Subject: Langley Research Center Pressure Systems Handbook

Responsible Office: Safety and Mission Assurance Office

TABLE OF CONTENTS

LIST OF TABLES

PREFACE

P. 1 PURPOSE

This Langley Procedural Requirement (LPR) implements the requirements of NASA NASA Procedural Requirements (NPR) 8715.1, NASA Safety and Health Programs," ground-based pressure vessels and pressurized systems safety requirements and is part of the Langley Management System (LMS). It establishes requirements and standards for pressurized systems within the framework of Langley Research Center (LaRC) safety policies and constraints. It provides a basis for safety and uniformity in the design, procurement, fabrication, and use of pressure vessels, piping, and associated equipment.

P.2 APPLICABILITY

a. This Langley Procedural Requirement (LPR) is applicable to all NASA LaRC organizations and all federal civil service personnel on Center.

b. This LPR is applicable to contractors, grant recipients, or parties to agreements only to the extent specified or referenced in the appropriate contracts, agreements, or grants.

c. Noncompliance with the requirements of this LPR may result in appropriate disciplinary action against civil service personnel or sanctions against contractors in accordance with the terms of their contracts.

d. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" denotes a discretionary privilege or permission, "can" denotes statements of possibility or capability, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

e. In this directive, all document citations are assumed to be the latest version unless otherwise noted.

P.3 AUTHORITY

a. NASA Procedural Requirements (NPR) 8715.1, NASA Safety and Health Programs.

P.4 APPLICABLE DOCUMENTS AND FORMS

a. Aeronautics and Space, CFR Title 14.

b. Hazardous Materials Regulations, 49 CFR, chapter I, subchapter C (pts. 171-180).

c. Continuing Qualification and Maintenance of Packagings, 49 CFR pt. 180.

d. Ocupational Safety and Health Standards, 29 CFR pt. 1910.

e. Fire Protection, 29 CFR pt. 1910, subpart L.

f. Langley Policy Directive (LAPD) 1150.2, Councils, Boards, Panels, Committees, Teams, and Groups.

g. LAPD 7000.2, Review Program for Langley Research Center (LaRC) Facility Projects.

h. LAPD 8730.1, The LaRC Metrology Program.

i. LPR 1710.10, Langley Research Center Energy Control Program (Lockout/Tagout).

j. LPR 1710.11, LaRC Fire Protection Program.

k. LPR 1710.41, Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds.

l. LPR 1710.42, Safety Program for the Recertification and Maintenance of Ground-Based Pressure Vessels and Piping Systems (PVS).

m. LPR 1740.2, Facility Safety Requirements.

n. LPR 1740.4, Facility System Safety Analysis.

o. LPR 1740.5, Procedures for Cleaning of Systems and Equipment for Oxygen Service.

p. LPR 1740.6, Personnel Safety Certificaiton.

q. LPR 1800.1, LaRC Occupational Health Program.

r. LPR 7123.2, Facility Configuration Management.

s. Langley Management System Center Procedure (LMS-CP) 4710, Facility Change Request Process.

t. LMS-CP-5616, Computerized Maintenance Management System (CMMS) Change Request.

u. LMS-CP-7151, Obtaining Waivers for Langley Management System (LMS) Requirements.

v. NASA Technical Standard (STD) 8719.17, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PVS).

w. NASA STD-8719.28, Wind Tunnel Model Systems Criteria.

x. LMS-BP-5688, Facility Systems Engineering Requirements Document Development.

y. LMS-Task Description (TD) 5569, Performing Visual Inspections.

z. Langley Form (LF) 51, Waiver Submittal Form.

aa. LF 121, LaRC Safety Documentation Review for Certified Operators.

ab. LF 122, Facility Safety Awareness and Procedure Review for Certified Operators.

ac. LF 159, Appointment for Operator Certification.

ad. LF 461, Environmental Project Planning Form.

ae. LF 533, Safety Permit - Pressurized Systems.

af. LF 611, Request for Component Exclusion from PVS Requirement.

ag. American Institute of Aeronautics and Astronautics (AIAA) S-080, Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components.

ah. AIAA S-081, Space Systems – Composite Overwrapped Pressure Vessels.

ai. American Petroleum Institute (API) STD 521, Pressure-Relieving and Depressuring Systems.

aj. American Society of Civil Engineers (ASCE) 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

ak. American Society of Mechanical Engineers (ASME) B16.11, Forged Fittings, Socket-Welding and Threaded.

al. ASME B31.1, Power Piping.

am. ASME B31.3, Process Piping.

an. ASME B31.5, Refrigeration Piping and Heat Transfer Components.

ao. Compressed Gas Association (GCA) E-4, Standard for Gas Pressure Regulators.

ap. CGA P-1, Standard for Safe Handling of Compressed Gases in Containers.

aq. FM Global, Factory Mutual (FM) Global Property Loss Prevention Data Sheets, (https://www.fmglobal.com/research-and-resources/fm-global-data-sheets).

ar. International Code Council (ICC), International Mechanical Code.

as. International Organization for Standardization (ISO) 5167, Measurement of Fluid Flow by Means of Pressure Differential Devices Inserted in Circular-Cross Section Conduits Running Full.

at. National Board of Boiler and Pressure Vessel Inspectors (NBBI), NB-23, National Board Inspection Code.

au. National Fire Protection Association (NFPA) 30, Flammable and Combustible Liquids Code.

av. NFPA 54, National Fuel Gas Code.

aw. Naval Ordnance Laboratory Technical Report (NOLTR) 70-208, Failure-Damage Assessment Technique for High-Pressure Gas Containment Vessels by V. C. D. Dawson and A. E. Seigel (1970).

ax. NFPA 58, Liquefied Petroleum Gas Code.

P.5 MEASUREMENT/VERIFICATION

None

P.6 CANCELLATION

LPR 1710.40N, Langley Research Center Pressure Systems Handbook, dated August 27, 2019.

/s/ David F. Young January 16, 2023

Center Deputy Director Date

Distribution:

Approved for public release via the Langley Management System; distribution is unlimited.

1. PURPOSE, APPLICABILITY, AND EXCLUSIONS

1.1 Purpose

1.1.1 This LPR establishes requirements and guidelines regarding the design, procurement, fabrication, modification, repair, operation, and recertification of pressure systems owned by Langely Research Center (LaRC), whether located on Center or off Center, and of pressure systems owned by others that are used at LaRC.

1.1.2 This document is written on the premise that the functions and responsibilities listed in Chapter 16 are essential to provide the checks and balances indispensable to ensure pressure system safety.

1.2 Applicability

1.2.1 This LPR is applicable to all pressure systems owned by or used at LaRC, including new, existing, temporary, and permanent systems.

1.2.2 Pressurized systems in wind tunnel models shall be approved by the Standard Practice Engineer (SPE) for Wind Tunnel Models and shall comply with NASA STD-8719.28.

1.2.3 Ground-based pressurized systems in LaRC facilities shall also comply with LPR 1740.4 and LPR 7123.2.

1.3 Exclusions

1.3.1 The categories of pressure systems listed in Table 1-1 below are not required to meet the requirements of this LPR if they meet the specified conditions for exclusion.

Table 1-1, Excluded Systems

Exclusion No.	Excluded item	Condition(s) for exclusion
X-1	Self-Contained Breathing Apparatus (SCBA) equipment	Complies with Occupational Safety and Health Administration (OSHA) regulations, 29 Code of Federal Regulation (CFR) Part 1910, Subparts 1910.134 through 1910.140.
X-2	Water piping systems under 160 psig and 210 °F	Water surge is not a design consideration or the risk has been mitigated.
X-3	Commercial-Off-The-Shelf (COTS) water heaters for buildings	Pressure-temperature relief valves replaced every 5 years.

