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Document 18.1
Pressure

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New document or new requirements

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18.1

Pressure*

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18.1

Pressure

1.0 Introduction

The importance of pressure safety at LLNL cannot be overemphasized. This document contains work requirements for LLNL pressure equipment as well as training requirements and responsibilities of workers who work with or supervise activities involving such equipment. Workers who design or work with pressure equipment should fully understand and comply with these requirements and those in Document 18.2, "Pressure Vessel and System Design," and Document 18.3, "Pressure Testing," in the *ES&H Manual.* If further help is necessary, contact the LLNL Pressure Safety Manager.

The documentation requirements in Section 3.0 do not apply to the systems listed below.

- Unmodified compressed-gas or liquid cylinders approved by the Department of Transportation (DOT) and the appropriate regulators.
- Utility systems that
  - Comply with applicable Plant Engineering standards, PEL-M-13200, Laboratory Gas Systems (see "LLNL Facility Design Standards")
  - Operate at a maximum allowable working pressure (MAWP) of no more than 2 MPa gauge (300 psig), and
  - Are inspected at installation and subsequently maintained by the Plant Engineering Department.
- Refrigeration systems that comply with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Codes and applicable Air Conditioning and Refrigeration Institute (ARI) standards.
- Systems that operate at an MAWP that is less than atmospheric pressure. (Design guidance for these systems is given in the ASME Unified Pressure Vessel Code and the *Mechanical Engineering Design Safety Standards*, M-012, Section 3.3, "Vacuum Systems.") However, the requirements <u>do</u> apply to vacuum systems that may be pressurized (i.e., for purging, or back-filling).
- ASME coded air-pressure tanks, liquefied petroleum gas tanks, anhydrous-ammonia tanks, and fired steam boilers that are inspected periodically in accordance with California Unfired Pressure Vessel Safety Orders or Boiler and Fired Pressure Vessel Safety Orders. The responsible designer shall notify Plant Engineering Maintenance & Operations (M&O) and facility management whenever such systems are installed.

The LLNL Pressure Safety Program is administered and monitored by the Hazards Control Department through the pressure safety manager. Responsible Individuals shall conduct all pressure work safely in accordance with the *ES&H Manual*. The pressure safety manager oversees the work of pressure installers and pressure inspectors and coordinates all pressure safety training. The Mechanical Engineering Department's Safety Committee and the pressure safety manager provide technical guidance for the program. In addition, pressure consultants are available to help on pressure safety design and to answer engineering questions.

2.0 Hazards of Pressure Systems

The hazards presented to personnel, equipment, facilities, the public, or the environment because of inadequately designed or improperly operated pressure or vacuum systems include blast effects, shrapnel, fluid jets, release of toxic or asphyxiant materials, contamination, equipment damage, personnel injury, and death.

3.0 Controls for Working with Pressure Systems and Vessels

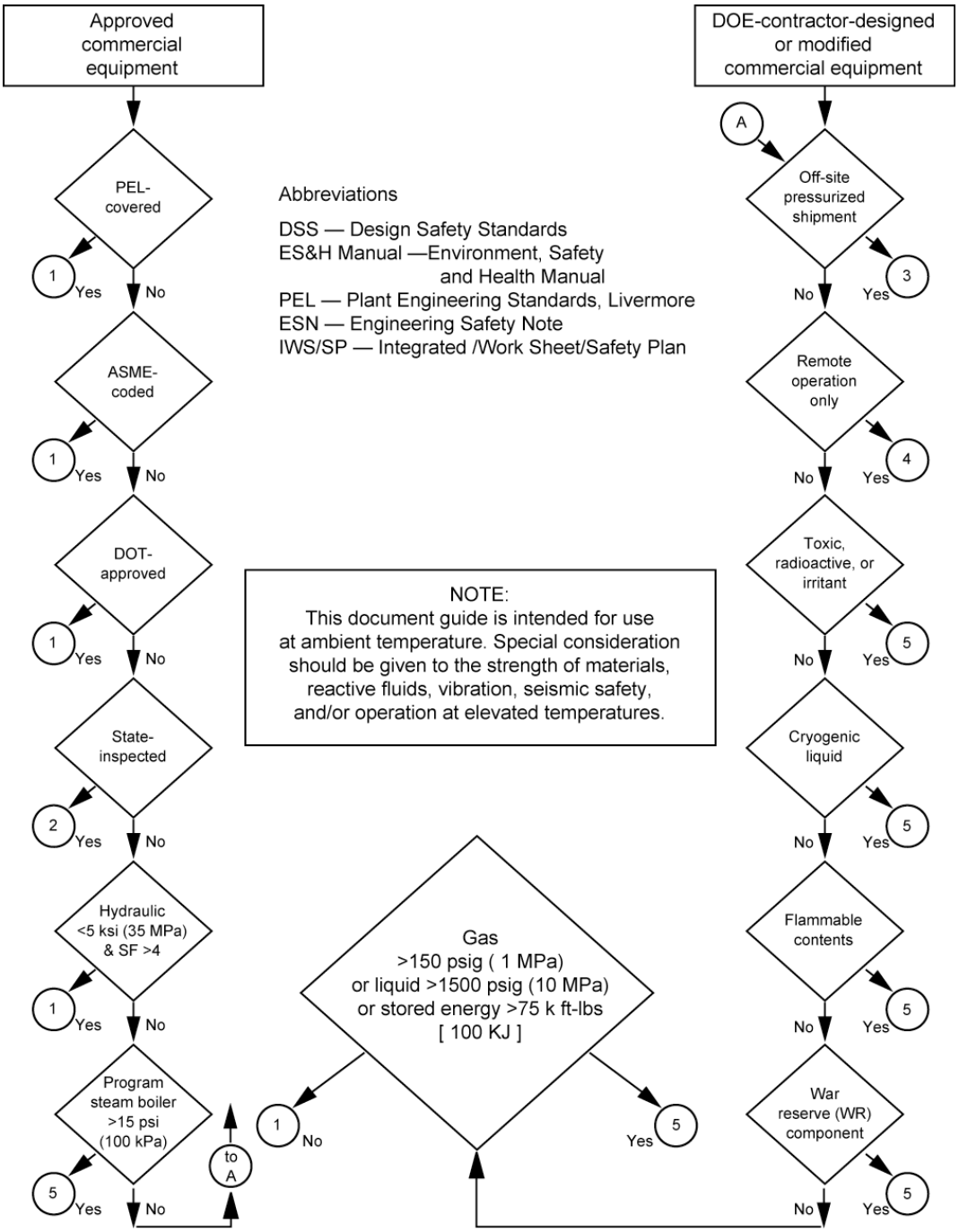
3.1 Design and Documentation

Pressure vessels and systems shall be designed and documented in accordance with the requirements in this document and in Document 18.2 (see Fig. 1). For example, gas systems with 1 MPa (≥150 psig) or liquid systems with 10 MPa (≥1500 psig) shall have an Engineering Safety Note (ESN). An ESN (or equivalent) is required as part of the documentation for most manned-area vessels and for all systems that handle toxic or corrosive materials.

3.2 Installation and Equipment

Installation. A pressure installer is authorized to assemble and install pressure equipment within a specified pressure range in accordance their training (see Sections 4.7 and 5.0). Systems that require an ESN shall be assembled by a pressure installer. This individual may also closely supervise systems assembled by an installer-in-training.

