TABLE OF CONTENTS

RECORD OF REVISIONS

Rev.	Date	Description	POC	RM
0	9/22/2023	Initial issue as section PS-REQUIREMENTS. Replaced most of the requirements in previous Sections ASME, NASME, and ADMIN that did not move to P101-34 and its subordinate documents.	Ari Ben Swartz, *ES-FE*	Dan Tepley, *ES-DO*

Contact the Standards point of contact (POC) for upkeep, interpretation, and variance issues.

Chapter 17	**Pressure Safety POC**

This document is online at https://engstandards.lanl.gov

ESM Usage

(Requirement 17-0XYZ): Where this phrase appears it is a LANL-internal reference in a basis file that captures and categorizes ESM drivers—and is not relevant to most users.

Fonts

Italics use: Where appropriate throughout the ESM, guidance is provided to aid in the implementation of requirements. Guidance will be *italicized* text and/or otherwise clearly indicated (e.g., by headings). Document titles in italics is normally simply a formatting style. Likewise, words and short phrases in italics and/or capitalized indicates them as a defined term (defined either in this document, the CoE Glossary (future), or the ESM chapter in which it appears).

All other text (plain type) indicates mandatory requirements (usually with "shall" or "must", or directive statement–e.g., "Provide …"

1.0 INTRODUCTION

The purpose of this document is to define the requirements to be used when performing pressure system design in the areas of planning, design, fabrication, assembly, examination, inspection and testing, and commissioning as well as decommissioning.

This document aims to seamlessly combine pressure safety requirements that originate from the Prime Contract (e.g., Title 10 CFR 851, Title 29 CFR, Department of Energy (DOE) O 420.1C, etc.), national consensus codes and standards, Los Alamos National Laboratory- (LANL) specific directives, and sound engineering and pressure safety design practices.

2.0 PRESSURE SAFETY IMPLEMENTATION PLAN

(Requirement 17-0201)

A. The purpose of the Pressure Safety Implementation Plan (PSIP) is for the Designer to provide a clear and concise summary of the pressure system(s) being designed and to demonstrate their understanding of the design requirements of Engineering Standards Manual (ESM) Chapter 17. These requirements apply to all pressure systems.

B. Each Designer must assess and plan for compliance with ESM Chapter 17 Pressure Safety. The design-specific PSIP shall be submitted to a qualified design reviewer (see Table 2 —*Authorized Reviewer/Approver for-fluid service (FS) Hazard Category Activities*, below) for review and approval in the early stages of project design (e.g., 30% complete) and resubmitted at later review phases (e.g., 60%, 90%) if/as it matures. If the design does not follow a 30/60/90-style design lifecycle, the PSIP shall be submitted at each applicable design stage (e.g., conceptual, preliminary, baseline, and final).

C. The pressure system Designer is responsible for issuing the PSIP. There are examples in the Chapter 17 SharePoint page.

D. The PSIP shall address all areas of pressure safety design compliance including the following items:

1. Design Criteria reference - Requirements and Criteria Document (RCD), Statement of Work (SOW), etc.

2. Service life of the installation
3. Define who is responsible for each work phase: design, fabrication, examination, and testing, and data input to the Pressure System Database (PSD)

Guidance: It is recommended that the PSIP identify a pressure system representative (PSR) as required by P101-34 to ensure the PSIDs are created in the PSD and updated with information as required for Acceptance for Use per P101-34 Attachment A, Acceptance for Use (AFU) of Pressure Systems.

4. Design pressure and design temperature ranges
5. Identification of the Design Basis. If more than one code of record (COR) is used, define the location of the code changes in applicable drawings, sketches, isometrics, etc.
6. Design output expectations (specifications, drawings, calculations, etc.)
7. Fabrication expectations (methods and qualification of fabrication personnel)
8. American Society of Mechanical Engineers (ASME) quality (procurement, inspection, examination, and testing requirements), if applicable.
9. Required Records
    a. Welding inspection, examination, and testing records shall be maintained in the pressure system design documentation package.
    b. Manufacturer's data reports (e.g., ASME U-1) shall be maintained as a record for all boilers and pressure vessels.
10. Review and define the required items from Attachment REQ-2, *New or Modified System Design Document Requirements*. This attachment includes two "Verification" columns for Designer and Design Reviewer that may be optionally utilized to aid in ensuring that all required documentation has been provided in the design package.
    a. For example, B31.3 Code requires retention of examination records:
        1) Examination procedures
        2) Examination personnel qualifications
        3) Examination reports
11. State whether the pressure system is a new system or an existing system modification. Obtain the pressure system ID (PSID) number(s) from the Pressure Safety Program and assign it to system design documentation.

    NOTE: For new pressure systems or existing pressure systems without an assigned PSID, obtain a PSID by emailing PSIDrequest@lanl.gov.

3.0 FLUID SERVICE DETERMINATION

(Requirement 17-0202)

A. General

1. LANL Fluid Service (FS) is defined by the best fit for each pressure system or sub-system and provides a sense of the hazard level of the pressure system.

LANL FS is generally driven by system pressure, temperature, fluid contents, or a combination of the three. (See Figure 1 below)

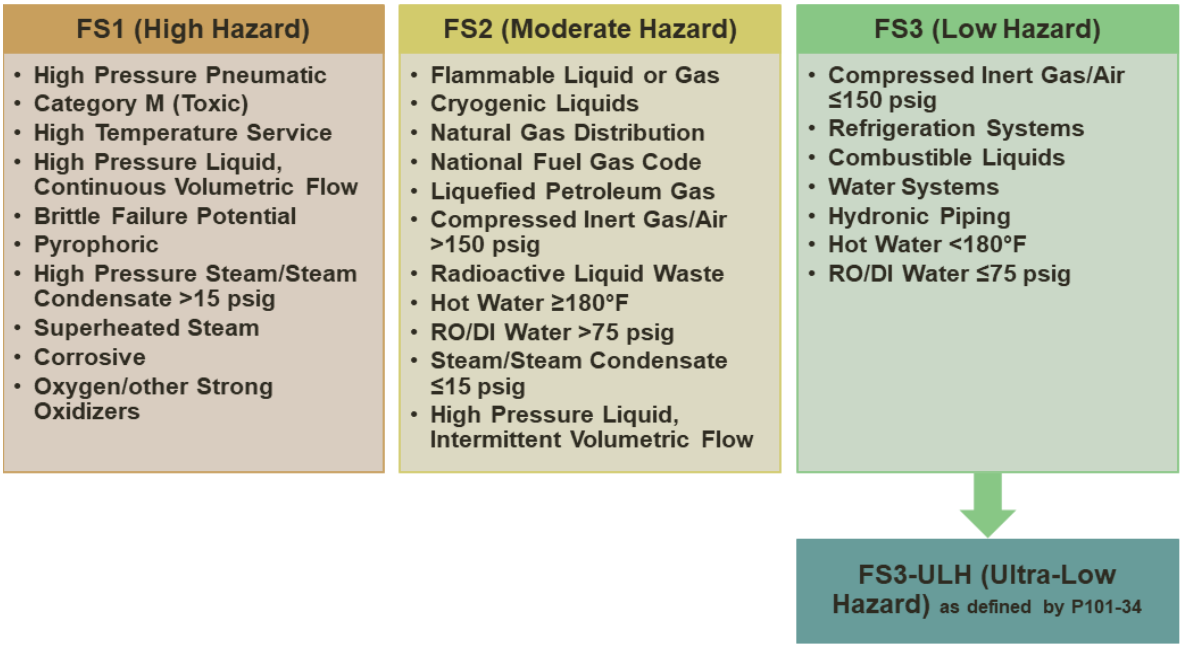
2. LANL FS also determines the minimum level of qualification required of the design reviewer, discussed in the Design Review section below. There may be more than one Fluid Service for a pressure system (or sub-system). If there is more than one Fluid Service for the pressure system, the most hazardous Fluid Service will be used to identify the pressure systems in the PSD.

3. Figure 1 provides a summary of common types of pressure systems and their LANL FS categories. P101-34 Section 9.1 and ESM Ch. 17 Att-GEN-1 provides detailed definitions.

4. The pressure safety committee (PSC) may evaluate the FS of a pressure system on an individual basis to determine if it meets Fig. M300 in B31.3 — even if listed in ESM Chapter 17 Attachment REQ-1, *Category M Fluid Service and Lethal Service* — and will consider relevant information in the evaluation, including protection of personnel from exposure during system operation.

5. The chief pressure safety officer (CPSO) — or delegated CPSO (DCPSO) if the CPSO is unavailable — will make the final determination of fluid category for a pressure system if there is any uncertainty.

Figure 1 Pressure Systems within Each FS Category



4.0 DESIGN REVIEW

(Requirement 17-0203)

NOTE: Reviewers should be identified early in the design process.

A. Design review of new or modified pressure systems is required for all pressure systems in the scope of ESM Ch. 17.

B. Design Review and Acceptance will be performed in accordance with Table 1 — authorized reviewer/approver for FS Hazard Category Activities (below).

C. The minimum required level of reviewer may be replaced by a higher hazard reviewer.

D. Reviewer shall be independent from the design.

E. Pressure safety officers (PSOs) will be trained and qualified to the applicable code(s) of record or work under a qualified individual.

F. Trained peer reviewers may only perform design reviews for FS3 & FS3-ULH fluid service programmatic systems that are not tied to a safety basis.

G. Peer reviewers may perform the role of examiner and inspector for applicable programmatic low and ultra-low risk pressure systems. The examiner is the person that does the work, and the inspector is the person that verifies the work is adequate. For example, the examiner would use the correct parts and fabricate and test the system to be leak-free, and the Inspector would verify as much of the work as necessary to ensure the work was done correctly.

H. The Designer shall ensure that Occupational Safety and Health (OSH) and/or Fire Protection subject matter experts (SMEs) be included as part of the design review. OSH is responsible for evaluating pressure system hazards related to occupational safety and health that are not in the scope of Pressure Safety (ref. P101-34 Section 3.3.1.a for a description of OSH's role for pressure systems). Fire Protection evaluates the fire risk of pressure systems and their impact on the location in which the pressure systems are placed.

I. Attachment REQ-2, *New or Modified System Design Document Requirements*, contains a comprehensive list of the base set of design documentation required to review and approve pressure systems. This attachment is intended for all pressure systems except FS3 and FS3-ULH temporary pressure systems that are not tied to a safety basis.

J. The AFU prior to operation of a pressure system shall be in accordance with P101-34 Attachment A, *Acceptance for Use (AFU) of Pressure Systems*.

Table 1. Authorized Reviewer/Approver for FS Hazard Category Activities

PSP SME	FS Hazard Category			
	FS1 (High)	FS2 (Moderate)	FS3 & FS3-ULH (Low & Ultra-Low)	
			Facilities, Utilities, and Programmatic (safety basis)	Programmatic
CPSO/DCPSO	**R**	**√**	**√**	**√**
PSO Duty Area B	**-**	**R**	**√**	**√**
PSO Duty Area A	**-**	**-**	**R**	**√**
Peer Reviewer	**-**	**-**	**-**	**R**

R Minimum required level of reviewer/approver

√ May approve/review

- May NOT approve/review

PSO Duty Area A and B are defined by and qualified as described in ESD-QS-001.

5.0 PERMITS AND REQUIREMENTS IDENTIFICATION

(Requirement 17-0204)

A. The Permits and Requirements Identification (PRID) process is a project planning Integrated Review Tool [see P351, *Integrated Review Tool (IRT)*] used by project leaders to identify required permits, requirements, and facilitate subject matter expert (SME) reviews in the early planning stages of a project. Pressure system designs should be included for PRID review when applicable.

B. Unless otherwise delegated, all PRID reviews shall be performed by the CPSO.

6.0 DESIGN CRITERIA

A. The Design Criteria is provided by the customer as input for the Designer.

B. The Designer is responsible for implementing the defined Design Criteria.

C. It is the responsibility of the Designer for defining any additional Design Criteria if necessary to assure a safe pressure system for the proposed installation in addition to the Design Basis. Examples include, but are not limited to, specification of additional nondestructive examination (NDE) and pass/fail criteria, evaluating and specifying materials of construction to ensure system integrity, and specifying necessary construction techniques for radioactive material handling service.

D. Designs or practices known to be unsafe are prohibited.

7.0 DESIGN BASIS

(Requirement 17-0205)

A. Design Basis, as defined by DOE G 413.3-12 Chg 1 (Admin Chg), *U.S. Department of Energy Project Definition Rating Index Guide for Traditional Nuclear and Non-Nuclear Construction Projects,* is "The set of requirements that bound the design of systems, structures, and components within the facility. Those design requirements include consideration of safety, plant availability, efficiency, reliability, and maintainability."

B. For ESM Ch. 17, Design Basis is considered the codes, standards and/or equivalent safety evaluations that ensure that new or modified pressure systems are designed, fabricated, tested, and inspected in a manner that will protect workers. The Design Basis also ensures that pressure systems can be maintained, repaired, and operated safely throughout its lifecycle in accordance with P101-34, Pressure Safety.

C. It is the responsibility of the Designer to define the Design Basis of a pressure system that meets the Design Criteria. See Attachment GEN-1, *Definitions and Acronyms*.

D. A pressure system design may contain multiple required codes and/or standards (e.g., ASME Boiler and Pressure Vessel Code (BPVC) vessels associated with ASME B31 piping).

E. A summary of the Design Basis options is provided below in Table 2. Detailed explanations of each Design Basis option and additional requirements that may affect the Design Basis are provided below the table.

Table 2, Design Basis

	Application of Design Basis		
Design Basis	**Boilers, Pressure Vessels, Air Receivers, and Supporting Piping**	**Non-Supporting Piping**	**Temporary Programmatic (not Safety Basis)**
ASME BPVC Section I through XIII	Required for BPVC Section I through XIII	Not allowed	Required for BPVC Section I through XIII
ASME B31 or NFPA 54/58 Piping Codes	Required for Supporting Piping	Allowed for Non-Supporting Piping	Required for Supporting Piping
LANL Ch. 17 NASME B31 Code Equivalencies	Not allowed	Allowed for Non-Supporting Piping	Allowed for Non-Supporting Piping
Title 10 CFR 851 Compliant Evaluation	Allowed for Pressure Vessels and Supporting Piping that cannot otherwise meet ASME code	Allowed for Non-Supporting Piping that cannot otherwise meet ASME code	Allowed for systems that cannot otherwise meet ASME code

7.1 APPLICATION OF ASME BOILER AND PRESSURE VESSEL CODE

When an ASME BPVC item is required (e.g., Section I, IV, VIII, X, XII, or XIII) the Design Basis of that item will be the ASME BPVC itself. Attachment REQ-3, *ASME Boiler and Pressure Vessel Code Application*, contains a summarized description of the scope of the ASME Boiler and Pressure Vessel Codes and their applicability at LANL. Additionally, the following applies to all ASME BPVC equipment in the scope of ESM Chapter 17:

A. BOILERS

1. Heating boilers that are included under the scope of ASME BPVC Section IV *Rules for Construction of Heating Boilers* shall meet same and be National Board Inspection Code (NBIC) numbered and registered *(Requirement 17-0206).*

2. Power boilers that are included under the scope of ASME BPVC Section I, *Rules for Construction of Power Boilers*, shall meet same and be NBIC numbered and registered *(Requirement 17-0207).*

   NOTE: Water heaters that are not considered boilers (outside the scope of ASME Section I or IV) shall meet other codes or standards (e.g., UL 1453).