Exclusion No.	Excluded item	Condition(s) for exclusion
X-4	Water storage tanks and small potable water heaters in heating boilers	In accordance with the limits in the American Society of Mechanical Engineers (ASME) “Boiler & Pressure Vessel Code,” Section IV, “Heating Boilers”, paragraph HLW-101.
X-5	Packaged, COTS, facility hot water boilers and low pressure steam boilers within the scope of ASME Boiler and Pressure Vessel Code, Section IV	H-stamped. Initial installation per ASME code requirements. Relief valves retested or replaced per the requirements of the Commonwealth of Virginia, Department of Labor and Industry.
X-6	Water deluge systems under 250 psig	No hazard to personnel in the event of failure.
X-7	Inert gas piping systems, e.g., control air, instrument air, and shop air systems	Design pressure not exceeding 150 psig. Line size not exceeding 2 inches for all methods of fabrication.Relief valves periodically retested every 5 years.

Exclusion No.	Excluded item	Condition(s) for exclusion
X-8	Steam and gravity-powered condensate return systems for building heating	Operating pressures up to 15 psig. If the excluded steam system is fed by a higher-pressure steam system, the first relief device following the pressure-reducing regulator shall be retested yearly.
X-9	COTS prepackaged pressurized water and steam cleaning systems	Maintained and operated in accordance with the manufacturer's recommendations.
X-10	Fire protection water systems for facilities	None.
X-11	COTS prepackaged refrigerators, freezers, and Heating, Ventilation, and Air Conditioning (HVAC) equipment	None.
X-12	Fire extinguishers, portable extinguishers, standpipe and hose systems, automatic sprinkler systems, fixed dry chemical extinguishing systems, carbon dioxide extinguishing systems, and halogenated extinguishing agent systems	Complies with 29 CFR Part 1910, Subpart L, "Fire Protection."
X-13	Glove boxes	None.
X-14	Fuel storage pressure systems	Meets applicable U.S. Department of Transportation (DOT) requirements.

Exclusion No.	Excluded item	Condition(s) for exclusion
X-15	COTS prepackaged hydraulic systems	None.
X-16	COTS welding equipment	None.
X-17	COTS laboratory equipment	Fluid delivery system shall have suitable overpressure protection and include gauges for system pressure detection.
X-18	Vacuum vessels	Volumes not greater than 100 cubic feet. Not connected to a positive-pressure fluid delivery system.
X-19	Vacuum piping	Nominal diameter of less than 6 inches. Not connected to a positive-pressure fluid delivery system.
X-20	Contractor-owned pressure systems	Used on a temporary basis for the purpose of construction activities. The owning Contractor shall meet all applicable Federal and State safety regulations.
X-21	Atmospheric storage tanks	Subjected to hydrostatic pressure only. Complies with applicable American Petroleum Institute (API) or Underwriters Laboratories (UL) standards.

Exclusion No.	Excluded item	Condition(s) for exclusion
X-22	COTS self-contained pressurized eye wash systems	Overpressure protection devices, if present, are periodically tested or replaced in accordance with manufacturers' recommendations.
X-23	Tube trailers	Periodically retested and requalified in accordance with 49 CFR pt. 180, provided that the owner's OSHA inspection requirements of 29 CFR 1910.101 are met.
X-24	Natural gas distribution systems	Design pressure not exceeding 22 psig.
X-25	Pressurized test articles or test articles containing pressurized components	Excluded if they have been reviewed and accepted by a formal safety review committee (see LAPD 1150.2) or by a formal Operational Readiness Review (ORR) board (see LAPD 7000.2).

Exclusion No.	Excluded item	Condition(s) for exclusion
X-26	Temporary, test-specific pressure systems	Excluded if risk assessment in accordance with LPR 1740.4 shows there is no risk to personnel, and any unmitigated risk to the facility has been accepted by the Organizational Director. Pressurized systems and components are not considered to fall into this category if they are used repeatedly for testing different test articles or configurations.

Note: For additional guidance on lockout/tagout procedures for pressure vessels listed in Table 1-1, see LPR 1710.10.

2. GENERAL REQUIREMENTS

2.1 Required Codes and Standards

2.1.1 Pressure systems and components owned by or used at LaRC shall be designed, fabricated, modified, repaired, and recertified, as a minimum, in accordance with the following codes and standards as applicable:

a. **American Institute of Aeronautics and Astronautics (AIAA)**

(1) S-080, Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components

(2) S-081, Space Systems – Composite Overwrapped Pressure Vessels

b. **American Society of Mechanical Engineers (ASME)**

(1) Boiler and Pressure Vessel Code

(2) B31.1, Power Piping

Note:The requirements in B31.1 apply to steam and condensate piping.

(3) B31.3, Process Piping

Note: The requirements in B31.3 apply to all piping other than steam and condensate piping.

(4) B31.5, Refrigeration Piping and Heat Transfer Components

c. **Compressed Gas Association (CGA)**

(1) E-4, Standard for Gas Pressure Regulators

(2) P-1, Standard for Safe Handling of Compressed Gas in Containers

d. **International Organization for Standardization (ISO)**

(1) ISO 5167, Measurement of Fluid Flow by Means of Pressure Differential Devices Inserted in Circular-Cross Section Conduits Running Full

e. **FM Global, Factory Mutual (FM) Data Sheets**

Note: Applicable pressure equipment codes and standards in FM data sheet series 12.

f. **International Code Council (ICC), International Mechanical Code**

g. **Code of Federal Regulations (CFR)**

(1) 29 CFR Part 1910, Occupational Safety and Health Standards

(2) 49 CFR Subchapter C, Hazardous Materials Regulations (pts. 171 – 180)

h. **Langley Research Center**

(1) LPR 1710.11, Fire Protection Program

(2) LPR 1710.41, Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds

(3) LPR 1710.42, Safety Program for the Recertification and Maintenance of Ground-Based Pressure Vessels and Piping Systems (PVS)

(4) LPR 1740.2, Langley General Safety Program Requirements

(5) LPR 1740.4, Facility System Safety Analysis

(6) LPR 7123.2 Facility Configuration Management

i. **NASA Technical Standard (STD)**

(1) NASA STD 8719.17, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PVS)

(2) NASA STD-8719.28, Wind Tunnel Model Systems Criteria

j. **National Board of Boiler and Pressure Vessel Inspectors (NBBI)**

(1) NB-23, National Board Inspection Code

k. **National Fire Protection Association (NFPA)**

(1) NFPA 30, Flammable and Combustible Liquids Code

(2) NFPA 54, National Fuel Gas Code

(3) NFPA 58, Liquefied Petroleum Gas Code

3. APPROVALS

3.1 Required Approvals

3.1.1 All new designs, procurements, fabrications, modifications, and repairs to pressure systems and system components within the scope of this LPR shall be approved by the following personnel:

a. The SPE for Pressure Systems or the SPE for Flight Systems, to ensure compliance with the required codes and standards.

b. The Facility Coordinator (FC) and Facility Manager (when applicable), to ensure coordination with all activities in the facility where the pressure system is located.

c. The Facility Safety Head (FSH), to ensure compliance with specific safety requirements of the facility where the pressure system is located.

3.1.2 Additionally, the following signatures may be required, depending on the scope of the required work:

a. The Authority Having Jurisdiction (AHJ), to ensure compliance with required codes and regulations for pressure systems containing flammable or combustible liquids, flammable gases, cryogenic liquids, oxidizers, pyrophoric substances, highly reactive substances, or toxic substances.

b. The cognizant Safety and Facility Assurance Branch (SFAB) Safety Engineer, to ensure compliance with all applicable facility safety requirements.

c. The SPE for Welding, for pressure systems containing welded or brazed components, to ensure compliance with welding process quality assurance requirements, procedures, and codes.