Equipment. Low- and intermediate-pressure fittings, pipes, tubing, valves, and gauges are available from commercial vendors. High-pressure components are available from the Mechanical Engineering (ME) High-Pressure Test Facility in B343. These items will be issued only to, or with written approval of personnel on the most current list of "Authorized Individuals for Pressure Work."(This list is maintained by the pressure



1. No ESN or IWS/SP is required (documented hazards are low). Go to "A."
2. No ESN or IWS/SP is required, but notify PE M&O and facility management. Go to "A."
3. Approved DOT and/or DOE shipping containers that comply with LLNL shipping requirements.
4. No ESN is required for the pressure equipment. Comply with Chapter 4 of the ME Design Safety Standards. An IWS/SP may be required (see Document 3.3, " Facility Safety Plans & Integration Work Sheets with Safety Plans," in the *ES&H Manual*.
5. An ESN, and/or IWS/SP is required, or you should follow PEL-M-13200.

Figure 1. LLNL Documentation guide for pressure safety.

safety manager and is updated annually.) Any pressure equipment reclaimed from another organization shall be inspected and approved by a pressure inspector before use in a pressure system. See Appendix B for information on regulators and manifolds.

3.3 Pressure Testing and Labeling

Pressure Testing. All pressure vessels or systems that require an ESN shall be pressure tested remotely before being used in a manned area. (See Document 18.3, for detailed testing procedures). Tests shall be observed or conducted by a pressure inspector.

Upon request, the pressure inspector will test, retest, or reinspect vessels and systems even though they may not be due for periodic reinspection or retesting.

Labeling. Each tested pressure vessel or system that requires an ESN shall have an "LLNL Pressure Tested" label (see Fig. 2).

Any vessel or system that does not qualify for operation in a manned area shall have a "For Remote Operation Only " label (Fig. 3) and an "LLNL Pressure Tested for Remote Operation Only" label (Fig. 4). These labels indicate that the system shall only be operated from behind certified barricades or outside a test cell and shall only be affixed to the equipment by pressure inspectors. This requirement is intended to prevent injury to personnel in the event of a pressure vessel or system failure.

3.4 Pressure Equipment Operation

An IWS/SP may be required for equipment used with hazardous material. Contact your area ES&H Team for guidance if necessary.

Pressure operators or Responsible Individuals have ultimate responsibility for the safe operation of pressure equipment. In addition, they shall ensure the following precautions are observed:

- A system or vessel is not operated until the operator reads and demonstrates an understanding of all applicable ESNs, IWS/SPs, and other related procedures.
- Individuals have a basic understanding of this document prior to operating systems containing gas cylinders.
- Flammable, radioactive, irritant, toxic materials, or oxygen is not used in systems unless specifically evaluated and approved for such use.

Pressure Safety Labels and Tags

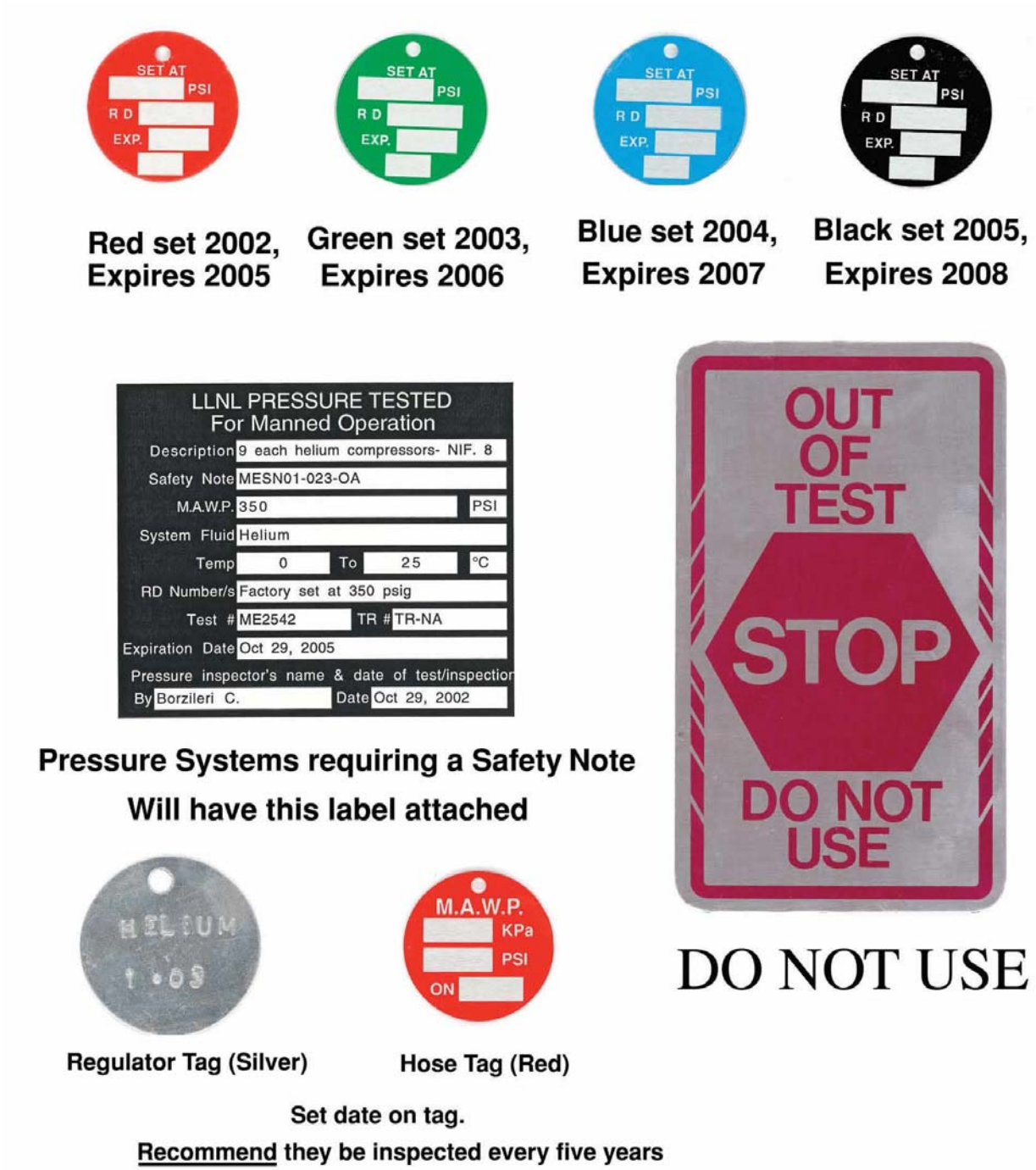


Figure 2. LLNL Pressure tested label for manned area (silver on black).

Figure 3. LLNL Remote operation label (silver on red).

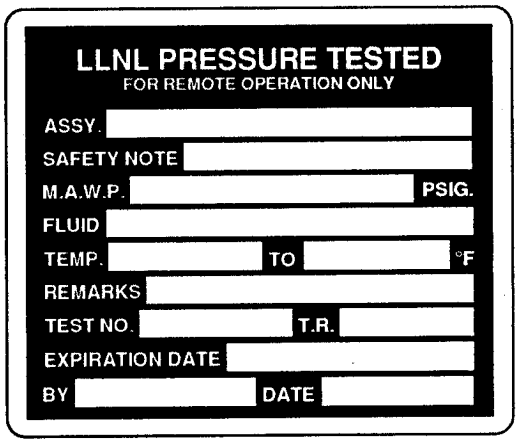


Figure 4. LLNL pressure tested remote operation only label (silver on red).