3. Controls, safety devices, and gas train for boilers with fuel input rating less than 12.5 MBTU/hr fall shall comply with ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers (Requirement 17-0208)*.

4. Controls, safety devices, and gas train for boilers with fuel input rating greater than or equal to 12.5 MBTU/hr fall within the scope of the National Fire Protection Association (NFPA) 85, *Boiler and Combustion Systems Hazard Code (Requirement 17-0209).*

5. Installation of new boilers shall comply with NBIC NB-23 Part 1, *Installation (Requirement 17-0210).*

6. Boilers providing hot water shall have the high temperature fuel cutoff set no higher than 195 ˚F. This ensures that discharge from the relief devices is only water, not a water and steam mixture, at LANL elevation. *Guidance: LANL elevation is conservatively estimated at 7500 feet, Ref. ESM Ch. 1 Section Z10, 9.0 "Constants"*

7. Boiler External Piping shall meet either ASME B31.1, *Power Piping*, or B31.9, *Building Services Piping*, as defined within the scope of each code.

B. PRESSURE VESSELS

1. Installation of new pressure vessels shall comply with NBIC NB-23 Part 1, *Installation. (Requirement 17-0211)*

2. Pressure vessels that are included under the scope of ASME BPVC Section VIII, *Rules for Construction of Pressure Vessels*, shall meet same and be NBIC numbered and registered. *(Requirement 17-0212)*

   NOTE: Pressure vessels may be built to Division 1, 2, or 3.

3. Pressure vessels that are included under the scope of ASME BPVC Section X, *Fiber-Reinforced Plastic Pressure Vessels*, shall meet same and be NBIC numbered and registered. *(Requirement 17-0213)*

4. Non-code stamped pressure vessels (i.e., vessels in the scope of Section VIII or X but not code stamped) are discouraged but may be permitted when documentation can be provided that the vessel design provides an equivalent

level of safety to the applicable ASME BPVC Section. See Attachment REQ-2, *New or Modified System Design Document Requirements*, for detailed information on the equivalency requirements. *(Requirement 17-0214)*

C. TRANSPORT TANKS

1. Transport tanks that are included under the scope ASME BPVC Section XII, *Rules for Construction and Continued Service of Transport Tanks*, shall meet same and be NBIC numbered and registered. *(Requirement 17-0215)*

2. Mobile pressure systems or vacuum systems must comply with Department of Transportation Code of Federal Regulations (Reference 49CFR) per P151-1, LANL Packaging and Transportation Program Procedure as administered by ALDFO, Facility and Operations (Associate Laboratory Directorate), Packaging and Transportation LOG-PT (or successor organization), and are not included in the ESM Chapter 17 unless they are under the criteria defined in this subsection. *(Requirement 17-0216)*

3. Fabrication of pressurized trailer cylinders in accordance with ASME BPVC Section XII, Rules for Construction and Continued Service of Transport Tanks, may be applied to satisfy the Department of Transportation (DOT) Code of Federal Regulations (CFR) requirements when approved by ALDFO LOG-PT (or successor organization) per P151-1, *LANL Packaging and Transportation Program Procedure*, except for dangerous goods (see below).

4. The rules of ASME BPVC Section XII, Rules for Construction and Continued Service of Transport Tanks, shall be applied to the construction and continued service of pressure vessels for the transportation of dangerous goods via highway, rail, air, or water. The general requirements given in Part TG of Section XII shall be met for all vessels within the scope of this Section. This Section shall apply specifically to pressure vessels intended for transporting dangerous goods (see Mandatory Appendix III) with design pressures appropriate for the transportation mode and volumes greater than 450 L (120 gal). 49CFR Parts 100 through 185, Transportation, covering the construction and continued service of pressure vessels intended for transporting dangerous goods shall be reviewed to determine if the requirements are more restrictive than the rules of this Section. Applicable state and local laws and regulations may contain additional requirements for pressure vessels used in the transportation of dangerous goods, which are not addressed in this subsection.

D. RELIEF DEVICES

1. When required by ASME BPVC or ASME B31 code, relief devices shall meet ASME BPVC Section XIII and be code stamped (e.g., relief valves for Section I boilers shall be "V" stamped). *(Requirement 17-0217)*

   Guidance: For applicable relief device marking see ASME BPVC Section XIII, Table 2.1-1, Permitted Pressure Relief Devices or Methods by ASME BPVC Section

E. REPAIRS AND/OR ALTERATIONS OF EXISTING ASME BPVC EQUIPMENT

1. ASME boilers and pressure vessels are to be repaired or altered as required by NBIC NB-23 Part 3, *Repairs and Alterations*, and must be performed by an institution holding an "R" stamp *(Requirement 17-0218)*. Note that repairs/alterations may require additional design information prior to approval for work to proceed (e.g., updated drawings, calculations, etc.).

Guidance: LANL holds an "R" stamp at time of writing; see LANL Quality Control Systems Manual (QCSM) (R Stamp Program).

F. NON-CODE TANKS

1. Atmospheric tanks intended for service less than 15 psig are outside the scope of ASME BPVC but shall meet other applicable codes or standards (e.g., API 620, 625, 650 or UL 142, 2085). *(Requirement 17-0219)*
2. System designs that utilize DOT vessels as fixed pressure vessels must plan either to maintain the DOT certification inspection intervals or qualify them as a non-code pressure vessel.
3. Atmospheric tanks or vacuum vessels are not required to be, but may be, fabricated to ASME BPVC Section VIII.

7.2 APPLICATION OF ASME B31 AND NFPA PIPING CODES

Attachment REQ-4, *Piping Code and Regulation Application*, contains a summarized description of the scope of ASME B31 and NFPA piping codes and their applicability to LANL. It is the responsibility of the Designer to assign the most applicable piping code(s) of record to their pressure system design, though Attachment REQ-4 provides guidance regarding the most common applications of the piping codes.

ASME B31.1 Boiler External Piping requires ASME quality marking (i.e., code stamp) and ASME SA and SB materials from BPVC Section II.

ASME B31.9 Boiler External Piping requires ASME SA and SB materials from BPVC Section II (quality marking is not required).

7.3 APPLICATION OF NON-ASME (NASME) CODE EQUIVALENCY EVALUATIONS

ESM Ch. 17 provides equivalent level of safety evaluations for pressure systems in the scope of either ASME B31.3 (Fluid Categories D and Normal, Metallic and Non-Metallic) or ASME B31.9. Use of these provisions is referred to as Non-ASME (NASME) Design Basis. The following attachments provide details on the application of NASME to pressure systems, including requirements for their use.

- Attachment REQ-5, *ASME B31.3 Non-Metallic Equivalent Safety Evaluation*
- Attachment REQ-6, *ASME B31.3 Metallic Equivalent Safety Evaluation*
- Attachment REQ-7, *ASME B31.9 Equivalent Safety Evaluation*

Guidance: If NASME is part of the Design Basis, the Designer is not required to follow every provided equivalency, e.g., they may choose to utilize the provisions for unlisted components but follow the rest of the ASME B31 code.

7.4 APPLICATION OF 10 CFR 851 EQUIVALENCY EVALUATIONS

10 CFR 851 Appendix A 4(c) provides allowance for equivalent safety measures when national consensus codes are not applicable:

> "*(c) When national consensus codes are not applicable (because of pressure range, vessel geometry, use of special materials, etc.), contractors must implement measures to provide equivalent protection and ensure a level of safety greater than or equal to the level of protection afforded by the ASME or applicable state or local code. Measures must include the following:*

(1) Design drawings, sketches, and calculations must be reviewed and approved by a qualified independent design professional (i.e., professional engineer). Documented organizational peer review is acceptable.

(2) Qualified personnel must be used to perform examinations and inspections of materials, in-process fabrications, non-destructive tests, and acceptance test.

(3) Documentation, traceability, and accountability must be maintained for each unique pressure vessel or system, including descriptions of design, pressure conditions, testing, inspection, operation, repair, and maintenance."

10 CFR 851 Appendix A 4(c) equivalency evaluations are most commonly applied to programmatic pressure systems that utilize vessels, components, and materials that cannot meet national consensus codes due to the unique nature of design/operating conditions or system components.

1. Pressure systems and/or components of pressure systems that cannot under any circumstances be designed to safely contain or relieve pressure shall be placed behind blast containment (i.e., a barrier or shielding) as a last resort means to protect workers from overpressure hazards. Blast containment is a method by which Designers can comply with 10 CFR851 Appendix A 4(c). This safety measure should only be considered when all other design options have been considered and deemed unsuitable for the pressure system design.
    a. These items shall be shielded behind blast containment (a.k.a. a barrier or shielding) designed to withstand the explosive forces and potential release of shrapnel in the event of over pressurization. OSH-ISH-FSD-009, *Programmatic Work with Explosives (Laboratory and Other High Explosive Operations)* contains pre-approved minimum shielding designs.
    b. Only after sufficiently designed shielding has been installed to protect the worker may the pressure system or components be considered excluded from ESM Chapter 17 design requirements.
2. Pressure systems that do not pose a risk to personnel (e.g., system is pressurized remotely), and where the risk of damage or system loss is acceptable to the ESM Ch. 17 POC and the pressure system Associate Laboratory Director (ALD) (or appointed designee), do not have to comply with the pressure system design requirements of ESM Chapter 17. The following three items must be satisfied:
    a. The adequacy of the methodology to isolate personnel from the potential failure of the pressure system must be verified.
    b. Adequate documented administrative controls (e.g., in an IWD or WCD) must be in place to prevent inadvertent pressurization when personnel are not isolated from the pressure system, for example:
        1) Disconnection of all pressure sources
        2) Double block-and-bleed of all pressurization sources
    c. Completion of the required documentation and Acceptance for Use process described in P101-34.

7.5 APPLICATION OF OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) REQUIREMENTS

(Requirement 17-0220)

A. Pressure systems shall meet the requirements of Title 29 CFR 1910 as follows:

1. A table that summarizes the applicable code and/or standard requirements of the CFR is in Attachment REQ-8, *OSHA Requirements for Pressure Systems*; see CFR for the complete text and all requirements.

   Guidance: Following the document(s) in the "LANL Applied Code" column satisfies the OSHA requirement for the systems listed.

2. The requirements of these paragraphs shall be integrated into the design when applicable. When the requirements are outside of the jurisdiction of pressure safety, OSH-ISH and/or Fire Protection Office (or successor orgs.) shall be involved in ensuring compliance.

7.6 DESIGN RESTRICTIONS FOR CREDITED PRESSURE SYSTEMS

(Requirement 17-0221)

A. Pressure systems that are credited in an approved safety basis (e.g., nuclear) may have design requirements that influence the Design Basis. These requirements must be incorporated into design for these systems and may go above and beyond national code requirements.

7.7 APPLICATION OF CODES, STANDARDS, OR DOCUMENTS NOT INVOKED BY 10 CFR 851

(Requirement 17-0222)

A. Requirements from other countries or international organizations that are not compliant with 10 CFR 851 pressure safety requirements are not allowed at LANL or to be used by LANL personnel unless reviewed and approved using the Alternate Method process described in Section PS-GENERAL - *General Information, Alternate Method/Variance or Clarification/Interpretation.*

   Two examples of requirements from entities not recognized by 10 CFR 851 are below.

   1. The Canadian Registration Number (CRN) system.
   2. The European Union (EU) Pressure Equipment Directive (PED).

B. Standards that do not affect compliance with 10 CFR 851 pressure safety requirements are permitted as part of the pressure system design. This includes, for example:

   1. Process Industry Practices (PIP)
      a. PIP INEG1000, *Insulation Design and Type Codes*
      b. PIP PCCIP001, *Instrument Piping and Tubing Systems Criteria*
      c. PIP PCSIP001, *Instrument Piping and Tubing Systems Specifications*
      d. PIP PIC001, *Piping and Instrumentation Diagram Documentation Criteria*

e. PIP PNCM0001, *Piping Material Specification Designator System*

2. Compressed Gas Association (CGA) (see 29CFR1910)
   a. CGA 341, *Specification for Insulated Cargo Tank for Nonflammable Cryogenic Liquids*
   b. CGA E-4, *Standard for Gas Pressure Regulators*
   c. CGA G1.2, Acetylene Metering and Piping
   d. CGA G-4.1, *Cleaning Equipment for Oxygen Service*
   e. CGA G-4.4 *Oxygen Pipeline and Piping Systems*
   f. CGA H-3, *Cryogenic Hydrogen Storage*
   g. CGA P-18, *Standard for Bulk Gas Storage Systems*
   h. CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components*
3. National Fire Protection Association
   a. NFPA 30, *Flammable and Combustible Liquids Code*
   b. NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*
   c. NFPA 55, *Compressed Gases and Cryogenic Fluids Code (e.g., Dewar vacuum jacket)*
4. UL enterprise – UL Research Institutes, UL Standards & Engagement, UL Solutions (formerly Underwriters Laboratories)
   a. UL 404, *Standard for Gauges, Indicating Pressure, for Compressed Gas Service*
   b. UL 207, *Refrigerant-Containing Components and Accessories, Nonelectrical*
   c. UL 1963, *Refrigerant Recovery/Recycling Equipment*
5. ASTM International (ASTM), formerly American Society for Testing and Materials
   a. ASTM G93, *Standard Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments*
   b. ASTM G128, *Standard Guide for Control of Hazards and Risks in Oxygen Enriched Systems*
   c. ASTM A380, *Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems*
   d. ASTM E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals*
6. American Petroleum Institute (API), where they do not conflict with 10 CFR 851
   a. API 520 Part I and Part II, *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries*
   b. API 521, *Pressure-Relieving and Depressurizing Systems*

c. API 570, *Piping Inspection Code: In-service Inspection, Rating, Repair, and Alteration of Piping Systems*

d. API RP 574, *Inspection Practices for Piping System Components*

e. API RP 575, *Inspection Practices for Atmospheric and Low-Pressure Storage Tanks*

f. API 579/ASME FFS-1, *Fitness for Service*

g. API RP 580, *Risked-based Inspection*

h. API RP 581, *Risked-based Inspection Methodology*

i. API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*

j. API 650, *Welded Tanks for Oil Storage*

k. API 653, *Tank Inspection, Repair, Alteration, and Reconstruction*

8.0 DESIGN REQUIREMENTS

8.1 ASME LISTED PIPING COMPONENTS AND MATERIALS

(Requirement 17-0223)

Pressure system components or materials that conform to a standard listed in the COR, are defined as listed components and listed materials, respectively. Designers shall make every effort to utilize listed components and materials when available.