3.1.3 Approval by the above listed personnel shall be verified by their signature and date on the design drawings, sketches, procurement requisition records, or work order functional approvals, as applicable.

4. WAIVERS AND INTERPRETATIONS

4.1 Waivers

4.1.1 Approval for a waiver from the requirements in this LPR shall be obtained by following the process described in LMS-CP-7151 and as further described herein:

a. In the “Recommending Authorities” section of LF 51, the “Other Recommendation Authority” is the chairperson of the Pressure Systems Working Groupand the “Engineering Technical Authority” is the applicable SPE.

b. All requests for waivers from the requirements in this LPR, including requirements in any referenced Agency standards, national consensus codes, or industry standards, shall include full justification for the waiver request and supporting data or analyses to demonstrate that safe operation can be achieved.

4.2 Interpretations

4.2.1 The SPE for Pressure Systems, the SPE for Flight Systems, the SPE for Welding, and the AHJ are granted authority to issue interpretations on the applicability of individual requirements in this LPR within their respective areas of expertise. Ground Based Pressure Systems interpretations shall be documented via Langely Form 611.

5. DESIGN OF NEW PRESSURE SYSTEMS (GROUND-BASED)

5.1 General

5.1.1 All new pressure systems shall be designed in compliance with the applicable codes and standards listed in Chapter 2 of this LPR.

5.1.2 The Cognizant Engineer shall ensure that all new pressure system designs include the following documentation, as applicable for each project:

a. **Requirements documents**

(1) Formal Requirements Document per LMS-BP-5688

(2) Statement of Work/Work Plan

b. **Engineering analyses and calculations**

(1) ASME piping code calculations, such as:

(a) Pressure and temperature design calculations

(b) Flexibility analysis

(c) Relief valve and/or rupture disc sizing calculations

(d) Vent line and vent header backpressure calculations

(2) ASME BPV code pressure vessel calculations, such as:

(a) Pressure and temperature design calculations for shells, heads, nozzles, and closures

(b) Nozzle load limitations

(c) Reinforcement of openings

(d) Relief valve and/or rupture disc sizing calculations

(e) Fatigue life for pressure vessels operating with cyclic pressure and/or temperature

(3) Flow sizing calculations for valves, control orifices, flow meters, and piping components

(4) For custom-made components and for code-unlisted components, calculations using closed-form equations, finite element methods, or other generally accepted engineering analysis methods to establish structural integrity and compliance with the required safety factors

c. **Catalog cuts of commercial-off-the-shelf (COTS) items**

d. **Engineering drawings (D-size format is preferred), sketches, and/or marked-up photographs**

(1) Process and instrumentation diagrams (P&IDs)

(2) Plan views, elevation views, section views, and detail views as needed to describe the required scope of work

e. **Parts lists and material specification tables**

f. **Coating system data**

(1) Pressure Systems constructed of carbon steel shall be coated with a protective coating system approved by the SPE for Pressure Systems. All coating system projects shall include a job plan that is based on the requirements as prescribed in the respective manufacturers coating system data sheet.

g. **LF 461, Environmental Project Planning Form**

h. **Facility Change Request (FCR)**

5.1.3 Facility Change requests shall be performed in accordance with LMS-CP-4710.

5.1.4 Design drawing packages and sketches shall include the following information:

a. Name of the Cognizant Engineer

b. Date

c. Facility name

d. Building number

e. Drawing or sketch title

f. Drawing or sketch number

g. Applicable design code(s) and/or standard(s)

h. Relevant engineering data, such as fluid service, design pressure, design temperature, material specification, non-destructive examination and inspection requirements, testing requirements, set pressure of relief devices, set points of all interlocks and protection devices, torque values of bolted connections, vent discharge elevations, direct buried piping depth, and requirements for welding and/or brazing.

6. FABRICATION OF NEW PRESSURE SYSTEMS (GROUND-BASED)

6.1 General

6.1.1 New pressure systems shall be fabricated in accordance with an approved design as per Chapters 3 and 5 of this LPR.

6.1.2 The Cognizant Engineer shall supervise the progress of pressure system fabrication to ensure compliance with this LPR.

6.2 Pressure Vessels

6.2.1 Pressure vessels shall be stamped by the fabricator in accordance with the ASME Pressure Vessel Code, Section VIII, Divisions 1 or 2.

6.2.2 The fabricator shall provide a copy of the vessel's code stamp documentation tothe Cognizant Engineer.

6.3 Piping Systems (Welded or Brazed)

6.3.1 Welded or brazed piping systems shall be fabricated by organizations that are holders of an ASME (or National Board) Certificate of Authorization for the application of a code stamp, such as the "U", "U2", "N", "R", or "PP" stamps. The Certificate of Authorization ensures that the fabricator is familiar with and uses the quality control measures required by the ASME codes for pressure vessels and piping.

6.3.2 Whenever a pressure system is fabricated by welding or brazing, the fabricator shall submit the following documents for approval by the SPE for Welding or designated representative prior to the start of any welding:

a. Welding or Brazing Procedure Specification (WPS/BPS)

b. Certified Procedure Qualification Records (PQR)

c. Certified Welder or Brazer Performance Qualifications (WPQ/BPQ)

6.3.3 All components installed in piping systems shall be permanently marked with legible raised lettering or stamping in order that required information (i.e., the manufacturer, pound class, model or part number, size, pressure rating, temperature rating, material of construction, and code of construction, as applicable) can be ascertained. Component markings can be limited to the manufacturer's name or trademark and the manufacturer's part number or model number if all other pertinent information as outlined above can be ascertained through the manufacturer's catalogs or data sheets.

6.4 Piping Systems (Non-Welded or Non-Brazed)

6.4.1 Non-welded or non-brazed piping and tubing systems shall be fabricated by persons that have received training in the specific fabrication methods utilized, who can demonstrate they understand proper material selection and the identification, installation, fit-up, alignment, and support of components to be used in such fabrications.

7. MODIFICATIONS AND REPAIRS TO PRESSURE SYSTEMS (GROUND-BASED)

7.1 General

7.1.1 Pressure systems shall be modified or repaired in accordance with an approved design as defined in Chapters 3 and 5 of this LPR.

7.1.2 The Cognizant Engineer shall supervise the progress of pressure system modifications and repairs to ensure compliance with this LPR.

7.2 Pressure Vessels

7.2.1 Modifications and repairs to code-stamped pressure vessels shall be performed by organizations that are holders of a National Board Certificate of Authorization for use of an “R” stamp.

7.2.2 Modifications and repairs to non-code-stamped pressure vessels shall be performed by organizations that are holders of a National Board Certificate of Authorization for use of a “U”, “U2”, “R”, “N”, or “PP” stamp.

7.3 Piping Systems (Welded or Brazed)

7.3.1 Modifications and repairs to welded or brazed piping systems shall be performed by organizations that are holders of one of the following ASME or National Board stamps: “U”, “U2”, “R”, “N”, or “PP”.

7.3.2 Whenever a piping system is modified or repaired by welding or brazing, the fabricator shall submit the following documents for approval by the SPE for Welding or designated representative prior to the start of any welding:

a. Welding or Brazing Procedure Specification (WPS/BPS)

b. Certified Procedure Qualification Records (PQR)

c. Certified Welder or Brazer Performance Qualifications (WPQ/BPQ)

7.3.3 Prior to welding on an existing pressure system, weld maps shall be reviewed and weld numbers shall be provided to the Pressure Systems Recertification Group.

7.4 Piping Systems (Non-Welded or Non-Brazed)

7.4.1 Modifications and repairs to non-welded or non-brazed piping and tubing systems shall be performed by persons who have received training in the specific fabrication methods utilized, who can demonstrate they understand proper material selection, and the identification, installation, fit-up, alignment, and support of components to be used in such fabrications.