- Flammable gas is not used with oxygen or compressed air unless there is a flash arrestor in the gas line and a check valve in the oxygen or air line. Pressurized oxygen and air (because of oxygen content) can react explosively with organic materials and flammable gases.
- The pressure source is limited to the MAWP of the system or a properly set relief device with sufficient flow capacity is installed between the source and the system. (See Document 18.2 for detailed requirements on relief devices.)
- Relief devices are set or retested only by authorized personnel from the Plant Engineering Instrument Shop (Bldg. 511 or 875), the ME High-Pressure Test Facility in B343, or by a Pressure Inspector. Unless otherwise noted in the ESN, these devices shall be set or retested every three years. The pressure operator or Responsible Individual initiates and ensures this requirement is met. All relief devices require documentation.
- When opening a valve to a pressure source, do not stand directly in front of any pressure gauges, especially non-safety types of pressure gauges.
- Work is not done on pressurized components unless the method is approved in an IWS/SP or is specifically authorized, in writing, by the authorizing organization Division Leader or a person of equivalent or higher authority.
- The pressure in the equipment is vented before removing a hose (lock out and tag practices from Document 12.6, "LLNL Lockout/Tagout Program," in the *ES&H Manual* apply, when applicable). Then, leaving the vent valve open, and starting at the pressure-source end, ensure that both ends of the hose are

disconnected before removing the hose restraints. In case of accidental pressurization, this method prevents "whipping" while the hose is partially disconnected. Hose ends should be bagged to keep them clean and free of insects when in storage.

- The high-pressure hose is assembled, installed, tested, and tagged by authorized personnel, and reinspected every six years.
- The ESN is revised and the system is retested or inspected by a pressure inspector when any modification is made to a pressure system that initially required an ESN. A revision to the ESN is not required when replacement is made with identical or equal components.

3.5 Maintenance

Pressure operators or Responsible Individuals shall ensure the following:

- Pressure equipment under their control is maintained properly.
- Relief devices are operational, properly labeled, and within the expiration date. Relief devices that are activated by anyone other than a pressure inspector shall be checked immediately and reset only by authorized personnel (see Section 4.0, "Responsibility," of this document).
- Worn or defective components are repaired or replaced only by a pressure installer (or a supervised installer-in-training) and checked by a pressure inspector. Any modification, other than the repair or duplicate replacement of components, shall be reflected in the revised ESN. In addition, replaced and new components shall be pressure tested. This test shall be performed at the initial test pressure of the system or vessel. Components may be tested independent of the system at proof pressure, then installed and leak-checked at the MAWP.
- Equipment not in use is removed or properly stored in place in accordance with the requirements of Document 12.6. Such equipment is re-evaluated at the end of one year.
- The "Lockout/Tagout Program" is used when an unexpected pressurization or release of stored energy could cause injury to workers.

3.6 Inspection and Retesting

All pressure vessels or systems designed for operation at LLNL that require documentation shall be pressure tested remotely before being operated in a manned area. Once tested, an LLNL pressure tested label shall be attached to the pressure vessel

or system. Documented and labeled pressure vessels or systems and their integral pressure-relief devices shall be maintained by the Responsible Individual and inspected by a qualified independent LLNL pressure inspector every three years as recommended by the National Board Inspection Code (NBIC). Inspection intervals for pressure vessels will be determined using in-service inspection criteria in the NBIC inspection code. Depending on the type of vessel service, the intervals may range from two years to a maximum of ten years. Relief devices on pressure vessels shall be inspected every three years. In addition, pressure systems and vessels will be reinspected before reuse whenever they are disassembled/moved or redesigned, or when the application changes, even if the working pressure is reduced.

3.7 Storage and Disposition

Whenever practical, the pressure from a system or vessel to be placed in storage shall be vented (leave a small residual pressure to keep the system clean and dry). If this is not possible, the system or vessel shall be clearly labeled to show its pressure and pressurizing fluid, and be labeled "Out of Test. Do Not Use." The ME High-Pressure Test Facility in B343 or the pressure safety manager shall be notified before disposal of a pressure vessel or system with a LLNL pressure label. For further guidance, see Appendix C, "Compressed Gas Cylinder Return and Disposal Procedure Flowchart."

3.8 Compressed-Gas Cylinders

All systems in manned areas that consist of unmodified, DOT-approved, compressed gas cylinders and the appropriate regulators may not require an ESN (see Fig. 1). Compressed gas cylinders are the most common source of gas for many operations. As a precaution, these cylinders shall be adequately secured when in use or storage. C-clamps and straps are considered a temporary measure (30 days or less).

The DOE, ASME, DOT, and OSHA all refer to the Compressed Gas Association (CGA) Pamphlet (CGA P-1, 1991) for instruction on how to safely handle compressed gas cylinders. The precautions below are from the CGA Pamphlet and shall be followed at LLNL.

Handling

- Use a four-wheel cylinder cart for moving Standard No. 1 and larger gas cylinders. These cylinders are difficult to move manually because of their shape, smooth surface, and weight.
- Make sure that the protective valve cover is in place when a cylinder is not connected to a regulator or manifold.
- Mark partial cylinders with the remaining product pressure.

- Always assume a cylinder is pressurized; handle it carefully and avoid bumping or dropping. Never drop cylinders from trucks or any raised surface to the ground.
- Lifting a standard cylinder, or any cylinder weighing more than 50 pounds, requires two people. Never lift a cylinder by the cylinder cap.
- Do not handle oxygen cylinders with greasy, oily hands or gloves. *The reaction between oxygen and hydrocarbons can be violent, even when small quantities are involved.*
- Secure cylinders in suitable cradles or skid boxes before raising them with cranes, fork trucks, or hoists. Do not use ropes or chain slings alone for this purpose.
- Never use a gas cylinder as a roller for moving materials or for supporting other items.

Storage

General Practices. Cylinders are sometimes shipped tied horizontally on wooden pallets, individually contained by saddle blocks, and double-banded to prevent rolling and sliding. These are *not* recommended methods for cylinder storage. Instead, the work practices prescribed in this section shall be followed (from Pamphlet CGA P-1, 1991):

- Store adequately secured cylinders upright on solid, dry, level footings, preferably outside of occupied buildings and away from traffic lanes.
- Shade cylinders stored in the sun during the summer, whenever possible.
- Store cylinders away from sources of intense heat (furnaces, steam lines, radiators).
- Do not stockpile gas, especially flammables, poisons, or corrosives, beyond the amount required for immediate use. Consider direct delivery from the Industrial Gas Cylinder Dock. At LLNL, delivery time for most gases is usually about two working days.
- Limit the use and storage of poisons and corrosives to less than one year to prevent stockpiling. Documentation will be required for these materials (see Fig. 1). The area ES&H Team industrial hygienist will establish and document the maximum quantities of such materials in use and storage to ensure reasonable turnover. The Emergency Preparedness Group will track the materials as an element of its Emergency Response Planning Program. Extended use or storage of hazardous materials will be negotiated and documented by the user, the industrial hygienist, and the Emergency Preparedness Group.

- Ensure that containers stored or used in public areas are protected against tampering and damage. Furthermore, containers stored inside or outside shall not obstruct exit routes or other areas that are normally used or intended for the safe exit of people.
- Always store cylinders with the protective caps in place.
- Use a storage basket for smaller cylinders (<5 L). These baskets are available commercially.