Example: B31.3 Tables 326.1 and A326.1 contain listed components; B31.3 Appendix A and Appendix B contain mostly listed materials but also contain components (pipe).

8.2 ASME UNLISTED, SPECIALTY, OR UNIQUE COMPONENTS

(Requirement 17-0224)

Pressure system components or materials used in systems built to ASME COR that are not listed in the code must be evaluated using the LANL unlisted component evaluation process.

NOTE: Alternately, if the conditions for its use as a Design Basis are met, the NASME process may be used to evaluate unlisted components (see NASME Pressure System Design section below).

A. Previously Approved Materials and Components

1. The master list of Approved Unlisted Materials and Components allowed for use is maintained by the chief pressure safety officer / deputy chief pressure safety officer (CPSO/DCPSO) and available for both internal and external web access.

2. When designing with these items, the Designer shall ensure that they are being used within allowable pressure, temperature, and other parameters. Additionally, the Designer shall make mention that the unlisted items being utilized are on the master list.

B. Approving a New Unlisted Item

1. Forms and instructions to assist in evaluating and gaining approval of unlisted components and materials are available here).
2. The Designer shall request approval of additional materials and components using the provided forms and forward to the CPSO/DCPSO for review and approval. When new items are approved for use, the Designer shall make mention that the unlisted items being utilized are on the master list.
3. The PSC will resolve disputes over unlisted component evaluations.

8.3 COMMERCIALLY AVAILABLE, OFF-THE-SHELF (COTS) EQUIPMENT

A. P101-34 Attachment D, *Procurement of Pressure Safety Goods or Services*, Section 3.2.1, provides a detailed definition of what is considered COTS equipment within the scope of the pressure safety program.

B. COTS containing equipment within the scope of ASME for quality marking (e.g., B31.1, Section I, IV, VIII, X, XII, or XIII) shall be quality marked. *Exception: COTS containing equipment within the scope of ASME Section VIII but with non-ASME quality marked vessels may be permitted upon design review acceptance.*

C. COTS equipment that has pre-installed relief devices utilize the manufacturer as the Designer to satisfy overpressure protection requirements for the equipment. Overpressure protection outside the confines of the COTS equipment remains the responsibility of the ESM Ch. 17 Designer.

8.4 NASME PRESSURE SYSTEM DESIGN

(Requirement 17-0225)

This section is only applicable if NASME equivalency can be applied; see Application of Non-ASME (NASME) Code Equivalency Evaluations section above.

1. Piping that is not part of a "supporting piping system" but is within the scope of B31.3 or B31.9 may apply the applicable, approved equivalency evaluations in the Attachments of this chapter. The pressure system must meet the approved equivalency restrictions defined in each NASME section.
2. The equivalency evaluations are not applicable to boilers, pressure vessels, air receivers, or supporting piping associated with the ASME quality marked item. The equivalencies can apply to all other piping within a system that has a vessel.

From Attachment GEN-1 Definitions and Acronyms:

Supporting piping systems – term shall be considered any and or all the piping necessary for the function of the pressure vessels or air receivers. Piping that is attached in excess of that required for the function of the pressure vessel or air receiver is not "supporting piping." This is analogous to the application of Boiler External Piping under ASME B31.1 and B31.9. See Figure 2 below.

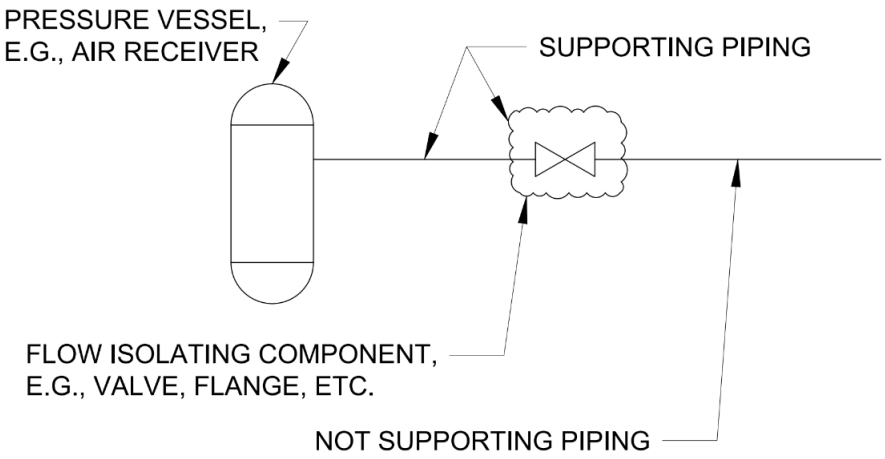


Figure 2

3. Previously approved components and materials on the Reputable Manufacturers List (RML) of approved NASME piping components allowed for use is maintained by the CPSO/DCPSO and available for both internal and external web access here.

4. The RML includes the equivalency evaluations (Att. REQ-5, -6, or -7) for which the approved components can be applied. If using the components on an unapproved NASME attachments, the Designer shall seek approval for use.

5. NASME materials and piping components are selected by the Designer based on the applicable equivalent safety evaluation. The design is reviewed using the Design Review process outlined in this chapter.

6. Items submitted to reputable manufacturers listing must be evaluated and accepted by the LANL CPSO/DCPSO prior to use. To submit a request for Reputable Manufacturers List (RML) additions, add desired components to the latest RML in empty rows at the bottom of the list. Format previous revision entries in black text and desired entries in red text. Submit revised RML to the LANL CPSO/DCPSO for review and acceptance. If accepted, reviewer will have the information included into the RML on the ESM website and notify requestor.

8.5 OVERPRESSURE PROTECTION REQUIREMENTS

(Requirement 17-0226)

A. General

1. Every pressure system shall have an overpressure protection evaluation. Overpressure protection (e.g., pressure relief devices) protects a system from over-pressurization during beyond-design-basis abnormal conditions. Requirements for overpressure protection evaluations is provided in the Overpressure Protection Evaluation section, below. *Guidance: Attachment GUIDE-1, Overpressure Protection Evaluation Guide, provides examples of overpressure protection evaluations for a common variety of pressure systems.*

   Guidance: The pressure system owning organization is responsible for implementing the necessary preventing maintenance for overpressure protection as required by P101-34.

2. It is the Designer's responsibility (defined as the "user" in ASME Section VIII) to size the relief device if one is required. ASME BPVC Section VIII uses the terms "user" or "designated agent" as shown in Nonmandatory Appendix NN, Guidance To The Responsibilities Of The User And Designated Agent. *Exception: COTS air compressor packages that have pre-installed relief devices utilize the manufacture as the "designated agent" to satisfy the ASME Section VIII requirements.*
3. Generally, pressure relief devices shall have a relief pressure setting not higher than the component with the lowest pressure rating in the portion of the system being protected. This requirement may vary depending on the Design Basis, particularly if ASME codes are involved.
4. Backflow preventer regulators shall not be used as pressure relief devices.
5. Pressure regulators are not considered pressure relief devices, however there are cases where there are alternative methods to relief devices that may be considered (e.g., the use of multiple regulators in series with appropriate administrative controls to detect a single regulator failure).
6. An oversized pressure relief valve (PRV) can chatter, which can damage the PRVs and/or the pressure system. This is especially true in the case of piping systems where the pressure system volume available for accumulation is small. *Guidance: Pressure Protection Design Guide WSRC-M-DP-G-0006, Rev. 5, contains information on PRV chatter.* For the protection of piping systems and their PRVs, the PRV capacity should not exceed the failure flow rate of the pressure system by more than a factor of two. For PRVs less than 1½" Nominal Pipe Size (NPS), greater ratios may be acceptable.
7. Relief devices that are ASME stamped (e.g., V, UV, UD, HV, etc.) are accepted as listed items for B31 design basis. Any non-stamped relief device with a set pressure of 15 psi or above that is used on a B31 design basis pressure system must be evaluated if required by the code of record as an unlisted component. Relief devices
8. A set pressure less than 15 psi are not within the scope of code stamping (i.e., non-stamped). *Guidance: Swagelok relief devices are accepted as listed components, but because they are non-stamped proportional relief devices, they must be used with great care and their use is discouraged.*
9. The nominal pipe size of piping, valves and fittings, and vessel components between a pressure system and its pressure relief device must be at least as large as the nominal size of the device inlet. *Example: A ½" inlet pressure relief device* ***cannot be*** *connected to a ¼" nominal pipe via reducing fittings. Conversely, a ¼" pressure relief device* ***can be*** *connected to a ½" nominal pipe systems using reducers.*
10. Power Boiler relief devices shall meet the requirements of ASME BPVC Section I and Section XIII.
11. Heating Boiler relief devices shall meet the requirements of ASME BPVC Section IV and Section XIII.
12. Pressure Vessel relief devices shall meet the requirements of ASME BPVC Section VIII and Section XIII.

13. ASME Fiber-Reinforced Plastic Pressure Vessel relief devices shall meet ASME BPVC Section X and Section XIII.
14. ASME Transport Tank relief devices shall meet ASME BPVC Section XII, Section XIII, and Title 49 CFR.
15. Other non-reclosing relief devices (e.g., rupture pin/buckling pin and spring-loaded) may also be used.
Guidance: See ASME Section XIII Parts 5 and 6 for more information on the use of these devices.
16. Pressure relief of DOT shipping containers (other than ASME Section XII) is governed solely by the Title 49 CFR and not within the scope of the ESM Chapter 17.
17. Liquid Service: Relief devices for vessels that operate with liquid must use relief protection designed for liquid service. *Example: If a relief device is installed at the bottom of a liquid-filled pressure vessel that has a gas space at the top, it would require a liquid-service relief device.*
18. Gas Service: Relief devices for vessels or piping that operate with compressed gases must use relief devices for gas service. *Example: If a relief device is installed at the top of a liquid filled pressure vessel in the gas space at the top it would require a gas service relief device.*

    NOTE: Pressure systems designed to be capable of withstanding the max fill pressure of a gas cylinder are not required to have overpressure protection (Requirement 17-0227).
19. Steam Service: Relief devices for steam service must use relief devices rated for steam service.
20. Cryogenic Service: Relief protection for cryogenic systems must be suitable for the design temperatures and pressures.
21. New or recertified pressure relief valves must be independently tested with a factory-locked set pressure. *Guidance: ASME-stamped relief devices and recertified ASME-stamped relief devices (e.g., "VR" stamped) are by default required to have locked setpoints with independent testing.*
22. Relief devices are required to vent to a safe location, in some cases the vent valve and relief device vents maybe required to be routed outside or to a fume hood or vent system. Designers should consult with OSH, Radiation Protection and/or Fire Protection to aid in this determination.
23. Relief device stop valves (a valve before or after the relief protection) are forbidden by ASME BPVC for steam boiler (Section I) or heating boiler (Section IV) applications. *(Requirement 17-0228)*
24. Relief device stop valves are discouraged for other applications but may be used when all the requirements of the ASME COR are met (e.g., locked open during normal operations). *Example: See ASME B31.3 para. 322.6.1, F322.6, and ASME BPVC Section VIII, Division 1, UG-156. (Requirement 17-0229)*
25. Operations where stop valves are closed must institute the practice defined in ASME B31.3 F322.6 or ASME Section XIII Nonmandatory Appendix B for control of the relief devices while closed and to ensure emergency venting as necessary.

B. Overpressure Protection for Fire *(Requirement 17-0230)*

1. Designers shall determine the need for overpressure protection for pressure systems due to exposure to fire or other unexpected sources of external heat.

   Example: ASME BPVC Section VIII, Division 1, Nonmandatory Appendix M, Part M-13 provides information and references and recommendations for sizing of relief devices for fire conditions. When a pressure vessel can be exposed to fire or other unexpected sources of external heat, the pressure relief device(s) shall meet ASME BPVC Section VIII, UG-153(a)(2) and/or UG-153(a)(3) as applicable.

Guidance: A vessel in a room with a rated fire suppression is not required to have a fire rated relief because the fire suppression system is a credited control.

C. Liquid Lock Overpressure Protection *(Requirement 17-0231)*

1. Liquid lock can be common in cryogenic pressure systems where cryogenic liquid is flowing through the system. Designers should avoid piping installations that could trap cryogenic fluid and, if this cannot be avoided, shall provide overpressure protection as described below. Liquid lock may occur in other types of pressure systems as well, such as systems with incompressible fluids that experience large temperature fluctuations without properly designed liquid expansion vessels.
2. An overpressure protection evaluation is required to determine if liquid lock relief valves are required.
3. If the analysis indicates the pressure increase of the trapped liquid will not exceed the design pressure temperature rating of the piping components, then liquid lock relief protection is not required.
4. If the analysis indicates the pressure increase caused by heating or cooling of the liquid filled piping can exceed the design temperature pressure rating of the piping components, then liquid lock relief protection is required.
5. When liquid lock relief protection is required relief devices must be installed between within the potential liquid lock boundary to prevent over pressurization of the pressure system.
6. Liquid thermal expansion relief valves shall not have a set point greater than leak test pressure or 120% of the design pressure, whichever is lower.
7. Systems do not require provisions for liquid lock relief when the pressure system fluid does not cause pressures in excess of design pressure at single fault conditions.

8.6 OVERPRESSURE PROTECTION EVALUATIONS

A. General

1. Every pressure system shall have an overpressure protection evaluation to determine the pressure relief device needs of the system. The format of the evaluation is not critical; however, the evaluation shall have an independent verification. The evaluation can be developed using AP-341-605, *Calculations*, or by using one of the calculation tools offered by the Pressure Safety Program. Available calculation tools may be found via the ESM Ch. 17 Reference Data SharePoint.
2. If a single-fault condition (not including failure of a relief device) would cause the design pressure of a piping system or the maximum allowable working pressure

(MAWP) of an ASME-stamped item to be exceeded, or cause backfill pressurization beyond the design basis of a vacuum system, overpressure protection is required to protect against over-pressurization.

a. Consideration must also be given to the possibility of latent failure that need to be addressed as single-fault conditions. See Attachment GEN-1, *Definitions and Acronyms*, for more information on latent failure.

3. ASME BPVC Section VIII Division 1 UG-154(e) *Overpressure Protection by System Design* or ASME BPVC Section XIII Part 13 *Rules for Overpressure Protection by System Design* may be used to substantiate the safety of the pressure system without the need for a pressure relief device.

4. Pressure system designs must include a calculation report that includes at least, but not limited to the following:

a. Determination of the maximum pressure that can occur (see A.2 above).

1) If this maximum pressure DOES NOT exceed piping system design pressure or pressure vessel MAWP, a pressure relief device is NOT required, and the calculation is complete.

NOTE: This does not apply to boilers, which are required by code to always be equipped with relief devices.

2) If the pressure CAN exceed the system design pressure or pressure vessel MAWP the calculation determines that a pressure relief device IS required and b. through f. below shall be included in the calculation.

b. Determination of the required relieving flow at single-fault condition (not including failure of a relief device) or latent failure (maximum pressure source flow rate).

c. Determination of the required pressure relief device set pressure (shall be set no higher than pressure system design pressure or vessel MAWP unless allowed by the COR).

d. Determination of the allowable overpressure permitted by the Design Basis.

e. Determination of the pressure relief device capacity at allowable overpressure as required by the COR for the application.

f. Determination of inlet/outlet pressure drop at relieving conditions; this plays a significant role and needs to be included in the relief calculations.