8. PROCUREMENT OF PRESSURE SYSTEMS (GROUND-BASED)

8.1 General

8.1.1 Procurements of pressure systems or of pressure system components shall be reviewed and approved as required in Chapter 3 of this LPR.

8.1.2 The requiring organization/customer is responsible for ensuring that all required approvals outlined in Chapter 3 are complete, and shall coordinate with the approvers listed in Chapter 3 and the Office of Procurement to ensure the requirements under Chapter 8 are fulfilled and included in solicitation and resultant contractual documents.

8.2 Procurement of Pressure Vessels and Tanks

8.2.1 All procurements for COTS pressure vessels and tanks for use at LaRC shall require the vessels to be code stamped by a recognized U.S. national standards organization such as ASME, API, DOT, or UL, as applicable.

8.2.2 All contracts or purchase orders for the acquisition of new, custom-built pressure vessels shall:

a. Require the vessels to be ASME code stamped

b. Contain the following wording:

"This solicitation includes fabrication of pressure vessels. A current ASME Certificate of Authorization for use of a "U" or "U2" code stamp shall be held by the organization performing the fabrication and stamping of the pressure vessels. The contract award process will be expedited by submittal of the Certificate of Authorization with the offeror's bid; however, early certification submittal is not required to ensure bid responsiveness. An offeror's ability to confirm that deliverable pressure vessels will be code stamped as required is a matter relating to the offeror's responsibility and will be determined prior to award."

8.2.3 All contracts or purchase orders for the acquisition of new, custom-built tanks shall require API or UL code stamping.

8.2.4 The Cognizant Engineer shall require all vendors supplying pressure vessels and tanks to furnish the following documents, as applicable:

a. Outline and Cross Sectional Drawings,

b. Bill of Materials,

c. ASME Code Calculations,

d. Welding Procedures (WPS),

e. Procedure Qualification Records (PQR),

f. Weld Maps,

g. Non-Destructive Examination (NDE) Records,

h. Heat Treatment Records,

i. Hydrostatic Test Records,

j. Code Reports (e.g., ASME Code Forms, Manufacturer's Data Reports, Nameplate Rubbing or Facsimile),

k. Charts (e.g., Hydrostatic Test, Post Weld Heat Treatment (PWHT)), and

l. Reports (e.g., Mill Test Report (MTR), Positive Material Identification (PMI), NDE, Radiography, Hardness Test, Safety Data Sheet (SDS)).

8.3 Procurement of Piping Systems (Welded or Brazed)

8.3.1 All contracts requiring fabrication, modification, or repair of ground-based, welded or brazed piping systems shall:

a. Require the fabricator to be a holder of an ASME code stamp

b. Contain the following wording:

"This solicitation requires fabrication, modification, and/or repairs to pressure systems. A current National Board or ASME Certificate of Authorization for use of any of the following stamps: "R", "U", "U2", "N", or "PP" is required. This certificate shall be held by the organization performing the work and shall be maintained valid and current throughout the contract performance period. The contract award process will be expedited by submittal of the applicable Certificate of Authorization with the offeror's bid; however, early certification submittal is not required to ensure bid responsiveness. An offeror's ability to confirm that the organization performing the work is a holder of any of the above stamps is a matter relating to the offeror's responsibility and will be determined prior to award."

8.3.2 The Cognizant Engineer shall require all vendors supplying piping system components to furnish the following documents, as applicable:

a. Outline and Cross Sectional Drawings,

b. Bill of Materials,

c. ASME Code Calculations,

d. Welding Procedures (WPS),

e. Procedure Qualification Records (PQR),

f. Weld Maps,

g. Non-Destructive Examination (NDE) Records,

h. Heat Treatment Records,

i. Hydrostatic Test Records,

j. Code Reports (e.g., ASME Code Forms, Manufacturer's Data Reports, Nameplate Rubbing or Facsimile),

k. Charts (e.g., Hydrostatic Test, Post Weld Heat Treatment (PWHT)), and

l. Reports (e.g., Mill Test Report (MTR), Positive Material Identification (PMI), NDE, Radiography, Hardness Test, Safety Data Sheet (SDS)).

9. DESIGN, FABRICATION, AND PROCUREMENT OF FLIGHT-GRADE PRESSURE SYSTEMS

9.1 Pressure Systems for Spacecraft

9.1.1 This section is applicable for all LaRC-owned pressure systems that are used in spacecraft or suborbital experiments.

9.1.2 All new pressure systems for spacecraft or suborbital experiments shall be compliant with ANSI/AIAA S-080.

9.1.3 All new composite overwrapped pressure vessels with metallic liners for spacecraft or suborbital experiments shall be compliant with ANSI/AIAA S-081.

9.2 Pressure Systems for Aircraft and Lighter Than Air Vehicles

9.2.1 This section is applicable for all LaRC-owned pressure systems for experiments that are used in aircraft or lighter than air vehicles.

9.2.2 All new pressure systems for experiments on aircraft or lighter than air vehicles shall be compliant with FAA regulations for Airworthiness Standards in CFR Title 14.

9.2.3 All new pressure systems for experiments on aircraft or lighter than air vehicles can use ANSI/AIAA S-080 as an alternative to using CFR Title 14 Airworthiness Standards. If ANSI/AIAA S-080 is used in lieu of CFR Title 14 Airworthiness Standards, then full compliance with ANSI/AIAA S-080 is required.

9.3 Ground Support Pressure Systems for Flight-Grade Pressure Systems

9.3.1 All new ground support pressure systems for flight-grade pressure systems shall be considered ground-based pressure systems and be compliant with this LPR.

9.3.2 Operation of new ground support pressure systems for flight-grade pressure systems during operations and testing of the flight system shall be operated in accordance with ANSI/AIAA S-080.

10. INSPECTION AND TESTING OF PRESSURE SYSTEMS (GROUND-BASED)

10.1 General

10.1.1 Minimum inspection and testing requirements for pressure systems shall be in accordance with the applicable design codes listed in Chapter 2 of this LPR.

10.1.2 The Cognizant Engineer shall ensure that the supplemental inspection and testing requirements in this Chapter are met.

10.2 Supplemental Inspection Requirements

10.2.1 In addition to the minimum requirements of the applicable codes and standards, the following requirements shall apply:

Table 10-1, LaRC Supplemental NDE Requirements

		Joint Type				
		Butt Weld	**Socket Weld**	**Branch Weld**	**Fillet Weld**	**Mechanical Joints**
Pressure Vessels	Code Stamped	Per Code Requirements				
	Not Code Stamped	100% VT 100% RT	100% VT 100% RT	100% VT 100% RT	100% VT 100% MT or PT	100% VT
Process Piping, Steam Piping, High Pressure Vent Piping, and Pumped/Gravity Condensate Return Piping	All	100% VT 100% RT	100% VT 100% RT	100% VT 100% RT	100% VT 100% MT or PT	100% VT
Service Air Piping	All	100% VT 100% MT	100% VT 100% MT	100% VT 100% MT	100% VT 100% MT	100% VT
Low Pressure Gas Vent Piping	All	100% VT 10% MT or PT	100% VT 10% MT or PT	100% VT 10% MT or PT	100% VT 10% MT or PT	100% VT
Liquid Drain Piping	All	100% VT	100% VT	100% VT	100% VT	100% VT
Structural attachments to piping	All	100% VT, MT, or PT of root pass	N/A	N/A	100% VT, MT, or PT of root pass	N/A
Vacuum Piping	Contact Pressure Systems SPE for NDE Requirements					

MT = Magnetic Particle Examination; PT = Dye Penetration Examination;
RT = Radiographic Examination; VT = Visual Testing

a. NDE in accordance with Table 10-1.

b. NDE shall be performed by inspectors certified via a program meeting the requirements of the American Society for Nondestructive Testing (ASNT) SNT-TC-1A or ASNT CP-189 to Level II or Level III requirements.