Posting and Hazard Identification. The hazard classification or the name of the gases being stored shall be prominently marked in container storage areas, and "NO SMOKING" signs shall be posted where appropriate.

Placards, container labels, and markings provide available information on the products involved. The material safety data sheet (MSDS) for the product(s) or other recognized emergency response guides should be consulted for the specific hazards, safety precautions, and related emergency response information.

Adequately Secured. All compressed gas cylinders in service or storage at the user's location shall be secured to prevent them from falling. Gas cylinders with a water volume of less than 5 L (305 cubic inches) may be stored in a horizontal position, as long as they are prevented from rolling, and will be considered to be adequately secured. Since 1980, cylinder and manifold racks have been fabricated, purchased, or equipped with two chains whenever possible. If available, both chains shall be used to secure these cylinders.

Cylinder Storage Sheds. Cylinder storage sheds and delivery sheds are not equipped with double chains. Thus, cylinders shall be adequately secured with individual restraining bars or chain restraints (1/4-in. welded chain and safety clips preferred). The rails on which the restraining bars slide shall be pinned and secured to the shed to prevent the bars from sliding off.

Compatibility. Cylinders shall be separated by compatibility of contents. For example, oxidizers shall be kept separate from combustibles or flammables by a minimum distance of 20 ft or by a non-combustible barrier that is at least 5 ft high with a fire-resistance rating of at least one-half hour. Your ES&H Team fire protection engineer or industrial hygienist can provide compatibility evaluations.

Corrosive and Toxic Gases

Many gases used throughout industry have additional hazards other than those of fire, asphyxiation, or oxygen enrichment. Exposure to some gases may present serious hazards to unprotected personnel. Before using a corrosive, toxic, or highly toxic gas, read the label and MSDS for the specific gas. Personnel working in the immediate area

where exposure to these gases is possible shall be informed on their hazards. Exposure to these gases shall be kept as low as possible, but in no case should concentrations exceed OSHA exposure levels or the current ACGIH threshold limit values (TLV) set by the American Conference of Governmental Industrial Hygienists (ACGIH). Contact your area ES&H Team industrial hygienist for information on these exposure limits.

See Document 14.3, "Toxic, Corrosive, or Reactive Gases," in the *ES&H Manual* for requirements and precautions for using and storing corrosive and toxic gasses.

Inspection

- Inspect hoses and manifolds frequently, and replace worn hoses and connections. Contact the Plant Engineering Instrument Shop (Bldg. 511) for hose or connector replacements.
- Report leaking cylinders that contain hazardous materials to the emergency dispatcher (dial 911 at Livermore or Site 300). Evacuate the area until the emergency response team arrives.
- Contact your area ES&H Team before handling faulty or corroded cylinders; these cylinders should be segregated. CAUTION: Only the vendor shall alter or repair cylinders or cylinder valves.

General Precautions

- Secure both ends of the hose with a hose restraint to prevent whipping in the event the hose or fitting fails. For systems in manned areas, support and secure the hose and tubing at least every 7 ft.
- Do not use an open flame to leak-check a gas cylinder; use soapsuds or a leak-detection solution.
- Remove the talc and dust from a new hose before connecting it.
- Do not use white lead, oil, grease, or any other non-approved joint compound to seal the fittings on an oxygen system; a fire or an explosion could occur if oxygen contacts such materials. Threaded connections in oxygen piping should be sealed with solder, glycerin, or other sealants approved for oxygen service. Gaskets shall be made of noncombustible materials. For additional information, contact the Plant Engineering Instrument Shop (Bldg. 511) or the High Pressure Test Facility in B343.
- Never interchange regulators and hose lines (with one type of gas for another). Explosions can occur if flammable gases or organic materials come in contact with oxidizers (e.g., oxygen) under pressure.
- Never use oxygen to purge lines, operate pneumatic tools, or dust clothing. Remember, oxygen is *not* a substitute for compressed air.

- Do not transfer or mix gases in commercial vendor- or Laboratory-owned DOT cylinders, or transfer gases from one DOT cylinder to another. The ME High-Pressure Test Facility is authorized to mix gases in distinctly marked Laboratory-owned cylinders. Anyone other than personnel from the ME High-Pressure Test Facility shall obtain approval from the pressure safety manager for filling or mixing gases in Laboratory-owned cylinders. Commercial gas mixtures are available through the MDD Industrial Gas Section of the Supply and Distribution Department.
- Do not use vendor-owned cylinders for purposes other than as a source of gas. These cylinders may only be pressurized by the owner.
- Do not strike a welding arc on a cylinder.

Operation

- Before installing a regulator on a compressed gas cylinder, vacuum the valve port clean or crack the valve gently to expel any foreign material. Do not *perform this task* if *the gas in the cylinder is toxic, reactive, or flammable.*
- After installing the regulator and before opening the cylinder valve, fully release (turning counterclockwise) the regulator pressure-adjusting screw.
- Open the cylinder valves slowly. Never use a wrench on a cylinder valve that will not rotate manually. Stand clear of pressure regulator gauge faces when opening the cylinder valves. If the valves are defective, return the cylinder to the MDD Industrial Gas Section.
- Keep removable keys or handles from valve spindles or stems in place while the cylinders are in service.
- Never leave pressure on a hose or line that is not being used. To shut down a system, close the cylinder valve and vent the pressure from the entire system.

Empty Cylinders

- Leave some positive pressure (a minimum of 20 psig) in empty cylinders to prevent "suck-back" and contamination.
- Close the valves on empty cylinders to prevent internal contamination; remove the regulators and replace the protective cap.
- Use a cylinder status tag to indicate whether the cylinder is "FULL," "IN SERVICE," or if it has "RESIDUE." This tag is to be installed by the MDD Industrial Gas Section and shall remain on the cylinder.
- Store empty cylinders separately from full cylinders.

- Properly label and dispose of cylinders. See Appendix C for guidance or contact the pressure safety manager for a complete set of the procedures, if necessary.
- Call the MDD Industrial Gas Section to pick up cylinders that are no longer needed.

Identification and Color Coding

Stencils, DOT shoulder labels, cautionary side-wall labels, or tags are used to identify the contents of all gas cylinders at LLNL. Do not remove these labels without specific authorization from the MDD Industrial Gas Section. Color codes are not used to identify contents.

3.9 Compressed Air Safety

Compressed air for general shop or laboratory use shall be limited to a maximum pressure of 207 kPa (30 psig) using restricting nozzles (supply pressure from regulator to nozzle can be up to 700 kPa [100 psig]; the nozzle reduces pressure). Compressed air at a full-line pressure of up to 700 kPa (without the use of restricting nozzles) may be used only to operate pneumatic tools and certain control instruments.

Observe the following safety rules when using compressed air:

- Do not use compressed air to clean clothing; the air jet tends to drive particles into the fabric, where they can cause skin irritation. Keep a clothes brush handy or, preferably, wear a lab coat.
- Be sure no one is in the path of the air stream when using compressed air to dry mechanical parts. Always wear goggles or a face shield to protect your eyes.
- Do not use air pressure to transfer liquids from containers with unknown MAWPs. Use a siphon with a bulk aspirator or a pump instead. If a standard 208-L (55-gal.) drum is pressurized to 100 kPa (15 psig), the force exerted on the head of the drum is about 25 kN (3 tons). This is not an acceptable practice.
- Limit the transfer pressure of liquid nitrogen dewars to 100 kPa (15 psig).
- Never apply air pressure to the body.
- Unless an automatic shut-off coupling is used, attach a short chain (or equivalent) between a hose and an air-operated tool to prevent whipping in the event the coupling separates.