Guidance: The following documents may be used to help evaluate the pressure systems for relief protection.

- Attachment GUIDE-1*, Overpressure Protection Evaluation Guide*
- API Standard 520 *Sizing, Selection, and Installation of Pressure-relieving Devices, Part I, Sizing and Selection*
- API Standard 520 *Sizing, Selection, and Installation of Pressure-relieving Devices, Part I, Sizing and Selection Part II, Installation*
- API Standard 521 *Pressure-relieving and Depressuring Systems*

- API Recommended Practice, Guide for Pressure-Relieving and Depressuring Systems

B. Overpressure protection evaluations for pressure systems using gas cylinders

1. An accurate gas cylinder supply pressure shall be used when performing the evaluation:

   a. Currently, LANL Gas Facility (LOG-PT) can supply four different standard gas cylinders. The gas cylinders are DOT specification packaging 3A2015, 3A2000, 3A2260, and 3AA2265. The maximum supplied pressure is 2265 psig at 21°C (70°F).

   b. However, gas cylinder supply pressure can vary greatly among gas cylinders even for a single gas. For example, nitrogen gas cylinders of varying sizes can provide 225 psig to 2640 psig with CGA 580, 3500 psig with CGA 680, and 6000 psig with CGA 677.

   c. In addition, DOT regulations also allow that some gas cylinders (DOT 49 CFR § 173.302a(b) DOT 3A, 3AX, 3AA, 3AAX, and 3T) may have an internal pressure 10% greater than the marked service pressure at 21 °C (70 °F) if the gas cylinders are stamped with a "+".

2. The replacement of a gas cylinder with a fill pressure that differs from the fill pressure defined in the original overpressure protection is considered a pressure system modification that requires a new overpressure protection evaluation.

3. A flow reducing orifice, also known as a Restrictive Flow Orifice (RFO), may be used on a gas cylinder to reduce the maximum flow below the capacity of the relief device selected for the system.

   Guidance: Use of orifices is not required provided the pressure relief device(s) have a capacity that meets or exceeds the maximum flow rate through the regulator.

C. Overpressure protection evaluations for pressure systems not using gas cylinder supply pressure

1. For a pumping system, the dead head pressure of the pump would need to be evaluated and if a relief device is required; the necessary relief device capacity would be based flow rate/differential pressure on the pump curve. Additionally, if a closed-loop pumping system connects to a makeup water system, full unregulated makeup water pressure (single-fault failure of makeup water pressure regulator) during normal pumping system operations may need to be considered.

2. For a compressor, the flow rate of the compressor at the delivery pressure, or the failure of the high limit switch needs to be evaluated.

3. Internal generation of pressure due to temperature change or a chemical reaction must also be considered when applicable.

4. Other non-reclosing relief devices (e.g., rupture pin/buckling pin and spring-loaded) may also be used. *Guidance: See ASME Section XIII Parts 5 and 6 for more information on the use of these devices.*

8.7 GAS CYLINDER PRESSURE SYSTEMS

A. Pressure systems that connect to gas cylinder pressure sources shall be connected using the correct CGA for the cylinder.

B. Designs including gas cylinders shall use compatible regulators (e.g., don't put an oxygen CGA on a nitrogen regulator). Regulators that are incompatible for the media are prohibited.

C. Piping components used between the gas cylinder valve and the regulator shall be rated for the full as-delivered pressure of the cylinder.

D. Designs without a pressure regulator in the system may be used if the entire system or sub-system are designed to withstand at least the maximum gas cylinder pressure (e.g., a manifold of multiple gas cylinders that connect to a downstream pressure system).

Guidance: Entire pressure systems are generally not designed without regulators because the change in pressure/flow rates as the gas cylinder contents deplete presents operational difficulties.

E. Gas cylinders pressure systems with regulators shall have a regulator manifold incorporated into the design as shown in Figure 3 below.

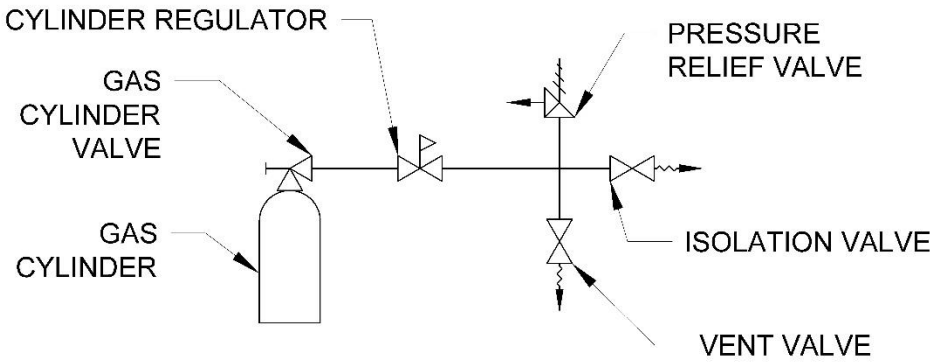


Figure 3

F. The following illustration Figure 4 shows the placement of a flow reducing orifice also known as a Restrictive Flow Orifice (RFO) on a gas cylinder.

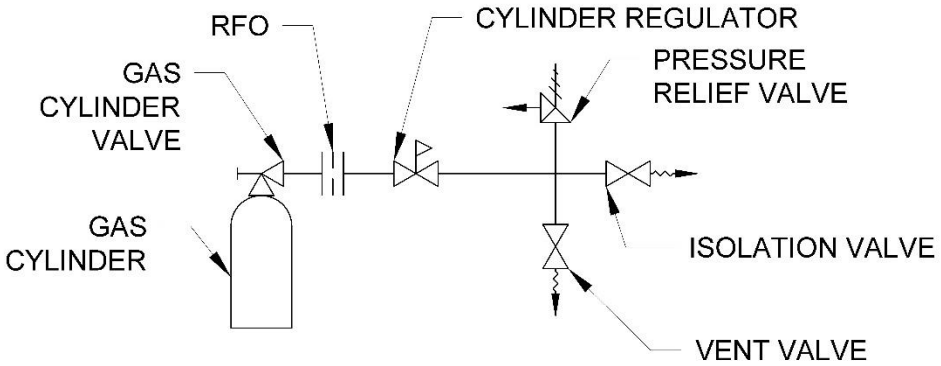


Figure 4

G. The same RFO may be placed after the regulator but may present operational issues since the orifice restriction may decrease operational flowrates. In addition, all items between the regulator and the orifice must be rated for maximum upstream bottle pressure (in the event a regulator fails open). This would include the gauges in the illustration above. It is recommended that RFOs be placed upstream of the regulator.

H. Pressure systems that have flow paths or vents that open directly or indirectly to the atmosphere do not require pressure relief devices (i.e., overpressure protection by system design). *Reference: ASME B&PVC Section XIII Part 11.*

I. Piping components used between the gas cylinder valve and the regulator shall be rated for the full as-delivered pressure of the cylinder.

8.8 GENERAL PRESSURE SYSTEM DESIGN

A. Flexibility Analysis

1. Flexibility analysis of a piping system shall be performed on all new pressure systems with a design temperature greater than 350°F or less than -238°F. Flexibility analysis should be considered for piping systems between -238°F and 350°F when supported beyond deadweight-only pipe support (e.g., lateral seismic supports) because free thermal displacement will be restricted. *(Requirement 17-0232)*

   a. Isometric drawings are required for flexibility analysis and are to be submitted as part of the design.

   b. Software may be used to perform flexibility analyses but must meet ESM Chapter 21, *Software*, requirements (e.g., when ML-1, 2, or 3); see Pressure System Design Software section below.

B. Piping, Tubing, and Flanges

1. Wall-thinning caused by bending of piping or tubing must be accounted for when performing design pressure calculations. This may also be achieved by utilizing an approved vendor tubing or pipe bender or providing a wall thickness 1.5 times the minimum required by the COR for the intrados or extrados of a curved pipe segment. *(Requirement 17-0233)*

2. Design of pressure systems that form and/or bend pipe or tube shall be specified by the Designer and if applicable meet COR requirements. *(Requirement 17-0234)*

   a. Flattening, corrugation, stretching, thinning, wrinkling, and ovaling of piping or tubing shall not exceed the design allowable.

   b. Designs shall address cold or hot formed pipe bends.

   c. Pipe bending shall follow a mandrel or guided bending process. Sand, beads, or other abrasive materials shall not be used to accomplish uniform bends for pressure system tubing or piping.

3. For systems that vent or discharge pressure to ambient surroundings (e.g., manual valves, nozzles, relief devices, solenoid valves), reaction thrust resulting from device discharge shall be evaluated. Systems shall be sufficiently braced to

withstand the maximum and sustained thrust potential. Thrust evaluations shall be documented and receive an independent verification (e.g., AP-341-605 meets this but most evaluations are simple enough that AP-341-605 is not necessary). If evaluations determine that the resultant thrust could impart significant loading onto the system, the anchor and any required piping support shall be defined. *(Requirement 17-0235).*

a. For compressed gas systems, thrust force is usually negligible but justification must still be provided. However, thrust force evaluation is not required when utilizing a compressed gas relief device not larger than ¼" NPS inlet and less than or equal to 150 psig setpoint.

4. Flange bolts and gaskets referenced in ASME PCC-1 *Pressure Boundary Bolted Flange Joint Assembly*, are defined by LANL as listed items if the COR recognizes the referenced code as listed.

C. Pressure System Design Software

1. Use of computer software (e.g., Cosmos®, NASTRAN®, COMPRESS, CAESAR®, Pro/Mechanica®, Ansys®, Algor®) to perform analysis of pressure systems and components is acceptable in performing engineering calculation. However, when the pressure system is ML-1, 2, 3 the software shall meet ESM Chapter 21, *Software* or P1040, *Software Quality Management*. *(Requirement 17-0236)*

D. Piping Supports

1. Follow the COR for piping supports. *(Requirement 17-0237)*

2. When a structural support design is presented by a qualified Designer and is determined to meet ESM Chapter 5, *Structural*, the design meets the ASME B31 piping support element fixtures requirements. Pre-engineered fixtures (e.g., off-the-shelf built to specifications such as Manufacturers Standardization Society (MSS) SP-58) shall meet the applicable ASME B31 COR. *(Requirement 17-0238)*

3. Comply with LANL Master Spec Section 22 0529 *Hangers and Supports for Plumbing Piping and Equipment* for general installations of piping systems.

E. Welding/Brazing Design *(Requirement 17-0239)*

1. Welding/brazing qualifications, welding/brazing procedure specifications (WPS/BPS), and welding/brazing performance qualification shall meet ESM Chapter 13.

2. The Designer shall provide the weld calculation and dimensions.

3. The Designer shall identify the weld process and WPS/BPS.

F. Soldering Design *(Requirement 17-0240)*

1. Soldering is only applicable when permitted by the COR.

2. The Designer shall specify the solder, the flux, and the joints and any pass/fail examination requirements.

3. The Designer is responsible for the pressure rating of the solder joint for the application.

4. The Designer shall specify the soldering process specification as required by the COR. For example, ASME B31.3 and B31.9 requires ASTM B828, *Standard*

Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.

8.9 PRESSURE SYSTEM MATERIALS

A. It is the Designer's responsibility to select materials suitable for the fluid service. Materials are to be selected that resist deterioration in service and meet the service life defined in the PSIP.

1. The Designer shall define the corrosion rate of the piping system based on system fluid and material selection. If necessary, the Designer shall implement corrosion control for the pressure system. See PS-GUIDE for guidance regarding corrosion.

2. Buried steel pipe shall be protected from corrosion by either cathodic protection or a coating.

   a. For cathodic protection design requirements, refer to ESM Ch. 7, *Electrical*, Section G4090, *Other Site Electrical Systems*, 1.0 Cathodic Protection.

   b. If a coating system is used it shall be holiday tested in accordance with ASTM G62, *Standard Test Method for Holiday Detection in Pipeline Coatings*. Method A or B shall be used for determining pinholes, voids, or metal particles protruding through the coating. Method B shall be used to verify the thin spots in the coating.

   Guidance: Master Specification Section 23 2113, Hydronic Piping, Part 3.6 Corrosion Control, contains detailed information for pipe coatings for black steel pipe. This information can be applied to any buried black steel pressure system; it is not exclusive to hydronic piping.

3. Pressure systems that require periodic inspection because of potential corrosion or required corrosion control shall be identified in the design. The expected corrosion rate shall be specified by the Designer. The pressure system owning organization is responsible for implementing necessary preventative maintenance governed by P101-34.

NOTE: The pressure system owning organization is responsible for implementing any necessary preventing maintenance for corrosion control as required by P101-34.

B. When specifying nonmetallic materials, the Designer will select materials that are compatible with the fluid service in the piping system and be capable of withstanding the Design Pressures and Design Temperatures. See PS-GUIDE for guidance regarding selecting nonmetallic materials.

C. The Designer shall select materials that will not contaminate the service fluid.

8.10 SYSTEM INTERACTIONS

(Requirement 17-0241)

A. Pressure systems that are interconnected shall be evaluated to eliminate or control the potential for adverse interactions. Some common examples of interconnected pressure systems include the following:

1. Multiple pressure sources containing the same or different fluids connecting to a common pressure system.
2. One pressure source connecting to multiple pressure subsystems that have incompatible fluids.

B. The following strategies are suitable to eliminate or control the hazards presented by adverse pressure system interactions:

1. Utilizing P101-3, *Lockout/Tagout for Hazardous Energy Control*
2. Utilizing administrative controls via work procedures/processes (e.g., integrated work document (IWD), WPD, etc.)
3. Designing systems that could interact with non-interchangeable fittings
4. Providing overpressure protection for each subsystem suitable to each of their design pressures
5. Designing the system with a double block and bleed configuration
6. Designing the system with double check valves in series where two or more incompatible fluid systems are pressurized by a common pressure source. See example in Figure 5 below.

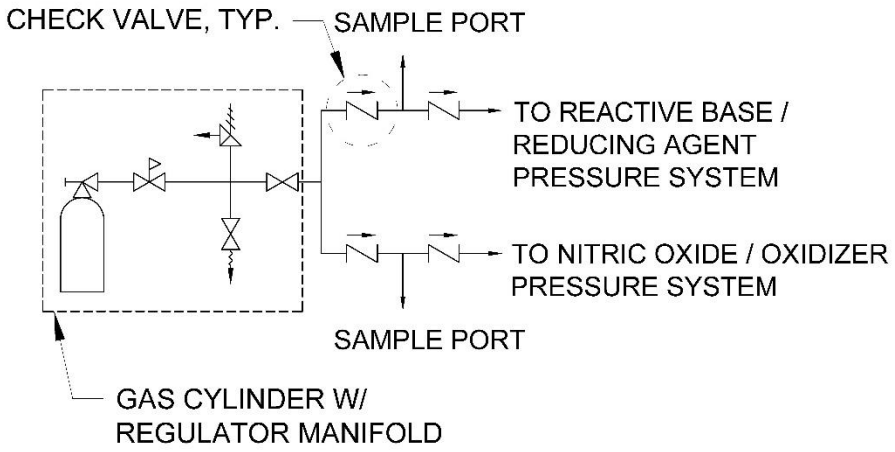


Figure 5

8.11 FLEXIBLE HOSES

(Requirement 17-0242)

A. Flexible hose assemblies without manufacturer's design pressure rating indicated on the hose/flexible tubing shall not be used.