(1) The Cognizant Engineer shall ensure that personnel conducting nondestructive examinations of LaRC pressure vessels and pressurized systems (PVS) are trained via a program meeting the requirements of ASNT SNT-TC-1A or ASNT CP-189.

c. When heat treatment or stress relieving of a pressure retaining component is required, it shall been done after all welding, weld repairs, and required NDE are complete.

(1) Additionally, an MT or PT examination of the heat-affected zone shall be conducted following the heat treatment but prior to the required hydrostatic test.

(2) All heat treated or stress relieved components or vessels shall be visibly marked with “Do Not Weld or Burn, Heat Treated.”

d. Inspection and acceptance criteria for socket welds and branch connection welds shall be in accordance with LPR 1710.41.

e. Acceptance criteria for butt welds in pressure systems shall be in accordance with ASME B31.3 for severe cyclic conditions.

f. In-process inspections shall be performed on brazed or soldered joints.

g. Film radiography shall be used for ground-based pressure system applications.

h. Radiographic inspection of piping girth butt welds shall utilize tangential techniques wherever possible.

i. Final interpretation and acceptance of radiographs of pressure systems shall be by a qualified third party reviewer. The SPE for Pressure Systems is responsible for establishing the technical qualifications of the third party radiograph reviewers.

Note: NASA LaRC has an Official Radiograph Interpreter who can be used as the independent third party reviewer of radiographs.

(1) When film radiography is utilized in ground-based applications, all radiographic film shall be turned over to the Pressure Systems Recertification Group Managerfor final retention and storage.

(2) The radiographic film shall be retained in a controlled environment repository for a minimum of five years.

j. As a minimum, acceptance criteria for the evaluation of visual inspections of pressure components shall be in accordance with LMS-TD-5569.

k. Welds attaching structural elements to a pressure retaining wall shall be nondestructively examined as follows:

(1) The root pass and final weld surfaces shall be visually examined followed by either an MT or a PT examination.

(2) The final weld surface shall be VT examined.

(3) Acceptance criteria shall be per ASME Boiler and Pressure Vessel (B&PV) Code Section VIII for attachments to pressure vessels and per ASME B31.3 (severe cyclic conditions) for attachments to piping.

10.3 Supplemental Hydrostatic and Pneumatic Testing Requirements

10.3.1 In addition to the minimum requirements for testing in the applicable codes, the Cognizant Engineer shall ensure that the following supplemental testing requirements are met:

a. Hydrostatic and pneumatic tests are used to qualify the structural integrity of new, modified, and repaired pressure systems. Both methods of testing are potentially hazardous. Adequate safety precautions shall be taken to ensure the safety of personnel and equipment.

b. Hydrostatic and pneumatic tests conducted in the field at LaRC shall be performed using written and approved test plans and operating procedures.

(1) A hydrostatic or pneumatic test plan shall include a drawing defining the extent of the system being tested; the location of high point vents and low point drains; test gauges to be used; relief valve(s) used to limit test pressure, water chloride content requirements; test blind rating requirements; test gasket requirements; and draining, drying, and closing requirements.

c. Pneumatic testing shall only be conducted when the appropriate SPE determines that hydrostatic testing is not feasible.

d. As a minimum, hydrostatic test plans shall be approved by the Cognizant Engineer and the appropriate SPE.

e. Pneumatic test procedures shall be approved by the FSH, the appropriate SPE, the Chairman of the Pressure Systems Working Group, and the LaRC Safety Manager.

f. When performing pneumatic testing, a gas complying with cleanliness requirements of the pressure vessel and system shall be used.

g. A relief device of adequate capacity set to relieve at a pressure no higher than 115 percent of the test pressure shall be provided.

h. A hazard zone shall be established by engineering analysis as described in Appendix D.

i. All personnel shall be excluded from the hazard zone while the pressure exceeds the design pressure of the system being tested.

j. Appropriate personal protective equipment shall be worn by any personnel required to enter the hazard zone during the test.

k. Hydrostatic and pneumatic tests of pressure systems shall be witnessed by the appropriate SPE or designated representative.

l. Following successful hydrostatic or pneumatic testing of vessels, piping, and tubing, a signed hydrostatic (or pneumatic) test certificate shall be provided by the fabricator or his/her testing agent.

m. The certificate shall include the date and time of the test, a short description of the tested system, the test pressure, holding time, and any other pertinent test parameters.

n. In the event that a required hydrostatic or pneumatic test is deemed to be impractical by the appropriate SPE, additional NDE shall be performed to ensure the structural integrity of the pressure system.

o. The SPE shall have the authority to establish the additional NDE requirements.

11. VERIFICATION AND SHAKEDOWN OF PRESSURE SYSTEMS (GROUND-BASED)

11.1 General

11.1.1 All new, modified, or repaired pressure systems shall undergo verification and shakedown prior to being placed in operational service.

11.1.2 The Cognizant Engineer shall verify that the pressure system has been constructed, repaired, or modified in accordance with the approved design documents and that the system fabricator has provided all documentation to substantiate compliance with the requirements of the design.

11.2 Process for Verification

11.2.1 The Cognizant Engineer shall verify that:

a. All new work, modification work, or repair work has been completed in accordance with the engineering design, specifications, and drawings/sketches and complies with the requirements of this LPR.

b. Deviations from the original design, if any, were approved by the appropriate SPE.

c. All nondestructive examinations have been completed and accepted.

d. All hydrostatic tests, leak tests, and any other testing required by the design, repair, or modification documents have been completed and accepted.

e. All safety and interlock devices have current calibrations, have been installed, and are operating properly.

f. The operation of devices, e.g., valves, actuators, transmitters, switches, and gauges, has been properly verified prior to pressurizing the system.

g. Shakedown procedures as suitable for the complexity of the new system, modification, or repair have been developed and approved by the appropriate SPE and the FSH, or a formal design review committee. The appropriate SPE and FSH have the authority to require additional approvers by the appropriate personnel listed in Chapter 3 of this LPR.

h. A low pressure leak test has been performed on the system.

(1) If a leak test cannot be performed during the Return to Service (RTS) or Acceptance Test Plan (ATP), then an independent hazard analysis shall be performed and approved by the SPE for Pressure Systems and SFAB Safety Engineer.

i. For systems under configuration control, a Facility Change Request has been initiated to update all affected documentation.

j. The system is ready to be pressurized as determined by the completion of the requirements above.

11.2.2 The Cognizant Engineer shall document completion of all the steps in the verification process listed in paragraph 11.2.1 through either:

a. Detailing the completion in a letter to the FSH and the appropriate SPE, or

b. Completing and submitting an LF 438.

11.3 Process for Shakedown

11.3.1 Shakedown shall be performed after the system has been verified. The purpose of shakedown is to validate system performance, to provide an opportunity for operator training, and to develop standard operating procedures.

11.3.2 The Cognizant Engineer shall oversee shakedown. During shakedown:

a. Testing of the system operating envelope shall be conducted in accordance with approved shakedown procedures.

b. The operators shall be properly trained.

c. At the successful completion of training, the operators shall be certified in accordance with Chapter 13 of this LPR.

d. The operating procedures, if applicable, shall be completed and signed off in accordance with the facility configuration management process in LPR 7123.2.

e. The system performance shall be demonstrated with system fluids (systems containing toxic, combustible, flammable, or otherwise hazardous fluids shall use an inert fluid first).

f. For cryogenic systems, cold shock testing shall be performed to test the welds and flexibility of the piping and ensure that cold shock liquid does not contaminate the system.