- Unless an automatic shut-off coupling is used, vent the pressure in an air line before changing the nozzles or fittings.
- Use Grade D breathing air. This type of air has been specifically approved by the Respirator Services Group (Bldg. 255) of the Hazards Control Department. Regular compressed air contains oil and other contaminants.
- Do not substitute compressed oxygen for air. Clothing saturated with oxygen burns explosively.

4.0 Responsibilities

All workers and organizations shall refer to Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *ES&H Manual* for a list of general responsibilities. This section describes specific responsibilities of LLNL organizations and workers who have key safety roles. This section describes the responsibilities of individuals involved in the LLNL Pressure Safety Program.

4.1 Management

Management shall ensure that pressure work performed by their personnel comply with the safety requirements of this document.

4.2 Department Head/Program Leader

Each department or program that works with pressure equipment shall assume an active role in the LLNL Pressure Safety Program. This involves the following:

- Assigning qualified personnel to perform the functions described in this document.
- Writing, reviewing, approving, and distributing ESNs (ensuring design adequacy) and IWS/SPs (ensuring safe operation) as required.
- Properly designing, assembling, installing, inspecting, labeling, operating, and maintaining pressure vessels and systems.

4.3 Pressure Safety Manager

The Pressure Safety Manager administers the LLNL Pressure Safety Program through the Hazards Control Department. He/she is also responsible for the following:

- Developing and implementing pressure safety classes.
- Requalifying Pressure Consultants, Inspectors, and Installers.
- Documenting and keeping records of pressure vessels and systems and of personnel authorized to work with such systems.
- Inspecting or retesting pressure vessels and systems.
- Reviewing IWS/SPs for pressurized vessels and systems.
- Providing guidance on establishing requirements and procedures for the LLNL Pressure Safety Program.
- Reviewing Lessons Learned applicable to pressure safety operations, both from inside LLNL and from external sources, to develop potential improvements to the LLNL Pressure Safety Program.
- Conducting self-assessments of the LLNL Pressure Safety Program. These assessments are separate from Directorate Self-Assessment programs, and do not conflict with them.

4.4 Pressure Consultant

Pressure Consultants can be LLNL engineers or scientists with the experience and knowledge necessary to perform the job. They are appointed by their Payroll Division Leader and approved by the Payroll Department Head. The appointment is documented in a memorandum, which is forwarded to the pressure safety manager. Pressure consultants are authorized to approve pressure designs, calculations, and requisitions or requests pressure equipment. All pressure work done in, by, or for a department or program is subject to the critical review and approval of a pressure consultant.

To qualify as a pressure consultant at LLNL, one shall satisfactorily complete courses HS5030, HS5050, and HS5060 and repeat course HS5101 every 3 years. See Section 5.0 for course numbers and titles.

4.5 Responsible Designer

A responsible designer designs pressure vessels and/or systems and prepares any required ESNs. He/she shall complete courses HS5030, HS5050, and HS5060. The Payroll Division Leader shall provide a written exemption for anyone released from

taking courses HS5050 and HS5060. This document is kept in the pressure safety manager's files.

Notify the affected facility management when planning to install a pressure system.

4.6 Pressure Inspector

A pressure inspector is one who is trained and qualified to inspect pressure equipment. He/she is normally assigned to work within a specific area of LLNL and is accountable to the pressure consultants in that area. While responsible for conducting, observing, and certifying pressure tests as directed by the responsible designer, the pressure inspector is also expected to provide technical guidance to pressure installers and installers-in-training.

To qualify as a pressure inspector, one shall do the following:

- Satisfactorily complete courses HS5030, HS5040, and HS5050 (see Section 5.0 for course numbers and titles).
- Be appointed by the pressure safety manager.
- Satisfactorily complete courses HS5070 and HS5071, as required.
- Be able to perform re-inspections and re-tests to maintain qualification as a pressure inspector.

4.7 Pressure Installer

A pressure installer is one who is qualified to assemble, install, and operate pressure equipment within a specified pressure range. When assigned by management, the pressure installer is authorized to work directly for a responsible designer.

To qualify as an installer, one shall do the following:

- Satisfactorily complete courses HS5030, HS5040 (for low and intermediate pressure installers), and HS5050 (for high pressure installers), and HS5090. In addition, re-qualification course HS5091 is required every 3 years. See Section 5.0 for course numbers and titles.
- Be certified by the payroll supervisor and the Payroll Division Leader. Certification shall ensure that the installer has had the equivalent of at least one year's experience working with pressure equipment within a specified pressure range.

4.8 Installer-In-Training

To qualify as an installer-in-training, one shall complete courses HS5030 and HS5040, and HS5050 (if applicable), and be in the process of becoming qualified as a pressure installer. The installer-in-training can be assigned to work for a responsible designer or pressure installer, or by a payroll supervisor who is directly in charge of the pressure work.

4.9 Pressure Operator

A pressure operator is one who is responsible for ensuring the proper operation, maintenance, inspection, and re-testing of a pressure system that requires an ESN.

To qualify as a pressure operator, one shall satisfactorily complete courses HS5030 and HS5040, and HS5050 for high pressure operations. See Section 5.0 for course numbers and titles.

> **The pressure operator is not authorized to install or modify equipment unless he/she is also a pressure installer.**

5.0 Training

5.1 Required courses

Below are the courses required for individuals who work with pressure systems. For more detailed information, refer to Fig. 5 of this document, the *LLNL Course Catalog,* or contact the Hazards Control Safety, Education, and Training Section.

*HS5030-W Pressure Safety Orientation.

*HS5031-W Pressure Safety Requalification.

*HS5040-W Intermediate-Pressure Safety.

*HS5050-W High-Pressure Safety.

*HS5060-W Pressure Seminar for Engineers.

HS5070 Pressure Inspector Training.

HS5071 Pressure Inspector Re-qualification.

HS5090 Pressure Installer Test.

HS5091 Pressure Installer Re-qualification Training.

HS5092 Intermediate-Pressure Installer Training—0 to 5000 psi.

HS5093 High-Pressure Installers Training—5,000 psi and above.

HS5101 Pressure Consultant Re-qualification.