B. Non-metallic hoses may be restricted from flammable service based on the COR.

C. Flexible hoses shall be installed and used in such a manner as to prevent kinking and to minimize torsion, axial loads, twisting, and abrasion.

D. Pre-approved flexible hoses accepted as Listed Components for ASME B31 and NASME Design Basis, respectively, are listed in the ASME Accepted Unlisted Items and NASME Reputable Manufacturers List.

E. All flexible hoses shall be procured in accordance with P101-34, *Pressure Safety*, Attachment D, *Procurement of Pressure Safety Goods or Services*, Section 3.2.4.

8.12 FLEXIBLE HOSE RESTRAINTS

(Requirement 17-0243)

A. General

1. When flexible hoses fail, they can pose a whipping hazard to the worker. Flexible hoses shall be evaluated for reaction thrust load in the event of a failure of the hose.
2. Flex tubing/hoses located inside glove boxes, equipment, or test setups where whipping poses no nuclear safety or personnel danger are excluded from requirements for flexible hose external restraints.

B. External Restraints

1. Flexible tubing and hoses over 12 in. and in service pressure greater than 150 psig must be constrained at both ends or shielded in case of end-connector failure. The maximum separation distance between flexible hose restraints must not exceed 6-ft. intervals. (e.g., an 8-ft. flex hose must use 3 restraints see REQ-9 attachment). Specifically prohibited are free-rotating/translating systems whose designs prohibit securing at 6-ft. intervals.
2. Attachment REQ-9, *Approved Flexible Hose Restraints and Thrust Load Evaluations,* contains information on pre-approved hose restraints and methods for calculating the force from a line failure. This attachment also includes information on other brands that are common and accepted when used within manufacturer guidelines.
3. Approved alternatives or restraining devices approved by a Designer may be used if the restraining device is demonstrated via evaluation to withstand the thrust loads posed by both the initial surge thrust and the sustained surge thrust.
4. Connection of the hose whip restraint to an anchor must be capable of restraining the hose in the event of joint separation.

C. Internal Restraints

1. Flexible hoses that are self-arresting with an internal valve enclosed within each hose end do not require hose restraint because these hoses do not whip. Examples include but are not limited to Global Passive Safety Systems Lifeguard Hose and U.S. Hose Corporation 402X with Spring Guard. Attachment REQ-9, *Approved Flexible Hose Restraints and Thrust Load Evaluations* contains information on pre-approved internal hose restraints and methods for calculating the force from a line failure.

8.13 VENTING OR DISCHARGE OF PRESSURE SYSTEMS

(Requirement 17-0244)

A. All pressure systems shall be designed with a means to manually vent pressure from the system. Loosening fittings to vent pressure is prohibited.

B. Vents and discharges (including relief devices) for hazardous pressure system fluids, e.g., steam condensate, radioactive, flammable, lethal, toxic, reactive, hazardous, or inert asphyxiant gases, must be evaluated for acceptable discharge locations by a Fire Protection, OSH-ISH, or other appropriate SME.

C. Some codes require vent screens, e.g., ASME CSD-1 and NFPA 54. Relief devices and vents that are in an environment which could cause the exhaust ports to be plugged (e.g., insect nests, water, or ice) shall be fitted with a screen or other device to keep them from becoming plugged. Screens/covers shall not inhibit the flow capacity of the relief device.

8.14 INSTRUMENTS

(Requirement 17-0245)

A. Instruments are generally defined as items that are NOT considered "inline portions of instruments" as defined by ASME B31.3 para. 300.2. Common instruments in pressure systems are temperature- or pressure-responsive devices such as pressure gages, pressure transmitters, and transducers.

B. When a manufacturer's published operating range is equal to, or greater than, the design pressure of the system, the instrument shall be considered as meeting the requirements of 10 CFR 851.

1. For pressure gauges, the maximum pressure and temperature rating is typically greater than the dial indicator range. If necessary, contact the manufacturer for these values.

C. When manufacturer's published operating range does not bound the design pressure, then safeguarding shall be applied to instruments to provide an equal level of protection in accordance with 10 CFR 851. These safeguards shall be in order of precedence: 1) engineering controls, 2) administrative controls, 3) personnel protective equipment.

D. When no pressure rating is available, the manufacturer shall be contacted to request this information. If the manufacturer is unwilling or unresponsive to provide a pressure rating, an evaluation of the instrument shall be performed to conservatively assign a pressure rating as follows:

1. Verify all pressure boundary components are sealed with in the instrument case to mitigate material impacting workers in the event of over-pressurization. This could include multiple layers of containment within the case itself.

2. The construction of the instrument shall be conservatively evaluated to estimate the MAWP of the instrument. Estimate a pressure rating for individual components within the instrument case, e.g., stainless steel tubing, plastic tubing, and valves. Use the lowest individually estimated pressure rating as the estimated pressure rating for the instrument.

E. Bourdon-tube pressure and compound pressure vacuum dial-indicating gauges that operate at pressures greater than 15 psig shall be fabricated to protect workers. Two methods that satisfy this requirement include the following:

1. Pressure gauges approved by Underwriters Laboratories (UL) in accordance with UL-404, Standard for Gauges, Indicating Pressure, for Compressed Gas Service – Standard for Safety.
2. Gauge design that incorporates the following
   a. Tempered safety glass, plastic face, or gauge shield; AND
   b. A blowout back or plug.

8.15 SPECIFIC REQUIREMENTS BY SYSTEM TYPE

A. Cryogenic and Pseudo-Cryogenic Pressure Systems *(Requirement 17-0246)*

1. Refer to P101-5, *Cryogens and Compressed Gases: Health and Safety Requirements*, for hazards, design, transportation, filling, storage, use, and specific commodity hazards related to cryogenic and pseudo-cryogenic pressure systems.
2. For systems using ball valves, the ball must have a pressure relief hole designed into the ball to prevent over pressurization inside the ball cavity due to thermal expansion when the valve is in the closed position. The closed position of the ball valve must be installed toward a path with a vent or relief system.
3. All valves and components must be suitable for cryogenic service.
4. Hoses used for cryogenic service must be convoluted stainless steel or specifically designed for cryogenic service.
5. Polymer-lined flexhoses shall not be used.
6. Nonmetallic materials must be compatible with the fluid and be suitable for both the temperature and pressure.
7. The system must be designed for safe cryogenic service for example double-walled pipe with integrated expansion joints.
8. Some pseudo-cryogenic liquefied gases have relatively low vapor pressures at low ambient temperatures and may require the use of check valves to prevent back flow into the container.
9. Design of cryogenic and pseudo-cryogenic liquefied gas pressure systems must take into consideration the effects that change of state of the fluid will have on the piping components (e.g., carbon dioxide "snow" particle impact will erode brass materials).
10. Depending on the fluid used for leak testing and the piping system design temperature it may be necessary to remove the gas or liquid to prevent "ice" formation in the cryogen system.
11. Attachment GUIDE-2, *Oxygen System Design Guide* has additional information on cryogenic oxygen.
12. Carbon dioxide cryogenic systems shall not be repurposed for oxygen because of the potential contamination from combustible materials.

13. Cryogenic Vessels *(Requirement 17-0247)*

    a. The internal portion of a stationary cryogenic vessel shall meet ASME Boiler and Pressure Vessel Code Section VIII.

    b. The vacuum jacket may either meet ASME BPVC Section VIII or other suitable commercial standard such as

        1) CGA 341, *Specification for Insulated Cargo Tank for Nonflammable Cryogenic Liquids*

        2) CGA H-3, *Cryogenic Hydrogen Storage*

        3) NFPA 55, *Compressed Gases and Cryogenic Fluids Code*

14. Relief valves shall be installed whenever cryogenic liquids can be trapped between closures (liquid lock), and on the exterior of the double wall piping to prevent over pressurization.

B. Gas Cylinder Systems

1. Pressure relief devices incorporated integrally into the design of CGA pressure regulators do not perform a pressure protection function for downstream components and shall not be considered as sufficient overpressure protection (ref. CGA Publication E-4).

2. Gas cylinder regulators must meet CGA requirements and use CGA-approved fittings. *(Requirement 17-0248)*

3. Restrictive flow orifices (RFOs) used before a regulator on a gas cylinder (i.e., on the inlet side of the gas regulator) must be rated for full bottle pressure. *(Requirement 17-0249)*

4. Pressure systems designed to be capable of withstanding the full gas cylinder pressure are not required to have overpressure protection *(repeat of Requirement 17-0227).*

    a. Design of pressure systems with gas cylinders shall include the allowable cylinder overpressures in accordance with 49 CFR 173.302a(b), *Special filling limits for DOT 3A, 3AX, 3AA, 3AAX, and 3T cylinders*, if the cylinder ordered or received includes a plus sign (+) after the test date marking on the cylinder.

    b. Pressure systems using hazardous gas cylinders must be designed and evaluated against the requirements of ESM Chapter 10, Hazardous Processes, and its Attachment A: *Hazardous Gas Design*.

    NOTE: ESM Chapter 10 defines Hazardous Gas as toxic, flammable, oxidizing, pyrophoric, or asphyxiating.

    Guidance: Attachment GUIDE-2 – Oxygen System Design Guide, provides guidance for determining risk level of oxygen systems and design recommendations for mitigating risk.

C. Vacuum Systems

1. Vacuum systems that contain a radiological, flammable, toxic, or fluid damaging to human tissues as defined by ASME B31.3 para. 300.2, OR with a design temperature of less than -20°F or greater than 366°F shall meet the requirements of this chapter. *(Requirement 17-0250)*

2. Vacuum systems must be designed for the highest internal pressure from back-fill pressurization, chemical reaction, or thermal effects (including single-fault condition) or equipped with relief device(s) to prevent over-pressurization. *(Requirement 17-0251)*

3. Vacuum systems that **do not** contain fluids or design conditions noted above are excluded from the requirements of this chapter. *NOTE: If connected to a pressurized gas for backfill purposes, the gas source **is** a pressure system and shall meet the requirements of this chapter.*

4. A vacuum vessel that is subject to **less than** 15 psig internal or external ambient pressure shall be designed in accordance with ASME BPVC Section VIII Division 1 for external pressure or the design shall be reviewed to ensure that equivalent safety is provided. *(Requirement 17-0252)*

5. A vacuum vessel subject to internal or external pressure of 15 psig **or greater** shall be designed in accordance with ASME Section VIII Division 1 for both internal and external pressure. *(Requirement 17-0253) NOTE: a design rating of full vacuum may be applied where applicable as defined in ASME Sec VIII-1.*

D. Oxygen and Other Strong Oxidizing Media Systems *(Requirement 17-0254)*

1. Oxygen Systems

   a. Oxygen-Fuel Gas pressure systems (e.g., oxy-acetylene) shall meet NFPA 51, *Systems for Welding, Cutting, and Allied Processes*. *(Requirement 17-0255)*

   b. Oxygen piping systems shall meet ASME B31.3. *(Requirement 17-0256)*

   c. Oxygen systems shall be designed, fabricated, cleaned, and tested to control ignition hazards at the design temperature, pressure, and oxygen concentration of the system. *(Requirement 17-0257)*

   d. High pressure oxygen systems above 350 psig require an Oxygen Hazards Analysis and Failure Modes and Effects Analysis (FMEA). This requirement may be applied by the CPSO on oxygen or other strong oxidizing media systems less than 350 psig depending on the application.

      Guidance: PS-GUIDE provides guidance for determining risk level of oxygen systems and design recommendations for mitigating risk.

2. General

   a. Regulators for oxidizing media must be oil free, cleaned for oxygen service, and contain materials suitable for the pressure and temperature of the system.

   b. Quick opening valves are not recommended, for example fast acting solenoid valves or quarter turn ball valves. Rapid changes in pressure due to quick opening components increase the risk of oxygen fire.

   c. The Designer shall specify items to stop the kindling chain reaction if a fire were to ignite.

   d. The Designer shall specify that cutting wheels on tubing cutters shall be free from grease, oil, or other lubricants not suitable for oxygen service.

   e. The Designer shall specify joints to be brazed, welded, compression fittings, butt welded, or flanged. Particulate generating fittings are not

allowed (e.g., NPT threads are an interference thread and generate particles). Purge gases may be required when brazing or welding to prevent the formation of oxides on the interior of the joint.

f. Oxygen or Oxidizing Service Cleaning

1) The Designer shall specify the cleanliness level (particulate and non-volatile residue) as determined by evaluation of the system temperature, pressure, and concentration of oxygen. Specifications for cleanliness of O_2 service pressure systems include:

a) ASTM G93 Standard Practice for Cleanliness Levels and Cleaning Methods for Material and Equipment Used in Oxygen-Enriched Environments

b) CGA G-4.1 Cleaning Equipment for Oxygen Service

c) EIGA/IGC 33 Cleaning of Equipment for Oxygen Service Guideline

2) Components, piping, and tubing specified for oxygen or oxidizer service must be cleaned as specified in this document, before assembly, and must be assembled in a manner that maintains cleanliness.

3) Additional information is contained in Attachment GUIDE-2, *Oxygen System Design Guide*, which may aid in meeting requirements stated here and below.

g. Material Requirements

1) Materials used for cleaning and leak-checking oxygen systems shall be compatible for use with oxygen. Hydrocarbon-containing soap solutions shall not be used for leak-checking these systems.

2) Oxygen systems with a design pressure greater than 350 psig shall contain no interconnecting hoses using polymeric materials.

3) Non-metallic materials used in oxygen service shall be evaluated for the oxygen concentration, design pressure, and design temperature.

h. Oxygen System Design

1) The oxygen system shall be designed to control ignition mechanisms. These mechanisms include but are not limited to adiabatic heating (heat of compression), particle impact, frictional heating, and mechanical impact. Example references include the following documents:

- ASTM G128, Standard Guide for Control of Hazards and Risks in Oxygen Enriched Systems
- ASTM MTG 36, Safe Use of Oxygen and Oxygen Systems, Second Edition 2007
- NSS 1740.15, JANUARY 1996, SAFETY STANDARD FOR OXYGEN AND OXYGEN SYSTEMS, Guidelines for Oxygen

System Design, Materials Selection, Operations, Storage, and Transportation

- NASA/TM-2007-213740, Guide for Oxygen Compatibility Assessments on Oxygen Components and Systems
- GLP-QS-8715.1.5 Revision C, Glenn Research Center, Glenn Safety Manual Chapter 5 Title: Oxygen

2) Only pressure regulators intended for oxygen service must be used. Oxygen regulators must not be used with other gases and must be maintained clean for oxygen service when not in use (see American Society for Testing and Materials (ASTM) G93, Standard Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments).

i. Oxygen System Lubricants

1) The Designer shall specify any oxygen system lubricants for the pressure system.

a) The Designer shall specify cutting lubricants for fabrication.

b) The Designer shall specify thread lubricants for assembly.

c) The Designer shall specify component assembly greases or packing materials.