12. CERTIFICATION AND RECERTIFICATION OF PRESSURE SYSTEMS (GROUND-BASED)

12.1 Certification of New Systems

12.1.1 Based on the complexity of the new system and at the discretion of the LaRC Safety Manager, the operational certification of new pressure systems shall be performed by one of the following:

a. An Operational Readiness Review (ORR) board, or

b. The cognizant SPEs and Technical Authorities.

12.2 Recertification of Pressure Systems

12.2.1 The Pressure Systems Manager (PSM) is responsible for the recertification of pressure systems at LaRC.

12.2.2 Pressure systems shall be recertified in accordance with the requirements in LPR 1710.42 by using one of the following methods:

a. Level 1 recertification. This method is applicable to the majority of ground-based, infrastructure, high-energy systems.

b. Level 2 recertification. This abbreviated method is applicable to ground-based systems that are specifically exempted from full recertification by the PSM based on factors such as limited risk, minimum complexity, and similar factors.

c. Permit recertification. This method is primarily intended for research laboratories where a compressed gas cylinder (i.e., K-bottle) is connected to COTS laboratory equipment via a pressure regulator, relief device, and tubing system. It may also be used to certify temporary pressure system installations. Systems undergoing permit recertification are documented via a completed and approved LF 533.

d. D.O.T. recertification. This method is applicable to pressurized forged vessels mounted on transportable trailers (i.e., tube trailers) whether they are used in mobile or stationary applications.

e. Boiler recertification. This method is applicable to the steam boilers in the Central Heating and Steam Generation Plant, Building 1215.

13. OPERATIONS AND MAINTENANCE OF PRESSURE SYSTEMS (GROUND-BASED)

13.1 General

13.1.1 Pressure systems under configuration control shall be operated in accordance with Standard Operating Procedures developed and approved in accordance with LPR 1740.4.

13.1.2 Facility Coordinators shall ensure that all pressure-retaining equipment (e.g., relief valves, control valves, gauges, transmitters) in pressure systems within their facility are included in the Computerized Maintenance Management System (CMMS) in accordance with LMS-CP-5616.

13.1.3 Pressure systems shall meet the requirements of NASA-STD-8719.17, LPR 1710.42, and this LPR to be certified for operation.

13.2 Operator Certification and Training

13.2.1 Pressure systems shall be run by system operators who have received training in the operational characteristics of the system and are knowledgeable of the operational procedures, checklists, inherent hazards, and operational limits associated with the system.

13.2.2 Operators of LaRC-owned pressure systems shall be certified in accordance with LPR 1740.6.

13.2.3 The FSH shall ensure that LF 121 and LF 122 include a suitable list of documents to ensure the operator has read and understands the operational procedures, checklists, inherent hazards, and operational limits associated with the system.

13.2.3.1 The certification of the operator shall be documented on LF 159.

13.2.3.2 The FSH shall ensure operator certifications are kept current.

13.2.4 The SFAB may periodically provide general pressure system awareness training that covers basic concepts, hazards, and engineering controls associated with pressure systems to interested Center personnel.

13.3 Operations and Maintenance Personnel Protection

13.3.1 When any servicing or maintenance operation could result in injury to personnel or serious damage to equipment due to the unexpected release of hazardous energy, the system shall be locked out/tagged out by a Safety Operator in accordance with LPR 1710.10.

13.3.2 The FC shall ensure that the Safety Operator is certified to perform work on the system requiring Lock Out/Tag Out (LOTO).

13.3.3 Any system containing toxic fluids, fuels, oxidizers, or other potentially dangerous media shall be purged in accordance with written procedures approved by the FSH.

13.3.3.1 The system shall be purged with an appropriate agent such as fresh air, water, inert gas, or a neutralizing agent, as appropriate, prior to initial use during a work shift, following last use during a work shift, and prior to disassembly or opening up the system.

13.4 Preventive Maintenance Requirements

13.4.1 Relief valves shall be included in LaRC's Preventive Maintenance Program for retesting and verification in accordance with the frequencies specified in LPR 1710.42.

13.4.1.1 Description of maintenance work and test results on relief valves shall be kept in a physical log book at the Component Verification Facility (CVF) and electronically input into CMMS.

13.4.2 Pressure sensing and indicating devices except for Category 1 and Category 2 devices subject to metrology requirements (see Appendix A) shall be included in LaRC's Preventive Maintenance Program for retesting in accordance with the frequencies specified in paragraph 15.12 of this LPR. A log describing the maintenance work and test results on pressure sensing and indicating devices shall be kept at the Component Verification Facility.

14. DOCUMENTATION AND CONFIGURATION CONTROL OF PRESSURE SYSTEMS

14.1 Required System Documentation

14.1.1 All ground-based infrastructure pressure systems shall be documented by means of:

a. A Process and Instrumentation Diagram (P&ID). The P&ID drawing shall identify all pressure sources, valves, vessels, drains, vents, flow direction, instrumentation, cleanliness level, and all safety devices and their set points.

b. A recertification file (i.e., White Book) containing supporting documentation for the pressure system.

14.2 Updating Configuration Controlled Items (CCI)

14.2.1 Whenever work activities result in changes to the configuration of a pressure system under configuration control, a Facility Change Request (FCR) form shall be initiated by the Cognizant Engineer after the approval of the design.

14.2.1.1 A FCR shall be initiated to update the system's P&ID.

14.2.1.2 A separate FCR shall be initiated to update the Pressure Systems Document (PSD), if applicable.

14.3 Archiving and Retention of As-built Pressure Systems Documentation

14.3.1 Prior to completion of the construction of a new pressure system or completion of modifications to an existing pressure system, the Cognizant Engineer shall ensure that:

a. All new P&ID are field verified to show the final system configuration and are archived in Engineering Drawing Files.

b. Existing P&ID that are affected by the work are redlined to show modifications.

c. A copy of salient documentation such as construction drawings, design documents, calculations, catalog cuts, certification records, test reports, NDE records, material records, special welding procedures, and shakedown records are given to the Pressure Systems Recertification Group for archiving in the recertification file.

14.4 On-Site Documentation

14.4.1 As a minimum, the owner of a pressure system shall maintain at the facility a current copy of the following documents:

a. P&ID drawing.

b. Operations and Maintenance (O&M) manuals of the equipment in the system.

c. Certifications of calibrated devices and the frequency of the required calibrations.

15. SUPPLEMENTAL REQUIREMENTS APPLICABLE TO SYSTEMS AND COMPONENTS

15.1 Anchoring of Components

15.1.1 All vessels and major components of a system shall be anchored to a stable foundation designed to withstand all static, dynamic, wind, and seismic loads acting on the pressure system.

15.1.2 The design of piping system supports and pressure vessel supports shall consider seismic loads in accordance with ASCE 7.

15.2 Bushings (Single Step)

15.2.1 Pipe bushings of one-size reduction (single-step) with *overlapping threads* on the inside and outside surfaces shall not be used in piping systems within the scope of this document.

15.2.2 Transitions requiring one-size reductions shall be made using concentric reducers, reducing couplings, or other fittings not having overlapping internal and external threads.

15.3 Cast Iron, Malleable Iron, and Ductile Iron

15.3.1 Pressure retaining components made of cast iron, malleable iron, or ductile iron shall not be used where they will be subject to vibration or shock loading.

15.4 Component Cleaning

15.4.1 Pressurized components shall be cleaned internally before use to be compatible with their intended use. For example, proper cleaning of components to remove oils and other hydrocarbon-rich residues in systems containing oxygen gas, liquid oxygen, or high pressure air may be required to prevent the formation of flammable or explosive mixtures.

15.4.2 Systems containing oxygen and other systems requiring cleanliness to 10 parts per million or less of hydrocarbons, including systems that will be providing purge, pressurization, and test fluids to oxygen systems, shall be cleaned in accordance with LPR 1740.5.