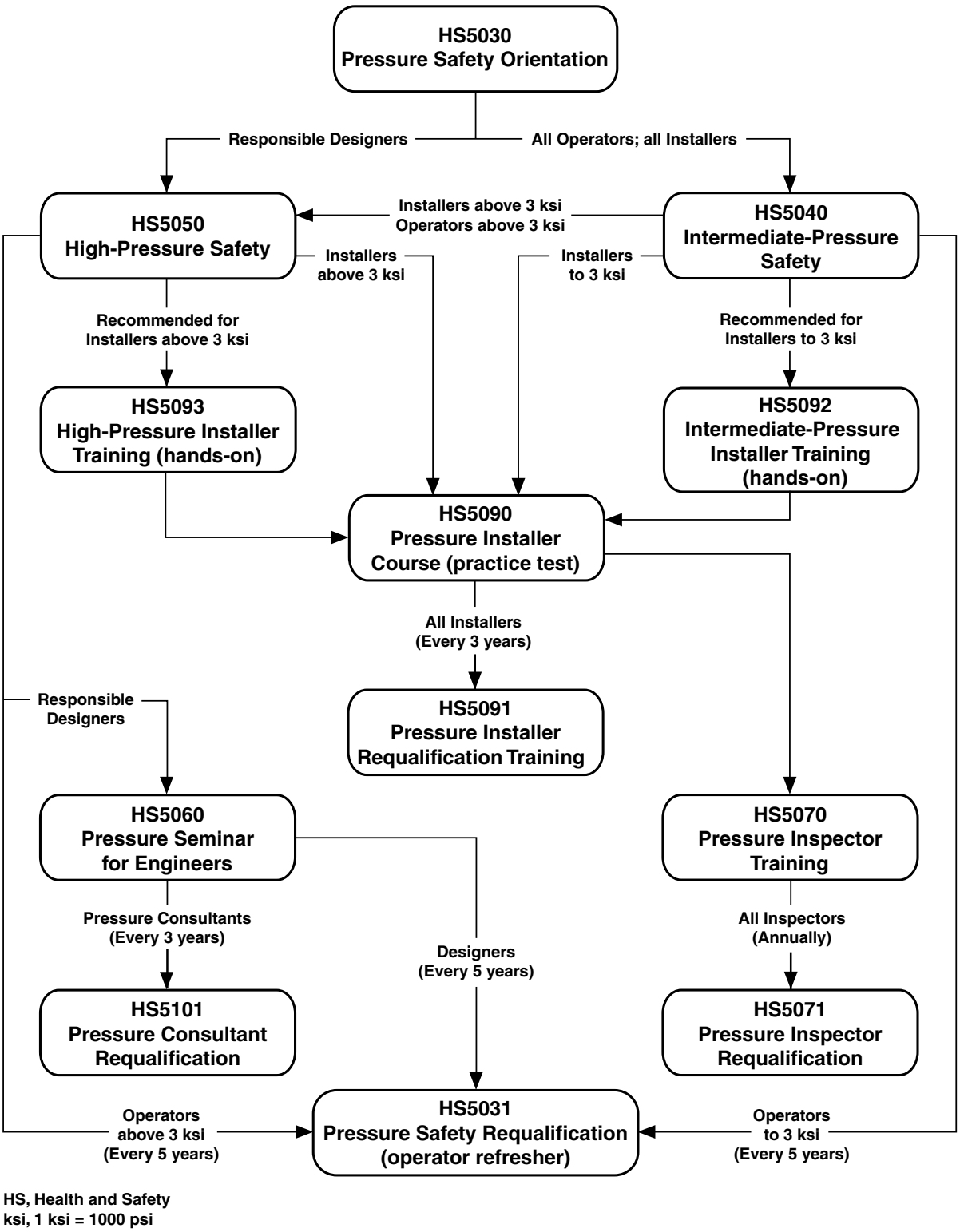


Figure 5. LLNL pressure safety training requirements.

5.2 Course Enrollment

To enroll in any of the above classroom courses, applicants enroll on-line or complete a Course Registration Form and send it to the Hazards Control Training Coordinator. CBT classes are by appointment only, contact ext. 31094.

*ES&H web training available at

http://www-hctrain.llnl.gov/

Course completions are recorded in LTRAIN.

6.0 Work Standards

6.1 Work Smart Standards

8 CCR §§ 450–560, "Unfired Pressure Vessel Safety Orders (Propane Tanks, Air Receivers)."

8 CCR §§ 750-797 and Appendices 1 & 2, Boiler & Fired Pressure Vessel Safety Orders.

29 CFR 1910.101, Compressed Gases General Requirements.

29 CFR 1910.103, Hydrogen.

29 CFR 1910.110, Storage and Handling of Liquified Petroleum Gases.

29 CFR 1910.132, Subpart I, Personal Protective Equipment.

29 CFR 1910.146, Permit Required Confined Spaces.

29 CFR 1910, Subpart J, General Environmental Controls.

29 CFR 1910, Subpart M, Compressed Gas and Compressed Air Equipment.

29 CFR 1910, Subpart O, Machinery & Machine Guarding.

29 CFR 1910, Subpart Q, Welding, Cutting, and Brazing.

49 CFR 100–199, Research and Special Programs Administration, DOT (Off-site).

ACGIH TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents, 1998 (excluding TLVs for Chemical Substances, Ergonomics, Ionizing Radiation, and Lasers).

ANSI Z21.13-1999, Gas-Fired Low-Pressure Steam and Hot Water Boilers.

ANSI/B 31.1, *Power Piping, ASME Code for Pressure Piping,* 1995.

ASME Boiler & Pressure Vessel Codes, Section I, "Boilers," 1998.

ASME Boiler & Pressure Vessel Codes, Section VIII, "Div. 1 & 2 Rules for Construction of Pressure Vessels," 1998.

Compressed Gas Association (CGA) Pamphlet P-1, *Safe Handling of Compressed Gases in Containers*, 1991.

Compressed Gas Association (CGA), Pamphlet P-12, *Safe Handling of Cryogenic Liquids*, 1993.

Compressed Gas Association (CGA) Pamphlet S-1.1, *Pressure Relief Device Standards, Part 1 Cylinders for Compressed Gases*, 1991.

DOE M 440.1-1, *DOE Explosives Safety Manual* (including DOE Explosives Safety Committee approved changes through May 2002).

NFPA 45, *Standard on Fire Protection for Laboratories using Chemicals,* 1996 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work* 1999 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquified Gases in Portable Cylinders*.

Public Law 91-596, § 5 (a) (1), OSHA Act of 1970.

UCRL-AR-128970 *LLNL Pressure Safety Standard*.

Uniform Mechanical Code, 1997.

Uniform Plumbing Code, 1997.

7.0 Resources for More Information

7.1 Contacts

For more information about the topics discussed in this document, contact the Hazards Control Department or the pressure safety manager (link ES&H Contact List).

7.2 Applicable Lessons Learned

Refer to the list of Lessons Learned at the following website:

http://www-r.llnl.gov/es_and_h/lessons/lessons.shtml

7.3 Other Sources

29 CFR 1910, Labor, General Industry Standards.

29 CFR 1926, Labor, Construction Standard.

49 CFR 173, Shippers—General Requirements for Shipping and Packaging.

Borzileri, C. and Traini, M., *LLNL Pressure Safety Program*, Lawrence Livermore National Laboratory, CA, ENS 92-06, 1992.

Borzileri, C., *Authorized Individuals for Pressure Work*, Lawrence Livermore National Laboratory, CA, 1998.

Borzileri, C., *Compressed Gas Cylinder Return and Disposal Procedure*, Lawrence Livermore National Laboratory, CA, 1993.

Borzileri, C., *Design and Documentation Guide for Toxic Gas-Handling Manifolds and Gas Cabinets*, Lawrence Livermore National Laboratory, CA, 1988.

Borzileri, C., *Engineering Safety Notes for Pressure Vessels and Systems [a guide]*, Lawrence Livermore National Laboratory, CA, 1989.

DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," Attachment 2, "Contractor Requirement Document," Sections 1-11, 13-18 (delete item 18.a), 19 (delete item 19.d.3) and 22.

Mechanical Engineering Design Safety Standards, Lawrence Livermore National Laboratory, Livermore, CA, M-012 (latest version).

Searle Medical Products USA, Inc., *Gas Data Book*, 6th ed., Matheson Division, Lyndhurst, NJ 07071.

U.S. Department of Energy, *Pressure Safety Guidelines Manual*, Washington, D.C., December 1993.

