor- Include link to Exhaust System selection- Updates to the use of hazard/risk assessment terms- Clarification of the management of gases external to the building- Updated the drawings to match the new connector style | R. Graves | ELC |
|  |  |  |  |  |
|  |  |  |  |  |

1. [Gas Matrix](https://sps01.itg.ti.com/sites/wwf/esh/standards/Knowledge_Bank/03-02_AppxA.xls)
2. Separation of Hazardous Production Materials (HPMs)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Material** | **Highly Toxic** | **Toxic** | **Acid** | **Base** | **Flammable** | **Oxidizer** | **Water-Reactive** | **Pyrophoric** | **Unstable****(Reactive)** | **Organic Peroxide** |
| Highly Toxic |  | NR | 1 hr | 1hr | 1hr | 1hr | 1hr | 1hr | 1hr | 1hr |
| Toxic | NR |  | S | S | S | S | S | S | S | S |
| Acid | 1 hr | S |  | S | S\* | S | S | S\* | S | S |
| Base | 1 hr | S | S |  | S | S | S | S | S | S |
| Flammable | 1 hr | S | S\* | S |  | S | R | S | S | S |
| Oxidizer | 1 hr | S | S | S | S |  | S | S\* | S | S |
| Water-Reactive | 1 hr | S | S | S | R | S |  | S | S | S |
| Pyrophoric | 1 hr | S | S\* | S | S | S\* | S |  | S | S |
| Unstable (Reactive) | 1 hr | S | S | S | S | S | S | S |  | S |
| Organic Peroxide | 1 hr | S | S | S | S | S | S | S | S |  |

NR = Not Required

1 hr = 1 hour fire resistance-rated construction

S = Separation by a partial noncombustible participation extending not less than 457 mm (18) above and to the side of the stored material

R = Separation rooms, which are not require to have a fire resistance rating

Note: HPM gases are required to be separated from HPM liquids and solids by 1-hour fire resistance–rated

construction or are required to be kept in approved gas cabinets. HPM gases also are required to be separated

from gases in other HPM hazard categories as required by Table 5.5, or are required to be kept in

approved gas cabinets.

\*Separation by not less than 6 m (20 ft) is permitted in lieu of a noncombustible partition.

1. *[Exhaust Chemistry Selection Guide](https://sps09.itg.ti.com/sites/fpst/exhaust/_layouts/xlviewer.aspx?id=/sites/fpst/exhaust/Resources/Exhaust%20chemistry%20selection%20guideline.xlsx&Source=https%3A%2F%2Fsps09%2Eitg%2Eti%2Ecom%2Fsites%2Ffpst%2Fexhaust%2FPages%2Fdefault%2Easpx&DefaultItemOpen=1&DefaultItemOpen=1)*
2. Burn Tube Design

Typical design for a 101.6 mm (4 inch) O.D. burn tube (See Drawing 1)



(Drawing 1)

Typical Design for a 152.4 mm (6 inch) O.D. burn tube (See Drawing 2)



(Drawing 2)



(Detail A)

“Burn Tube Exhaust Flow Calculator”

**Double-Click on the Excel Spreadsheet below to “Activate” calculator**



\*Minimum airflow cooling calculation is 1.42 cubic meters (50 cubic feet) per liter (at maximum flow rate) of pyrophoric gas.