2) Hydrocarbon-based lubricants shall not be used in gaseous oxygen or liquid oxygen (LOX) systems because they can easily ignite; the incorrect use of hydrocarbon-based lubricants is a common cause of oxygen system fires.

Guidance: The best lubricants for compatibility with high-pressure oxygen are highly fluorinated materials.

3) In addition to the above references, the following documents specifically address lubricants:

- MIL-PRF-27617 *Performance Specification, Grease, Aircraft and Instrument, Fuel and Oxidizer Resistant*
- DOD-PRF-24574 (SH) *Performance Specification, Lubricating Fluid for Low and High Pressure Oxidizing Gas Mixtures*
- ASTM G63, *Guide for Evaluating Nonmetallic Materials for Oxygen Service*

E. Hydrogen and Flammable Fluid Pressure Systems *(Requirement 17-0258)*

1. Hydrogen, Deuterium, and Tritium Pressure Systems

a. For hydrogen, deuterium, and tritium pressure systems, the requirements of ASME B31.3 shall be applied for items that fit within the scope of the code. Application of ASME B31.12 to these systems is optional. *(Requirement 17-0259)*

b. Systems containing hydrogen, deuterium, or tritium shall be evaluated for hydrogen embrittlement.

c. Tritium system design basis shall include DOE-HDBK-1129, Tritium Handling and Storage.

d. Flame arrestors, when used, must be rated for hydrogen.

2. Flammable Fluid Pressure Systems

a. Electrical components (solenoid valves, power strips, electrical control cabinets) must be intrinsically safe when required by the National Electric Code (NEC).

b. Flammability of binary gas mixtures shall be determined in accordance with the CGA P-23.

c. The Lower Explosive Limit (LEL), Upper Explosive Limit (UEL) of the fluid shall be in accordance with the Safety Data Sheet (SDS) of the material.

d. If the LEL or UEL limits must be determined see ASTM E681, Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases), or other equivalent methods.

e. Bonding and grounding must be evaluated for storage vessels and nonmetallic hoses, storage vessels, and systems by Fire Protection, OSH-ISH, or other appropriate SMEs.

f. An Emergency Isolation Valve (EIV) is required outside the building for a flammable gas distribution system inside a facility.

F. Facility Natural Gas and Liquefied Petroleum Gas *(Requirement 17-0260)*

1. LANL natural gas from the outlet of the natural gas distribution low-pressure regulator or meter to the appliance must comply with NFPA 54, National Fuel Gas Code.

a. Other codes may apply for safety features of the gas supply, e.g., ASME CSD-1 or NFPA 85 for boilers.

2. Comply with LANL Master Spec Section 23 1123, *Facility Natural-Gas Piping,* for general installations of NFPA 54 systems. Update 23 1123 for boilers installations with specific gas train requirements like ASME CSD-1 or NFPA 85.

3. Facility piping systems that supply liquefied petroleum gas shall comply with NFPA 58, *Liquefied Petroleum Gas Code* or ASME B31.3, *Process Piping*.

NOTE: The LANL master specifications do not currently cover NFPA 58 design.

G. Natural Gas Distribution (LANL Natural Gas Distribution System to Outlet of Low-Pressure Regulator or Meter) *(Requirement 17-0261)*

NOTE: This article contains supplemental information to ESM Chapter 3 Civil Section G30, paragraph G3060 Natural Gas and the two documents should be used concurrently. If/when G3060 indicates that it supersedes this material, then follow it preferentially.

1. Introduction, Purpose, and Scope

a. The 49 CFR 192, Transportation of Natural and Other Gas by Pipelines; Minimum Federal Safety Standards; and ASME B31.8, Gas Transmission and Distribution Piping Systems apply to the LANL natural gas

distribution system until the outlet of the low-pressure regulator to the building or appliance. Both the ASME and the CFR must be satisfied (the most stringent code or CFR requirement shall apply).

b. While ASME Codes are issued at discrete intervals, the CFR may change at any time. The design should check the official website for the most current requirements.

2. Definitions

a. Specified Minimum Yield Strength (SMYS):

1) For steel pipe manufactured in accordance with a listed specification, the yield strength specified as a minimum in that specification; or

2) For steel pipe manufactured in accordance with an unknown or unlisted specification, the yield strength determined in accordance with §192.107(b).

b. Hydrostatic Design Basis (HDB) for plastic pipe is in accordance with PPI TR-4/2.

c. Class Location Unit is an onshore area that extends 220 yards (200 meters) on either side of the centerline of any continuous 1- mile (1.6 kilometers) length of pipeline.

3. Mandated Codes and Standards

a. 49 CFR 192, Transportation of Natural and Other Gas by Pipelines; Minimum Federal Safety Standards

b. ASME B31.8, Gas Transmission and Distribution Piping Systems

c. ASME B31.8S, Managing System Integrity of Gas Pipelines

4. Design Basis

a. Design pressure is 100 psig for wall thickness and testing.

b. Design temperature for buried pipe (most commonly HDPE) is 60°F.

c. Design temperatures for above ground pipe (most commonly steel) are:

i. Winter: 5°F dry bulb.

ii. Summer: 89°F dry bulb, 60°F wet bulb.

d. Pipe shall be limited in design to less than 20% of SMYS.

e. Maximum normal operating pressure is 60 psig.

f. Piping shall be designed for a Class Location Unit 4.

g. Piping components shall be as listed in 49 CFR 192.7 or Appendix B, and items that conform to standards or specifications referenced in ASME B31.8.

h. Cast iron and ductile iron pipe is prohibited from use.

i. Each pipeline must be designed with enough flexibility to prevent thermal expansion or contraction from causing excessive stresses in the pipe or components, excessive bending or unusual loads at joints, or

undesirable forces or moments at points of connection to equipment, or at anchorage or guide points.

j. A service regulator shall have a relief device included in the design.

k. A low-pressure regulator shall have a relief device included in the design.

l. Branch connections less than 4:1 run: branch ratio may use ASME B16.11 fittings (weld-o-lets).

m. Metallic welding shall comply with ESM Chapter 13 - *Welding, Joining & NDE*.

n. Plastic Pipe: Comply with ESM, Chapter 13 – *Welding, Joining & NDE* and 49 CFR 192.283 and 192.285. Do not use electrofusion fittings without contacting a LANL U&I Group gas system representative.

o. The requirements of 49CFR192.629 Purging of pipelines, B31.8 841.2.7 Precautions to Avoid Explosions of Gas–Air Mixtures or Uncontrolled Fires During Construction Operations, and B31.8 831.4.2 Special Requirements (j) shall be met.

p. LANL Utilities and Infrastructure (UI) shall provide the labor to perform connection at distribution tie-in and all hot-tap operations.

q. The thickness of the base metal must be specified (t); the minimum leg dimension of the fillet weld (0.7t throat dimension), and the maximum leg dimension of the end fillet weld (1.0t throat dimension).

r. Any special joint preparation shall be identified and engineered.

s. If an approved welding procedure specification (WPS) does not exist for the required weld, a new WPS shall be generated.

t. Calculations shall be provided when performing horizontal directional drilling (HDD) or other pipe pulling operations to ensure the piping will handle all stresses experienced during and after construction.

u. All piping systems shall be tested after construction to the requirements of the B31.8 and Title 49 CFR 192 except for pre-tested fabricated assemblies and welded tie-in connections where post construction tie-in testing is not practical.

v. The circumferential welds associated with connecting pretested assemblies, pretested repair pipe lengths or sections, and welded tie-in connections not pressure tested after construction shall be inspected by radiographic or other accepted nondestructive methods in accordance with para. B31.8 826.2.

w. Nonwelded tie-in connections not pressure tested after construction shall be leak tested at not less than the pressure available when the tie-in is placed into service.

x. Butt weld ends shall be in accordance with ASME B31.8 Mandatory Appendix I, End Preparations for Butt Welding.

5. Special Interpretations

a. Minimum plastic pipe SDR is SDR11 for HDD.

b. Design shall provide the total connected natural gas load in BTUs per hour, input requirement for each connected device in BTUs per hour with device room location, and pressure requirement at building wall.

c. Meters: Provide a gas meter for any building with a heating unit with an input BTU requirement of 5,000,000 BTU/hr or greater. The meter shall

1) be installed downstream of the low-pressure natural gas regulator.

2) be electronic and connected to the building automation system for monitoring.

3) incorporate pressure and temperature compensation.

d. Comply with the following LANL master specification and drawing details:

1) Master Specification 33 5100, *Natural-Gas Distribution*

2) Civil Detail ST-G3010-1, Valve Box

3) Civil Detail ST-G3060-1, *Site Gas Piping Tie-in*

4) Civil Detail ST-G3060-2, *Gas Regulator Station*

6. LANL Special Requirements

a. Provide 1 inch, 1-1/4-inch, 2-inch, or 3-inch Polyethylene service line and 2-inch minimum polyethylene (PE) main line as required for the delivery and to integrate with the existing piping.

b. When pneumatically testing piping, the test area shall be cleared of unauthorized personnel. ASME PCC-2, Repair of Pressure Equipment and Piping, Part 5, Article 5.1, paragraph 6.2 Pneumatic Pressure Test of Pressure Vessels or Piping, (page 202) may be used for the test clearance area determination.

c. Plastic piping shall be polyethylene, high density ASTM D2513, PPI-PE4710, SDR 11 iron pipe size, ASTM D3350 cell classification number 445574C, Driscopipe 8100 or Yellowstripe 8300), no substitution.

d. Steel pipe shall be protected from the burial corrosion by either cathodic protection or a coating.

e. For cathodic protection design requirements, refer to the ESM Electrical Chapter 7, Electrical, Section G4090, Other Site Electrical Utilities, 1.0 cathodic protection.

f. A factory applied fused coating system consisting of; an adhesive primer layer, with minimum 10 mil thermoplastic elastomer layer and minimum 40 mil polyolefin top layer containing UV protection; or alternatively an epoxy primer layer with minimum 50-mil high-density polyethylene top layer.

g. If a coating system is used it shall be holiday tested in accordance with ASTM G62, Standard Test Method for Holiday Detection in Pipeline Coatings. Method A or B shall be used for determining pinholes, voids, or metal particles protruding through the coating. Method B shall be used to verify the thin spots in the coating.

h. Use steel pipe if gas line is installed less than 20 feet from steam and condensate lines.

H. Steam/Condensate Pressure System Design *(Requirement 17-0262)*

NOTE: This article contains supplemental information to ESM Chapter 3 Civil Section G30, paragraph G3040 Steam/Condensate. The two standards should be used in conjunction during design.

1. Special requirements exist for boiler external piping. Reference the B31 COR and the figures to determine applicability and requirements:

   a. B31.1 Power Piping

      1) Figure 100.1.2-1, *Code Jurisdictional Limits for Piping — An Example of Forced-Flow Steam Generators with No Fixed Steam and Waterline*

      2) Figure 100.1.2-2, *Code Jurisdictional Limits for Piping — An Example of Steam Separator Type Forced-Flow Steam Generators with No Fixed Steam and Waterline*

      3) Figure 100.1.2-3, *Code Jurisdictional Limits for Piping — Drum-Type Boilers*

      4) Figure 100.1.2-4, *Code Jurisdictional Limits for Piping — Isolable Economizers Located in Feedwater Piping and Isolable Superheaters in Main Steam Piping (Boiler Pressure Relief Valves, Blowoff, and Miscellaneous Piping for Boiler Proper Not Shown for Clarity)*

   b. B31.9 Building Services Piping

      1) Figure 900.1.2, *Code Jurisdictional Limits for Piping — Drum-Type Boilers*

2. Steam/condensate pressure systems not exceeding 150 psig design pressure nor outside the 0-366°F design temperature range, ASME B31.9, *Building Services Piping*, is the most applicable design code, or other design codes such as ASME B31.1, *Power Piping*.

3. For steam/condensate outside the B31.9 scope limits, comply with ASME B31.1, *Power Piping*.

   a. Condensate piping outside of the building that returns to a central steam plant shall comply with ASME B31.1, *Power Piping*.

4. For new buildings in Technical Area 3 (TA-03) using the site steam distribution system (TA03-0022), design for incoming temperature/pressure of 500°F and 125 psig; operating pressure/temperature of 85 psig/366°F. For the condensate return system design for 250°F and 125 psig; operating pressure/temperature of 85 psig/200°F.

5. The use of cast iron is not permitted.

6. Refer to the following for additional information that may aid in the design of steam/condensate pressure systems:

   a. Master Specification 23 2215, *Steam and Condensate Heating Piping and Specialties (Note: B31.9 COR)*

b. Master Specification 33 6300, *Steam Energy Distribution (Note: B31.1 COR)*

c. Civil Standard Detail ST-G3040-1, *Site Steam/Condensate Tie-in (Note: B31.1 COR)*

d. Civil Standard Detail ST-G3040-2, *Site Steam Drip Leg (Note: B31.1 COR)*

e. Mechanical Detail ST-D3020-2, *Steam Pressure Reducing Valve (PRV) Station (Note: B31.9 COR)*

f. Mechanical Detail ST-D3020-3, *Steam Drip Leg (Note: B31.9 COR)*

g. Mechanical Detail ST-D3020-4, *Steam Drip Pan Elbow (Note: B31.9 COR)*

9.0 FABRICATION/ASSEMBLY REQUIREMENTS

(Requirement 17-0263)

A. Piping and Tubing

1. Cold spring (twisting or distortion of piping or components for alignment) that introduces strain in equipment or piping components shall be accounted for in the design so as not to be detrimental to pipe supports, or equipment (nozzle loads).

2. If misalignment occurs during fabrication and cold spring is not included or allowed in the design piping must be reworked to remove cold spring.

3. ASTM B88 and B280 tubing that meets UL 207 and UL 1963 wall thickness standards are acceptable for use.

   Guidance: Check the ASME Allowed Unlisted Components List for the allowable pressure ratings.

B. Tubing Joint Assembly

1. Swagelok compression tubing fittings are approved for use as listed components. Any other manufacturer's flareless or compression tubing fittings are not considered listed and shall be evaluated prior to use.

2. Intermixing of manufactures proprietary piping components is not allowed (e.g., Swagelok compression tube fitting bodies with Parker ferrules).

3. Flareless and compression tubing joints shall be assembled per the manufacturer's instructions.

4. Swagelok compression fittings shall be assembled and reassembled as required by the Swagelok manufacturer documents.

   a. Reference MS-13-151, *An Installer's Pocket Guide for Swagelok Tube Fittings*

   b. Swagelok Tube Fitter's Manual, 2016 or latest edition.