Appendix A

Terms and Definitions

Engineering safety note (ESN)	An engineering safety note is a management-approved (by division leader or higher) document that describes the anticipated hazards associated with a piece of equipment or a process. It describes the responsible individual's approach, analysis, and rationale used to assure the design safety of the equipment, system, or process. An ESN does not have to be prepared by a member of the Engineering directorate as long as the individual is technically qualified to prepare the ESN. Mechanical Engineering and Electronics Engineering Safety Notes are assigned a safety note number by the Engineering Records Center where a copy is kept on file. The designations for safety notes are as follows: MESN = Mechanical Engineering Safety Note (signed by an ME Division Leader) EESN = Electrical Engineering Safety Note (signed by an EE Division Leader) LLSN = LLNL Safety Note (signed by a non-Engineering Division Leader) The LLSN designation was established to permit institutional (non-Engineering Directorate) safety notes to be assigned a document number by the Engineering Records Center and archived there (optional).
Engineering safety note equivalent	A file or drawing that includes properly approved design and additional information contained in an ESN.
High pressure	Gas pressures greater than 21 MPa gauge, (3000 psig); liquid pressures greater than 35 MPa gauge (5000 psig).
Intermediate pressure	Gas pressure from 1 to 21 MPa gauge (150 to 3000 psig); liquid pressure from 10 to 35 MPa gauge (1500 to 5000 psig).
Leak test or check	A pressure or vacuum test to determine the existence, rate, and/or location of a leak.

Low pressure	Gas pressures less than 1 MPa gauge (150 psig); liquid pressures less than 10 MPa gauge (1500 psig).
Manned-area vessels/ systems	Pressurized vessels or systems approved for operation within specified limits and with personnel present.
Maximum allowable working pressure (MAWP)	The maximum pressure at which a vessel or system is designed to operate safely. This is also the basis for all pressure testing. Working pressure, rated pressure, service pressure, and design pressure are the same as the maximum allowable working pressure. *Do not exceed this pressure when setting vessel or system pressure-relief devices.*
Maximum operating pressure (MOP)	The maximum pressure at which a vessel or system is normally operated—usually 10 to 20% below the MAWP.
Pressure system	An assembly of pressure components that performs an intended function.
Pressure test	A test that ensures • A vessel or system will not fail or permanently deform. • The vessel or system will operate reliably at a specified pressure.
Pressure vessel	A relatively high-volume pressure component (such as a spherical or cylindrical container) that has a cross section larger than the associated pipe or tubing.
Remote operation	A pressure operation that shall not be conducted with personnel present. The equipment shall be installed in test cells, behind certified barricades, or be operated from a safe location. Unless otherwise specified in an ESN, manned-area operations of a remote operation vessel or system are limited to a maximum pressure of 20 percent of the previously attained MAWP or test pressure.

Appendix B

Regulators and Manifolds

The distribution systems of gas cylinders consist of regulators and manifolds. For a cylinder to be effective and safe, regulators must take in gas from the supply system and reduce the pressure to a lower working pressure while simultaneously controlling the flow rate. It is important to obtain the correct regulator and ensure it is consistent with the gas involved and the operation intended. Manifolds distribute and control the gas flow from regulators.

B.1 Regulators

Following are LLNL requirements for regulators:

- Regulators should be taken to authorized personnel in the Plant Engineering Instrument Shop (Bldg. 511), the ME High-Pressure Test Facility (Bldg. 343), or to Site 300 (Bldg. 875) for inspection, adjustment, and tagging.
- For temporary storage, used regulators shall be labeled and placed in plastic bags to keep them clean.
- Supervisors should make periodic surveys of their areas for surplus regulators. These regulators should be sent to the Plant Engineering Instrument Shop (Bldg. 511) to be examined, cleaned, adjusted, repaired, and tagged.
- Only the Plant Engineering Instrument Shop (Bldg. 511) or authorized personnel can alter, adjust, or repair regulators. Any regulator reapplied to an oxygen cylinder shall be degreased by the Plant Engineering Instrument Shop or by authorized personnel.
- When a regulator is removed from flammable, toxic, or radioactive systems, all hazardous gases shall be safely vented (and purged if required) from the regulator assembly.
- Only regulators that are designed and approved for a specific gas and cylinder shall be used. Make sure that the threads on regulators correspond to those on the cylinder-valve outlet. Never force connections that do not fit. Use only oxygen regulators for oxygen service.
- All damaged, defective, or unreliable regulators shall be replaced immediately.
- Line regulators are only permitted for in-line installations up to a maximum pressure of 1 MPa (150 psig).

- Single-stage cylinder regulators (except acetylene regulators) shall be equipped with a single-relief device that is set to open at a value below the highest graduation on the low-side gauge. These regulators are adjusted to limit the output pressure to 75% of the highest output-gauge reading.
- Two-stage regulators for inert gas are equipped with two relief valves that protect the regulator diaphragms and gauges from excessive overpressure. Relief valves on regulators used with flammable, toxic, or radioactive gases shall be safely vented.
- Two-stage regulators shall be adjusted so that the output pressure does not exceed 75% of the highest output-gauge reading. The low-side relief valve is set to open at a value below the highest graduation on the low-side gauge.
- It is recommended that regulators be inspected every five years, but this is not a requirement.