15.5 Color Coding and Labeling

15.5.1 All pressure systems shall be labeled and color coded in accordance with LPR 1740.2 to properly identify the general hazard or risk level.

15.5.1.1 Whenever a pressure is included in the label, it shall be the normal operating pressure of the system.

15.6 O-Ring-Type Union Assemblies

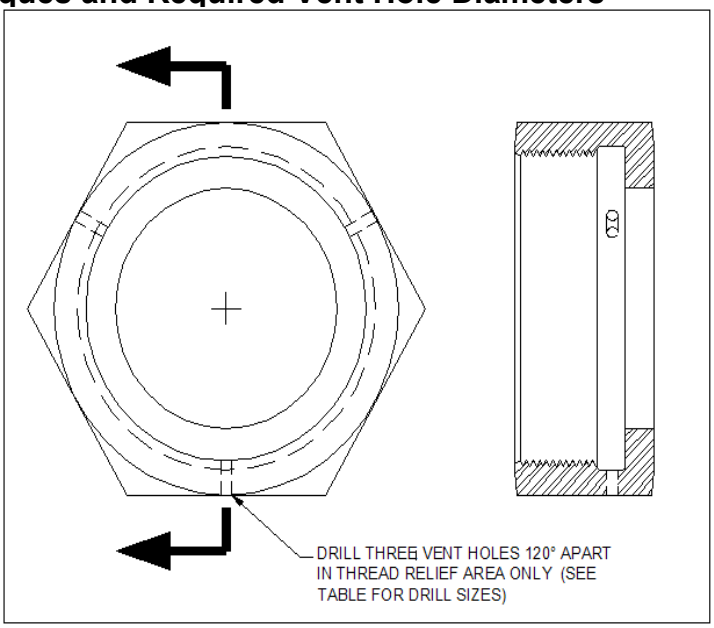
Note: O-Ring Type union assemblies are those unions in which sealing is accomplished using an O-ring that is recessed in a close-tolerance grove in one of the two mating metal pieces (e.g., CPV Unions).

15.6.1 O-Ring-type union assemblies 1-1/4 inch" and larger in size shall not be used in compressed gas systems above 2400 psig.

15.6.2 O-Ring-type union assembliesin systems operating above 2400 psig shall have vent holes drilled and be torqued to the values listed in Table 15-1.

Table 15-1, O-Ring Nut Torques and Required Vent Hole Diameters

Size (IN.)	TORQUE (FT-LB)	VENT HOLE DIAMETER (IN.)
1/8	10 - 25	1/16
¼	10 – 25	1/16
3/8	12 – 30	1/16
1/2	15 – 40	3/32
3/4	20 – 50	3/32
1	25 – 60	3/32



15.7 Filters and Filter Elements

15.7.1 Filters shall have the filter housing ASME code stamped with all welds 100 percent radiographically examined.

15.7.2 The vendor/supplier shall provide an ASME U-1A Form “Manufacturer’s Data Report” and documentation as applicable per Section 8.2.4 for each filter provided.

15.8 Filter-Regulators

15.8.1 Filter-regulators with see-through bowls shall not be used unless the bowl is made of impact-resistant glass or impact-resistant polycarbonate plastic.

15.9 Direct Buried Piping

15.9.1 Threaded fittings shall not be used in direct buried piping applications.

15.9.2 Underground piping should be buried at a minimum depth of 30 inches below grade.

15.9.3 Detectable Mylar tape or equivalent shall be used to mark the location of direct buried pipe at LaRC, to include laying detectable tape approximatey six inches below the surface of the ground directly above the buried piping.

15.10 Flexible Hoses

15.10.1 Flex hoses shall not be used in a system in lieu of rigid piping or tubing unless it is required for vibration isolation, motion allowance, component flexibility, or when the use of rigid piping or tubing has been determined by the appropriate SPE to be impractical.

15.10.2 Procurements of assembled flex hoses shall require the following:

a. The Maximum Allowable Working Pressure (MAWP) and the flex hose manufacturer's name shall be marked on the outside of the hose.

b. When the procurement requires the manufacturer to conduct a pressure test on the flex hose prior to delivery, a signed pressure test certificate shall be supplied by the manufacturer.

c. If not tested by the manufacturer, the flex hose shall be tested by the Component Verification Facility prior to use.

d. A tag shall be affixed to the flex hose, irrespective of being tested by the manufacturer or by the Component Verification Facility, indicating the date of the pressure test and the test pressure.

15.10.3 Flex hoses shall be restrained as follows:

a. Flex hoses with swaged end connections that could subject personnel to a whipping hazard in the event of failure of the end connections shall be fitted with anti-whip restraints and have sufficient intermediate restraint along their lengths to mitigate the hazard.

b. Flex hoses with welded or brazed end connections do not require anti-whip devices.

c. Flex hoses less than 2 feet in length do not require anti-whip restraints.

15.10.4 Flex hoses in liquid systems that do not meet the exemptions listed in Section 15.9.3 shall be evaluated by the appropriate SPE to determine anti-whip restraint requirements.

15.10.5 Prior to initial use, all flex hoses shall be hydrostatically tested to 150 percent of the MAWP stamped on the hose exterior.

15.10.5.1 Flex hoses should not be retested to 1.5 MAWP following initial use. Any hose requiring retesting shall be restested to the MAWP of the hose.

15.10.6 No testing shall be performed on hoses lacking documentation, markings, or tags from the Component Verification Facility indicating the pressure rating of the hose.

15.10.7 Flex hoses shall be replaced every five years when:

a. The flex hose is fabricated with swaged ends and its rupture would cause unacceptable hazard to personnel or unacceptable risk to the facility or the mission.

b. The hose is exposed to agents or conditions that are known to deteriorate its inner or outer layers.

15.10.8 A pressure test tag or band shall be placed on all flex hoses indicating the date and pressure of the last test.

15.10.8.1 Flex hoses with missing test tags that are still traceable shall be retested to 150 percent of MAWP or replaced.

15.10.9 A flex hose, with leaks, flat areas, kinks, blisters, sharp ends, twists, damaged end fittings, cracks in the inner liner, severe corrosion (including the hose restraints), or has other signs of deterioration shall be removed from service and destroyed.

15.10.10 Flex hoses shall not be subjected to normal or sustained operating pressures greater than the manufacturer's recommended MAWP.

15.10.10.1 Additionally, due to the probability of plastic yielding, any flex hose that experiences momentary pressures in excess of two times its MAWP shall be immediately removed from service and destroyed.

15.10.11 Flex hoses installed for temporary use shall be included in LaRC's CMMS.

15.10.12 Flex hoses installed for permanent use are not required to be tracked through CMMS but will fall under the pressure systems recertification program.

15.11 Gas Cylinders

15.11.1 Pressure systems using compressed gas cylinders as their source of fluid shall include **adequately-sized** pressure relieving devices on the downstream side of the pressure regulator.

15.11.2 All components in the system upstream of the relief device shall be rated for the full pressure stamped on the gas bottle.