5. If the design uses flared tubing joints (e.g., Society of Automotive Engineers Standards 513 and 514), it shall specify the acceptance criteria of the flare and the flare imperfections.

6. Personnel fabricating system using compression tubing joints must be trained in accordance with UTrain Course 30831, *Compression Fittings Assembly* or approved equivalent.

C. Threaded Joint Assembly

1. NPT joint assembly shall be in accordance with ASME B1.20.1 3.1.9 Wrench-Tight Engagement between External and Internal Taper Threads.
2. Intermixing of different thread types is not allowed (e.g., straight thread and pipe thread).
3. The design shall specify if threaded fittings must be lubricated and the type of lubricant that is compatible with the system fluid (e.g., halocarbon, hydrocarbon, fluorocarbon, etc.).
4. Unless otherwise specified by the Designer, NPT pipe fittings shall use polytetrafluoroethylene (PTFE) tape.
5. Other types of threaded fittings shall be assembled per the manufacturer's directions.

D. Flanged Piping Joint Connection Assembly

1. The fastener assembly load (torque) design must follow the most applicable of the following:
   a. Manufacturer standards, joint design, and the materials of construction,
   b. A published specification or controlled standard based on the COR,
   c. ASME PCC-1, *Pressure Boundary Bolted Flange Joint Assembly*, as allowed by the COR,
   d. ASME BPVC Section VIII, Division 1, Mandatory Appendix 2, *Rules for Bolted Flange Connections with Ring Type Gaskets*, as allowed by the COR,
   e. Applicable B31 piping COR calculations, or
   f. Special calculations by the Designer accepted by the Owner.
2. Assembly torque of flange bolts must include directions on the use of lubricant or directions not to use lubricant. If lubricant is required, the type of lubricant and how it will be applied must be specified.
3. Flanges must be repaired or replaced whenever any damage has been caused to the sealing surface that prevents the gasket from sealing. Excessive torque beyond torque specifications to achieve a leak-free seal is strictly prohibited.
4. Nuts must have full thread engagement on the bolts or studs. One to two exposed threads are the preferable amount that defines full thread engagement. The minimum acceptable engagement is the outer edge of the nut being not less than flush with the end of the bolt or stud.
5. The faces and bolt holes of flanges must be concentrically aligned, with the flange faces parallel as required by the COR.
6. Bolted flanges shall be retorqued approximately 24 hours after initial torque following assembly, and prior to any leak or pressure tests.
7. New flange gaskets may be required when flanges are loosened.

8. The Designer shall specify the fasteners required to assemble flanges.
    a. The internal and external thread class of the fasteners per ASME B1.1, *Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms)*
    b. Bolt or stud in accordance with ASME B18.2.1, *Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)*
    c. Nut in accordance with ASME B18.2.2, *Nuts for General Applications: Machine Screw Nuts; and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)*
    d. Washers in accordance with ASME B18.21.1, *Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)*

NOTE: Flange bolts and gaskets referenced in ASME PCC-1 Pressure Boundary Bolted Flange Joint Assembly, are defined by LANL as listed items if the COR recognizes the referenced code as listed.

E. Welded and Brazed Joint Assembly

1. The Designer shall specify welding or brazing requirements necessary to meet any applicable code(s) of record and ESM Chapter 13.
2. Welding procedures and personnel shall be certified for the application that they are performing through the LANL welding program, as defined by ESM Chapter 13. See also LANL Master Specification Sections 01 4444, *Offsite Welding and Joining Requirements;* 01 4455, *Onsite Welding and Joining Requirements*; and 01 4631, *Welding of B31 Piping*.
3. Onsite welding must be performed by welders that are currently certified, having completed testing and qualification in accordance with ESM Chapter 13, GWS 1-05, *Welder Performance Qualification/Certification*.
4. Welding on pressure systems must be inspected by a certified welding inspector, AWS CWI, when mandated by applicable ASME BPVC or B31 codes as defined in ESM Chapter 13.
5. Dissimilar material connections involving welding or brazing of piping components or attachments to those piping components shall be specified in the engineering design.

F. Adhesive Joint Assembly

1. Solvent welding is governed by ESM Chapter 13.
2. Adhesives, cements, and sealers used to join piping components shall be compatible with the materials being joined and shall conform to applicable ASTM specifications when required by the Design Basis.

G. Soldered Joint Assembly

1. Soldering is permitted if allowed by the applicable COR or Design Basis.
2. Personnel performing soldering shall meet the process defined by the Designer. For example, ASME B31.3 and B31.9 requires ASTM B828, *Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings*.

10.0 EXAMINATION/INSPECTION/TESTING REQUIREMENTS

10.1 EXAMINATION

(Requirement 17-0265)

A. Nondestructive Examination (NDE) shall be done in accordance with the Design Basis.

B. Piping codes, if part of the Design Basis, defines the minimum required examinations and pass/fail criteria that are required.

C. Examination personnel must have the knowledge, skills, and abilities to perform the required test process adequately and safely. In some cases, specific training, qualification, or certification requirements will apply. Examination personnel shall be trained and qualified to the requirements of the COR when applicable. ESM Chapter 13, *Welding, Joining & NDE*, provides a database of qualified examiners and the specific examination methods for which they are qualified.

NOTE: Additional examination and inspection outside of ESM Chapter 17 and the Design Basis may be required by ESM Chapter 16, Building Code Program.

10.2 INSPECTION

(Requirement 17-0266)

A. Pressure system inspection activities that occur within the scope of ESM Ch. 17 and their requirements are detailed here. *NOTE: inspection activities for existing pressure systems are detailed in P101-34 Attachment A, Acceptance for Use (AFU) of Pressure Systems.*

B. Inspection shall be done in accordance with the Design Basis or the COR.

C. For inspections to ASME code Design Basis pressure systems, LANL will appoint the Owner’s Inspector, Owner's Inspector delegate, and/or Authorized Inspector as applicable.

D. Inspection activities shall be performed by an Inspector with an appropriate level of qualification as defined by Table 2, *Approved Inspector for Design Basis Activities*.

Table 2. Approved Inspector for Design Basis Activities

	Design Basis			
PSP Inspector	**ASME BPVC Section I through XIII, and B31.1 Boiler External Piping**	**Supporting Piping & ASME B31 or NFPA 54/58 Piping Codes**	**Non-Supporting Piping & NASME B31 Code Equivalencies**	**10 CFR 851 Compliant Evaluation**
Authorized Inspector	**R**	**√**	**√**	**√**
Owners Inspector or Designee	**-**	**R**	**R**	**√**
Inspector	**-**	**-**	**-**	**R**

R Minimum required level of applicable Inspector

√ May serve as applicable Inspector

- May NOT serve as applicable Inspector

NOTE: Table 2 does not include all ESM inspection activities for example ESM Chapter 16, *Building Code Program*.

10.3 PRESSURE AND LEAK TESTING

(Requirement 17-0267)

A. General Requirements

1. Testing requirements will be specified in the design and performed according to the COR. *For 10 CFR 851 Design Basis, it is recommended to follow the most applicable ASME B31 code's testing requirements for the sake of simplicity in providing an equivalent level of protection.*
2. There are several ASME Code Cases and/or Interpretations that provide additional clarification of testing requirements. See Common Applicable ASME Code Codes and Interpretations, below, for a non-exhaustive list of common applicable Code Cases and/or Interpretations. Details on the interpretations can be found by accessing the ASME Interpretations Database and entering the Record #, Interpretation #, or keyword information.
3. A written test plan must be created to define the testing and requirements and to record testing results. The test plan will contain the following (at a minimum) and the results of the test recorded and documented:
   a. Test system description
   b. Design basis including the COR, if applicable
   c. Date of the test
   d. Design pressure

e. Acceptable test pressure range

f. Test duration

g. Test instrumentation used

h. Instrument calibration records

i. Test pressurization system (means of achieving test pressure and media used for testing)

j. Test pressurization system relief device (if required)

k. Necessary data required for any NDE

1) NDE method used, including NDE procedure if applicable

2) Examiner qualification

l. Exclusion zone required during testing

m. Required personal protective equipment (PPE)

n. Result of the test, pass/fail

o. The examiner and inspector employee or Z number and signature

NOTE: Form 2304, Pressure and Leak Test Plan, may be used for this section.

4. Pressure or leak tests must be conducted from a safe distance with positive control of personnel access.

5. All uninvolved persons will be removed from the test area and barricades installed.

6. Personnel exclusion zones for pneumatic leak testing are based on the contained energy of the system in accordance with ASME PCC-2, Article 5.1 Mandatory Appendix II and III or equivalent.

   NOTE: Pneumatic tests above 1000 lb.-ft. stored energy requires CPSO/DCPSO review and approval of exclusion zone. Pneumatic tests below 1000 lb.-ft. stored energy do not require additional approval.

   NOTE: For piping systems the volume of the stored energy calculation is based on a length of 8 (confirm value in AMSE PCC-2, Article 5.1) pipe diameter.

7. Personnel, including personnel performing the test, are not allowed in the exclusion area while the pressure test or leak test is pressurizing or while the test pressure is being held. Entry into the exclusion zone for examination is only allowed after the hold period, and the pressure must be reduced to the design pressure when allowed by the COR.

8. Pressure or leak testing shall not be performed when metal temperatures are near the ductile-brittle transition temperature, as that may lead to brittle fracture.

9. Hydrostatic or pneumatic testing media may not contain radioactive nuclide materials to prevent inadvertent release.

10. Pressure or leak testing may not be performed with cryogenic, flammable, Category M (toxic), corrosive, pyrophoric, oxygen or strong oxidizers, steam, radioactive, or radioactive liquid waste fluids.

11. Hydrostatic tests shall be performed with water. If water is not suitable (could freeze, or cause adverse effects to piping or process), another suitable non-toxic liquid may be used. Considerations shall be made for the disposal of any testing fluid.

12. Pneumatic tests shall be performed with air or other inert gases except when permitted otherwise by design.

13. Initial service leak tests are permitted for ASME B31.3, ASME B31.9, and B31.3/B31.9 NASME equivalency design basis pressure systems when they meet the prerequisites for this testing method (e.g., must be Category D fluid to qualify for B31.3 initial service leak test).

14. Test instrumentation used to meet the pressure and leak testing requirements of this document must be calibrated as required by P330-2, *Control and Calibration of Measuring and Test Equipment (M&TE)*.

    Calibration is the process of verifying the capability (accuracy, range, and tolerance) and performance of M&TE either by direct or comparative methods to a National Institute of Standards and Technology (NIST) traceable measurement standard.

    Organization-specific procedures may also be necessary. The AP-341-801, *Post Modification/Post Maintenance Testing*, defines required post modification testing / post maintenance testing (PMT) of active structures, systems, and components (SSCs) performed after completion of modifications and maintenance activities but before returning the SSC to service.

    NOTE: If the designer is using equipment that requires calibration, the equipment must be enrolled in the LANL Calibration Program. The Metrology Program and Calibration Laboratory (MPCL) will ensure that requirements for acceptability have been properly met. The MPCL may be able to accept factory calibrations, so long as the factory calibration fulfills DOE/NNSA requirements for vendor provided calibrations.

15. Test plans shall provide a means for a controlled release of pressure (e.g., vent or drain valves). Loosening of fittings, caps, plugs, or flanges to release pressure is not permitted.

16. All leak testing methods require examining for leaks. If leakage is below the acceptance criteria, the system passes. If leakage is above the acceptance criteria, the system shall be depressurized, the leak location repaired, and the system re-tested.

17. Preliminary leak testing is allowed in accordance with the COR and shall be defined in the test plan.

18. Relief devices and other protective measures shall be utilized to protect against over pressurization during the testing in accordance with code of record requirements. This requirement is applicable to pneumatic, hydrostatic, and hydro-pneumatic testing.

    a. Relief devices shall have a set pressure and capacity calculation to verify and prevent the system from exceeding the test pressure constraints of the code of record.

    b. The relief device shall not be adjustable and shall be sealed at the required set pressure.

c. A vacuum breaker valve may be required to prevent a system from being exposed to external pressure.

19. Temporary pressure systems utilized for pressure or leak testing (e.g., portable testing rigs) must also meet the requirements of this chapter.

Guidance: A test and inspection plan in accordance with ESM Chapter 16, Building Code Program, may also be required.

B. Modifications to Existing Systems

1. For existing pressure systems that require system modifications, or any other action which requires the system to be opened and modified by installing a new joint (or removal and replacement of components for maintenance purposes), the affected section of piping must be tested and examined as follows in Figure 6:

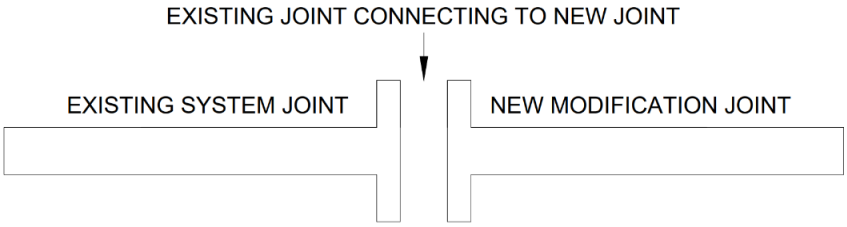


Figure 6

a. For welded connections on FS1 and FS2 systems (N/A for FS3 and FS3-ULH) where elevated pressure leak test is not possible (e.g., unknown if existing system can withstand full COR test pressure):

1) Full penetration weld: perform volumetric examination.

2) Partial penetration weld: perform surface examination.

3) Perform in-service leak test as follows:

a) Verify the joint is leak free with internal pressure. If possible, gradually increase pressure until the line pressure is reached, holding the pressure at each step long enough to equalize piping strains. Systems under 1000 lb.-ft. stored energy can be brought up in one step.

NOTE: The procedure for executing the in-service testing defined does not require any instrumentation (e.g., calibrated pressure indicator, reference indicator on system, etc.).

b) Between each pressure step, examine the affected joints for indications of leaks.

b. For welded connections that can be leak tested at elevated pressure (e.g., tested at full design basis/COR test pressure):

1) Test plan must be approved by pressure safety SME as part of the pressure system design review or subsequent submittal reviews.

c. For mechanical (e.g., threaded, flanged) connections:

1) FS1 systems: CPSO/DCPSO must approve test method.