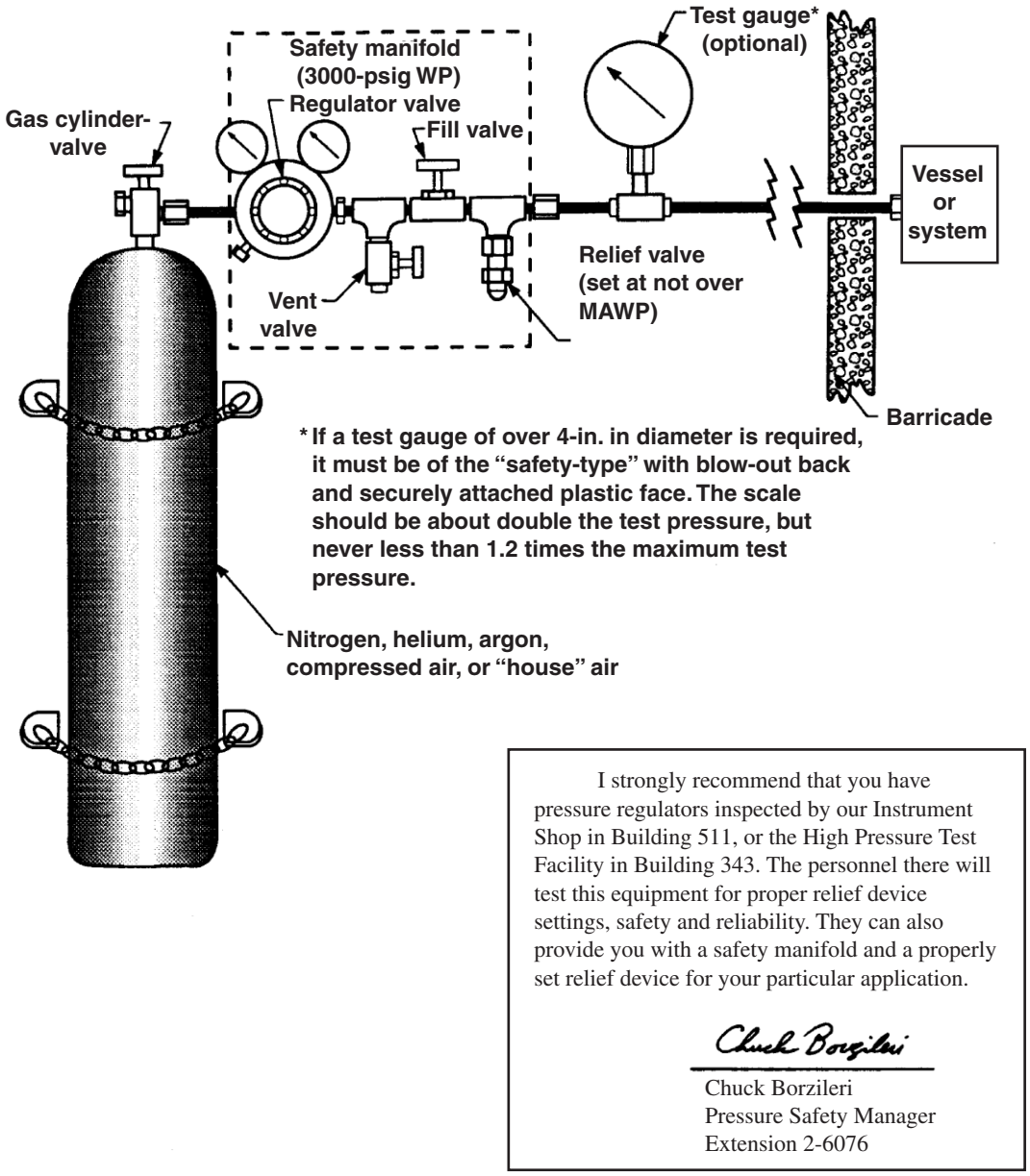
B.2 Industrial Gas Cylinder Manifolds

Following are LLNL requirements and guidance for industrial gas cylinder manifolds:

- Before submitting a job order for a manifold, arrangements should be made with the MDD Industrial Gas Section of the Supply and Distribution Department for the gas cylinder supply needed and the storage requirements.
- Only qualified LLNL crafts persons (pressure installers and pressure inspectors) shall assemble high-pressure manifolds. Compressed gas cylinder manifolds for both job-order work and purchase-order contract work shall be supplied, fabricated, inspected, pressure tested, and tagged by LLNL. An assembled manifold provided by LLNL can be installed as a unit by others (from Plant Engineering standards).
- Manifold pigtails shall not be left disconnected because they can become clogged with insects. This can cause spontaneous ignition, creating enough heat and overpressure to burst the pigtail, valve, or manifold. Either replace empty cylinders immediately or have the excess pigtails and valves removed or capped to keep the system clean.

B.3 Safety Manifolds

Authorized personnel in the High-Pressure Test Facility or Plant Engineering Instrument Shop can provide a safety manifold system. This system is designed to reduce the pressure from a standard cylinder and provide relief protection for down-stream systems (relief device) (see Fig. B-1). It can also be used for low-pressure applications (0–1 MPa [0–150 psi]) that do not require formal documentation. Use of this system at higher pressures would require further documentation, such as ESN and/or OSP.



I strongly recommend that you have pressure regulators inspected by our Instrument Shop in Building 511, or the High Pressure Test Facility in Building 343. The personnel there will test this equipment for proper relief device settings, safety and reliability. They can also provide you with a safety manifold and a properly set relief device for your particular application.

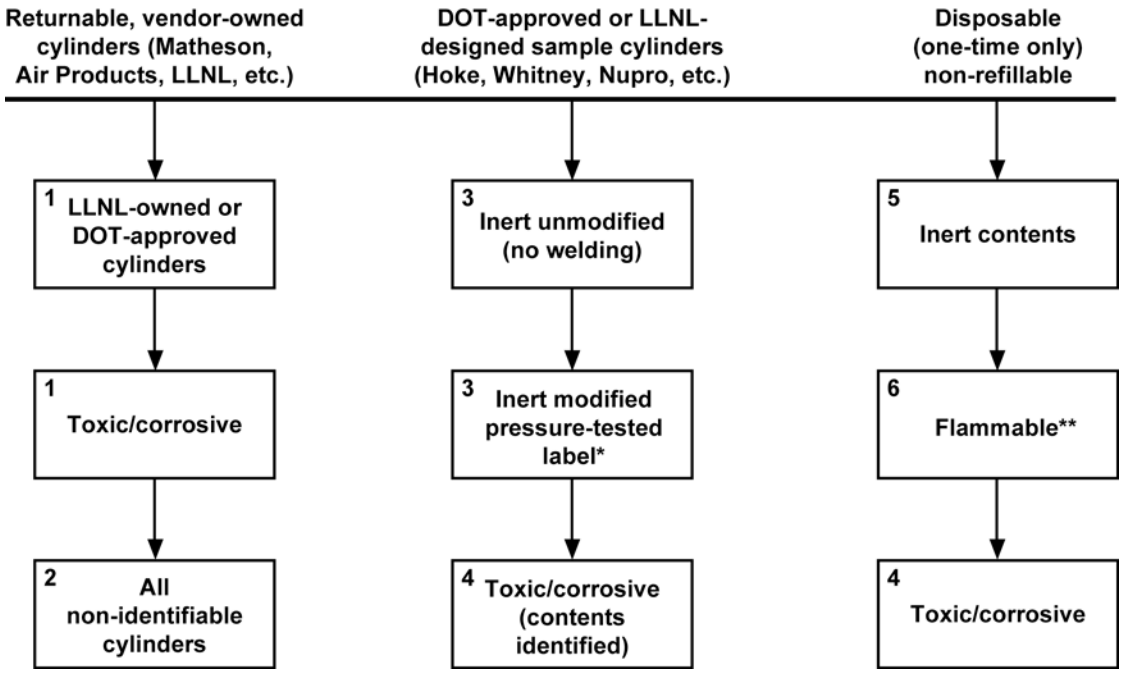
Chuck Borzileri

Chuck Borzileri
Pressure Safety Manager
Extension 2-6076

Figure B-1. Safety manifold.

Appendix C

Compressed Gas Cylinder Return and Disposal Procedure Flowchart



1. Place in the M.T. rack of gas storage sheds; the cylinder status tag should indicate residue.
2. All compressed-gas cylinders whose contents are not known shall be identified before they can be transported. Contact the Analytical Science Division of Chemistry and Materials Science for analysis.
3. Attach a completed cylinder tag and send to the High-Pressure Test Facility, B-343. Cylinders shall be emptied and previous contents identified as inert. Cylinders will be placed in storage for reuse.
4. Contact your Environmental Analyst or Hazardous Waste Management for evaluation and proper disposal requirements.
5. Vent and de-valve cylinder. Cylinder shall be clearly labeled EMPTY before sending to Reclamation.
6. Verify that the content of the cylinder is not an "acutely or extremely hazardous" material, as per the tables in the *EPD Training Manual.* A cylinder containing "acutely or extremely hazardous" material shall be handled as hazardous waste. For cylinders that DO NOT contain "acutely or extremely hazardous" material,
   - Determine if the cylinder is empty; a pressure gauge attached to the cylinder that reads between 1 psig and 0 psig, or a continuous hissing sound is not heard when the cylinder is open.
   - De-valve and send empty cylinders to DUS or dispose of them in the municipal garbage.
   - Handle all non-empty cylinders as hazardous waste.

* Notify the Pressure Safety Manager of the M.E. test number on the label.

** Make sure that flammable cylinders are empty before attempting to de-valve the cylinder.