2) All other fluid category systems: perform in-service leak test as described in 1.a.3) above.

d. For leak testing pressure system modifications that only consist of ASME B31 piping code or LANL CPSO-approved components, with mechanical connections and/or code tested sub-assemblies, where mechanical connections are assembled in accordance with manufacturer's instruction or the applicable code or standard:

1) Perform an in-service leak test described by 1.a.3) above, or may also be performed by either or both tests as follows:

a) *Vacuum rate-of-rise method:* To execute a vacuum rate-of-rise leak test, the relevant sections of the system are evacuated to a predetermined absolute pressure level. The evacuation is stopped, and the system pressure (absolute) monitored for at least five minutes. The acceptance criteria shall be specified by the Designer and shall be determined independently for each unique leak test situation based on system parameters such as volume, number of joints, and system function. Acceptance criteria shall be specified as an acceptable rate of absolute pressure rise. PSO approval is required for specified acceptance criteria greater than 10^{-3} standard cc/sec.

b) *Pressure Decay Method:* Trial run of substitute referee inert gas at same operating conditions as will exist with process gas: Conduct a trial run at the same pressure, temperature, and other salient operating conditions as process gas with substitute inert gas prior to introduction of the process gas. The pressure system shall be examined for evidence of leakage at the joints during the referee inert gas test. The acceptance criteria shall be specified by the Designer and shall be determined independently for each unique leak test situation based on system parameters such as volume, number of joints, and system function. PSO approval is required for specified acceptance criteria greater than 10^{-3} standard cc/sec.

2. Pressure systems that that are modified as stated above but include new joints connecting to new joints (not existing construction) must undergo a Designer-specified pressure and or leak test per the Design Basis. Example illustration shown below.

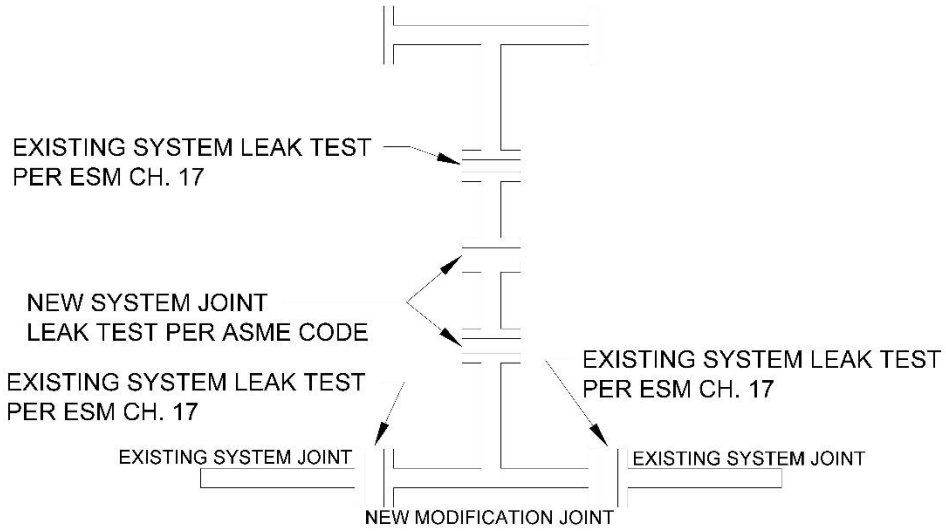


Figure 7

C. Modifications to Radiological Contaminated Existing Systems

1. Perform in-service leak test as follows: Gradually increase pressure in steps until the operating pressure (pressure during normal system operating conditions) is reached, holding the pressure at each step long enough to equalize piping strains. For systems under 25 psig and under 1000 lb.-ft. stored energy, pressure can be brought up in one step. Follow with an in-process examination:

   a. In-process examination of tie-in to existing contaminated piping: The in-service leak test will be performed first by a return to service and then by a subsequent check for gross leaks which might be indicated by contamination release. The assembly and testing are performed inside a bag or within a leak-tight enclosure such as an in-service glovebox and evaluated in accordance with proven radiation monitoring/sampling.

   b. In-process examination of tie-in to existing contaminated wet vac piping: The in-service leak test will be performed by a return to service and subsequent check for gross leaks which might be indicated by contamination release. The assembly and testing are performed inside an in-service glovebox providing confinement for leakage and protection for personnel. Alternatively, assembly and testing are performed inside a bag and evaluated in accordance with proven radiation monitoring/sampling prior to removal of the bagging.

   NOTE: The procedure for executing the in-service leak testing does not require any instrumentation (e.g., calibrated pressure indicator, reference indicator on system, etc.).

   Guidance: The bag methods described above may also be used for non-radiological contaminated existing systems (e.g., ASME B31.9).

   NOTE: The methods described above are qualitative determinations. If a quantitative measurement is required a quantified "bag" method may be created based on pressure and volume of the bag or container over time.

D. ASME B31.5 Refrigerant Piping

1. A pressure test for system integrity in accordance with ASME B31.5 paragraph 538.4.2 *Pressure Test* is required prior to leak testing.

2. The application of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) 15-2019 Addendum e paragraph 9.13.6.1 *Leak Testing Protocol* provides the same or greater level of leak detection as ASME B31.5 paragraph 538.4.3 *Leak Test*. As such, any of the three methods of leak testing below may be used to satisfy the leak testing requirement:

   a. Bubble leak testing per B31.5 paragraph 538.4.3

   b. Pressure testing per ASHRAE 15 Addendum e 9.13.6.1

   c. Vacuum testing per ASHRAE 15 Addendum e 9.13.6.1

E. Common Applicable ASME Code Codes and Interpretations

1. The following official ASME B31 piping committee Code Cases and Interpretations that provide helpful clarification regarding code requirements for leak testing. Copies of these documents are maintained on the ESM Ch. 17 SharePoint.

2. ASME B31.1

   a. Interpretation # B31.1-23-02, ASME B31.1-2016/2018/2020, Para. 126.1, Listed Components (Record # 21-849)

3. ASME B31.3

   a. B31 Case 180 Leak Testing of Subassemblies of Jacketed Piping for use in ASME B31.3 Piping Systems

   b. Interpretation 25-04, B31.3-2012, Interpretation of Para. 345.5.5 Pneumatic Leak Test Procedure (Record # 14-0269)

   c. Interpretation, B31.3-1996 through 2010, Interpretation of Para. 345.2.2 Leak Test Acceptance Criteria (Record #s 12-56 and 12-666)

   d. Interpretation 24-16, B31.3-2012, Interpretation of Para. 322.6.3 Relief Devices (Record # 13-0266)

   e. Interpretation # B31.3-18-04, B31.3-2016, Interpretation of Para. 302.3 Allowable Stresses and Other Stress Limits (Record # 17-3163)

   f. Interpretation # B31.3-19-06, B31.3-2016, Interpretation of Paras. 302.2.5 and 301.2.2, Relief Device (Record # 19-495)

   g. Interpretation # B31.3-20-05, B31.3-2018, Interpretation of Para. 345.5.2 Leak Test Relief Device Requirement (Record # 20-1159)

   h. Interpretation B31.3-20-07, B31.3-2018, Interpretation of Para. 345.8.2 Leak Tests (Record # B31.3-20-07)

   i. Interpretation 8-31, B31.3 1987 Edition with Addenda through B31.3c 1989, Paragraphs 345 and 345.2.2; Leak Test as Nondestructive Examination (Record # N/A)

4. ASME B31.9
    a. Interpretation # B31.9-18-02, ASME B31.9-2017, Para. 937.4.4 – Pneumatic Test Pressure (Record # 18-2184)
    b. Interpretation # B31.9-18-01, ASME B31.9-2017, Para. 937.4.4 – Pneumatic Test Pressure (Record #18-1857)
    c. Interpretation # B31.9-22-04, B31.9=2020, Paragraph 904.7, Successful Service (Record #21-612)
    d. Interpretation # B31.9-22-05, B31.9-2020, Paragraph 923.1.2, Unlisted (Record #21-611)

11.0 PROCUREMENT

A. Purchases of pressure safety restricted goods (e.g., boilers, pressure vessels, pressure regulators, relief devices) by LANL personnel shall be in accordance with P101-34, Attachment D, *Procurement of Pressure Safety Goods or Services*.

1. Form 2309, *Regulator and Relief Device Procurement Pre-Approval*
2. Form 2310, *ASME Vessel Procurement Pre-Approval*

B. Specification for procurement of a relief valve shall include at minimum the information stated below. This information is required by Form 2309.

1. Metadata: PSID, TA-Building
2. System design pressure or MAWP
3. Regulator and relief device identification number
4. RFO (if required)
5. Service fluid
6. Nominal size of piping system to which the relief device is connected
7. Pressure source maximum failure flow rate

    Guidance: Specification sheets from manufacturers usually include the information below on relief devices.

8. Relief device
    a. Manufacturer
    b. Model number
    c. Materials of construction (spring, seat, body, etc.)
    d. Relief device inlet size and end connection type
    e. Relief device outlet size and end connection type (if applicable)
    f. Relief device set pressure (psig or psid)
    g. Relief device flow capacity at defined overpressure beyond set pressure
    h. Orifice trim (if applicable)
    i. ASME BPVC section (if applicable)
    j. Temperature range

C. Specification for purchase of a rupture disk (burst disk) shall include at minimum the information stated below. *This information is required by Form 2309.*

1. Metadata: PSID, TA-Building
2. System design pressure or MAWP
3. Regulator and relief device identification number
4. RFO (if required)
5. Service fluid
6. Nominal size of piping system to which the relief device is connected
7. Pressure source maximum failure flow rate

Guidance: Specification sheets from manufacturers usually include the information below on rupture disks and holders.

8. Disk Holder
    a. Manufacturer
    b. Model number
    c. Materials of construction
    d. Nominal inlet size and end connection type
    e. Nominal outlet size and end connection type (if applicable)
    f. Flow capacity at defined overpressure beyond set pressure
    g. Temperature range
9. Disk specification
    a. ASME BPVC section (if applicable)
    b. Disk size and materials
    c. Rated burst pressure
    d. Burst pressure tolerance (standard or close)
    e. Temperature rating at rated burst pressure
    f. Vacuum rating and support (if applicable)
    g. Coating or lamination (if applicable)
    h. Reverse ratio (recommended to be < 1)
    i. Damage ratio (recommended to be < 1)
    j. Maximum recommended operating ratio

    Guidance: Rupture disk life is affected by the stress history (pressure and temperature) applied to the disk. Relatively low operating pressures and static conditions will generally result in very long disk life, while cyclic conditions approaching the burst pressure will result in shorter disk life.

10. Disk type examples
    a. Conventional tension-loaded rupture disk

b. Pre-scored tension-loaded rupture disk

c. Composite rupture disk

d. Reverse buckling rupture disk with knife blades

e. Pre-scored reverse buckling rupture disk

NOTE: See ASME Section XIII Part 4 for derating values and K values of rupture disks. If a rupture disk is placed directly upstream of a pressure relief valve, requirements of ASME Section XIII Part 8, 8.2, shall be met.

D. Specification for procurement of an ASME quality marked (stamped) item will contain the minimum information stated below. This information is required by Form 2310.

Guidance: Specification sheets from manufacturers usually include the information below on ASME quality marked (stamped) items.

1. Metadata: PSID, TA-Building
2. System design pressure or MAWP
3. Vessel type ASME BPVC section
4. Corrosion allowance
5. Manufacturer model/part number, or design drawings for a custom-designed item
6. Heat input/output rating (for boilers) or pressure vessel size (for others)
7. MAWP
8. Minimum/maximum design temperatures
9. ASME relief required (yes or no)
10. Boiler fuel gas system safety requirements (N/A if not boiler)
11. Relief device provider (fabricator, vendor, designer, or N/A)

12.0 DRAWINGS AND SKETCHES

(Requirement 17-0268)

Pressure systems must have, at minimum, an accurate system sketch.

A. Pressure systems must have as a minimum an accurate system sketch. The system sketch documents the fluid flow path and the relationship of all wetted/pressurized components in the fluid system; this includes the piping, system components, process equipment, and any instrumentation and controls. The sketch is a functional representation of the pressure system and is not an isometric representation of the system.

B. Sketches shall contain standard LANL symbols and acronyms to aid in the interpretation of the sketches. For piping components, LANL CAD Standards Manual Section 300, App. G3, G4, and J provide standard symbols and acronyms.

C. System sketches may be hand drawn or drawn using a program like PowerPoint or Visio. Computer-Aided Drafted (CAD) drawings are also acceptable but not required by ESM Chapter 17.

Guidance: ESM Ch. 17 Reference Data SharePoint provides a simple PowerPoint template for creating system sketches.

NOTE: Other LANL requirements may require formal CAD drawings not required by ESM Chapter 17.

D. Pressure systems that require a flexibility analysis require isometric diagrams and dimensions included in the design.

E. Process Industry Practices (PIP) line classes, insulation, piping, and tubing may be used if they do not conflict with the LANL drafting requirements when the LANL drafting standards are required.

13.0 LABELING AND TAGGING OF COMPONENTS

(Requirement 17-0269)

A. Equipment that has preventive maintenance requirements (e.g., boilers, pressure vessels, relief devices, etc.) must be uniquely identified for the pressure system component. This is best achieved by physically labeling or tagging components in the field and including the same identification in any preventative maintenance procedures. Physical labeling or tagging of components must match the system drawing, sketch, or schematic.

B. For small-scale pressure systems, labeling or tagging may not be necessary if the components are easily identified in the field with the sketch or drawing.

C. Components in a pressure system other than piping, tubing, flanges, and fittings are to be identified in accordance with the system drawing, sketch, or schematic, and ESM Chapter 1 Section 200, *Item Numbering and Labeling*.

D. Piping or tubing lines are not readily traceable back to the pressure source (e.g., piping or tubing that goes underground or passes between walls or structures) must be permanently marked with the contents. Suitable marking methods shall be used to prevent damage to the piping system (e.g., some marking methods containing chlorides or halides that can induce stress corrosion cracking of austenitic stainless steels cannot be used).

NOTE: Detailed labeling requirements exist in LANL Master Specification 22 0554, Identification for Plumbing, HVAC, and Fire Piping and Equipment

14.0 RECORDS

(Requirement 17-0270)

A. Pressure system documents generated by the ESM Chapter 17 design process are considered records, and shall be managed per LANL P1020, P1020-1, P1020-2, and P1020-3. Section 2.0 of this document, *Pressure Safety Implementation Plan*, references pressure system documentation required by this chapter, as applicable.

B. Only records required for AFU (P101-34 Attachment A) are required to be uploaded to the PSD. However, the PSD can be used for all records generated during design as well as other records required by additional policies, procedures, facility requirements or organizational requirements.

Guidance: It is recommended that all documents related to the PSID be archived in the PSD for easy retrieval and change management.

NOTE: Other records may be required by other policies, procedures, facility requirements or organizational requirements. These records are not in the scope of this chapter and are not required to be uploaded into the PSD.

15.0 ATTACHMENTS

Attachment REQ-1, Category M Fluid Service and Lethal Service

Attachment REQ-2, New or Modified System Design Document Requirements

Attachment REQ-3, ASME Boiler and Pressure Vessel Code Application

Attachment REQ-4, Piping Code and Regulation Application

Attachment REQ-5, ASME B31.3 Non-Metallic Equivalent Safety Evaluation

Attachment REQ-6, ASME B31.3 Metallic Equivalent Safety Evaluation

Attachment REQ-7, ASME B31.9 Equivalent Safety Evaluation

Attachment REQ-8, OSHA Requirements for Pressure Systems

Attachment REQ-9, Approved Flexible Hose Restraints and Thrust Load Evaluations