15.11.3 No consideration for reduced pressure in a partially full gas bottle shall be made to meet design requirements.

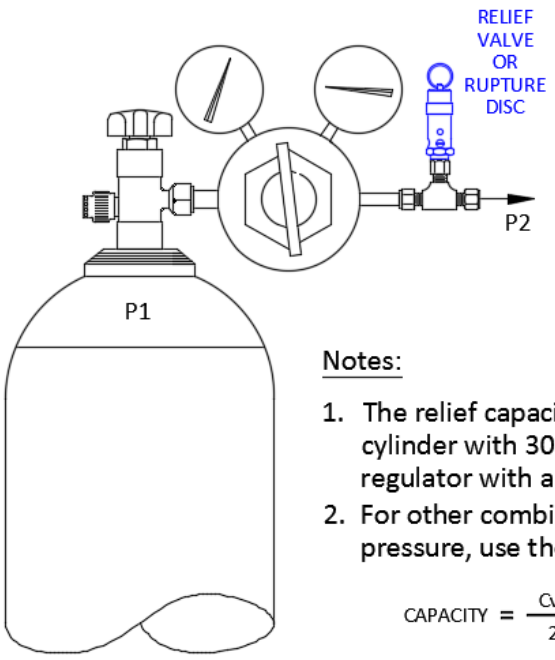
Note: Compressed gas cylinders are commonly referred to as "K bottles," stemming from their D.O.T. designations, as follows in Table 15-2:

Table 15-2, Cylinder Types and Sizes

Cylinder Type	DOT Specification	Dimensions (Diameter x Height)	Internal Volume (ft^3)	Tare Weight (lb)
6K	3AA-6000	10" x 51"	1.50	303
4K	E9421-4500	9.25" x 51"	1.61	145
3K	3AA-3600	10" x 51"	1.54	189
T/UT	3AA-2400	9.25" x 55"	1.73	143
K/UK/NPK	3A-2015	9" x 51"	1.54	133
SS	3A-2015	7.50" x 49"	0.97	110
S	3AA-2015	7.37" x 46"	0.95	76

15.11.4 A typical sketch of a gas cylinder connection is shown in Figure 15-1.

Note: Figure 15-1 is included for informational purposes and does not imply that other configurations are unacceptable at the discretion of the cognizant SPE.



REQUIRED RELIEF CAPACITY		
TYPE OF GAS	Regulator Cv	RV FLOW, SCFM
AIR	0.06	90
NITROGEN	0.06	94
ARGON	0.06	66
OTHER (NON-TOXIC)	0.06	DIVIDE AIR CAPACITY BY THE SPECIFIC GRAVITY OF THE GAS

Notes:

1. The relief capacities shown in the table are computed assuming a gas cylinder with 3000 psig maximum nominal pressure and a pressure regulator with a maximum flow factor Cv = 0.06.
2. For other combinations of regulator flow factor and cylinder nominal pressure, use the formula below or contact the cognizant SPE.

$$\text{CAPACITY} = \frac{Cv \times P1}{2 \times \sqrt{Sg}}$$

VALID FOR UPSTREAM PRESSURE (P1) GREATER THAN 2 TIMES THE DOWNSTREAM PRESSURE (P2). ALL PRESSURES IN PSIG.

Figure 15-1, Basic design for connection of equipment to compressed gas bottles

15.11.5 Components and equipment downstream of the pressure relief valve shall have a MAWP equal to or higher than the relief valve setting.

15.10.6 Gas cylinders shall be requalified in accordance with 49 CFR § 180.209, Table 1, “Requalification of Cylinders”.

15.12 Isolation & Depressurization

15.12.1 When a system is depressurized for the purpose of performing modifications, servicing, or maintenance operations, the procedures for locking and tagging out in LPR 1710.10 shall be followed.

15.12.2 Pressure gauges and pressure transmitters shall not be relied upon as the single means to verify a system is de-energized.

15.12.2.1 Depressurization of systems shall always be verified by the opening of vent valves or by other positive means.

15.13 Pressure Reducing Valves and Pressure Regulators

15.13.1 A pressure indicating device, whether a bourdon-tube gauge or a pressure transmitter, shall be installed on both the inlet and outlet sides of a pressure regulator or a pressure reducing valve to ensure proper monitoring of upstream and downstream pressures.

15.13.2 A pressure relief valve shall be installed on the downstream side of pressure reducing valves or pressure regulators unless all the components on the downstream side have a MAWP equal to or greater than the upstream side MAWP.

15.13.2.1 When a relief valve is required, it shall be installed as close as practical to the source of pressure without any intervening valves or closures.

15.14 Pressure Sensing and Indicating Devices

Table 15-3, Summary of Pressure Sensing Device Requirements

	Bourdon tube gauges with safety case	Bourdon tube gauges *lacking* safety case	Bourdon tube vacuum gauges	Pressure transmitters and transducers	Pressure Switches	Differential Pressure Gauges
Allowable Working Range	0 – 80% of full scale	0 – 60% of full scale	0 – 100% of full scale	0 – 100% of full scale	0 – 100% of full scale	Contact Pressure Systems SPE for differential pressure gauge requirements
Test Pressure	100% of full scale	100% of full scale	100% of full scale	100% of full scale	N/A	
Type of Test (1)	Dead Weight	Dead Weight	Vacuum pump	Dead Weight	Set point and functional verification	
Retest Period	5 years	5 years	Per LPR 1740.4	5 years	Per LPR 1740.4	
Rejection Criteria (3)	EC, EW, ST, BG, SE	EC, EW, ST, BG, SE	EC, EW, ST, BG, SE	EC, EW, SE	EC, EW, ST, BG, SP	
Test Label (2)	Required	Required	Required if tested	Required	Required	

Notes for Table 15-3:

(1) Dead weight test media shall be water or oil. Oil shall not be used for gauges used with oxygen or other oxidizing agents. Oxygen-service pressure indicating devices undergoing verification shall be thoroughly dried then cleaned per LPR 1740.5 prior to returning to service.

(2) The test label shall include maximum test pressure, test date, and initials of testing personnel.

(3) EC = excessive corrosion, EW = excessive wear, ST = sticktion, BG = broken glass, SE = span error in excess of 5% of full scale, SP = setpoint error in excess of 3% of set value

15.14.1 In addition to the requirements in this LPR, pressure sensing and indicating devices identified as Category 1 or 2 Measurement and Test Equipment (M&TE) are subject to metrology requirements in LAPD 8730.1.

15.14.2 Differential pressure gauges shall be rated for full system pressure.

15.14.3 A safety case shall include a solid front and a full-area blow out back.

15.14.3.1 Blow out plugs shall not be considered sufficient to meet this requirement.

Note: See Figures 15-2 and 15-3 for examples of blow out plugs.

15.14.4 Bourdon-tube pressure gauges shall comply with applicable national consensus codes and the following additional requirements:

a. Gauges having a safety case shall have a MAWP of 80 percent of full scale.

b. Gauges lacking a safety case, except vacuum gauges, shall have a MAWP of 60 percent of full scale.

c. Panel mounting of bourdon-tube gauges shall allow the full-area blowout back to function properly.

15.14.5 Any bourdon-tube pressure sensing and indicating device that is subjected to pressures above 100 percent of its full scale range shall be immediately removed from service.

15.14.6 Pressure sensing and indicating devices that are critical interlocks shall be tested as required by LPR 1740.4 under the cognizance of the FSH.

15.14.7 Verification of pressure sensing and indicating devices shall be performed as follows:

a. Bourdon-tube pressure gauges shall be tested at the Component Verification Facility prior to initial installation and subsequently re-tested every five years to ensure proper operation.

b. Following verification, the tester shall keep a log that includes all pertinent test results, observations, the date of the test, and the device identifier listed in CMMS.

15.14.7.1 Pressure sensing and indicating devices in excluded systems shall also be re-tested every five years if their reading is required in the system’s SOPs.

15.14.8 Criteria for rejection of pressure sensing and indicating devices that are not subject to metrology requirements shall be as follows:

a. Bourdon-tube gauges, pressure and vacuum – excessive corrosion or wear of the moving parts or of the pressure-retaining parts, sticktion, broken glass, and span error in excess of five percent of full scale.

b. Pressure transmitters and transducers – excessive corrosion or wear of the pressure-retaining parts and span error in excess of five percent of full scale.

c. Pressure switches – excessive corrosion or wear of the moving parts or of the pressure-retaining parts, sticktion, broken glass, and setpoint error in excess of three percent of set value.

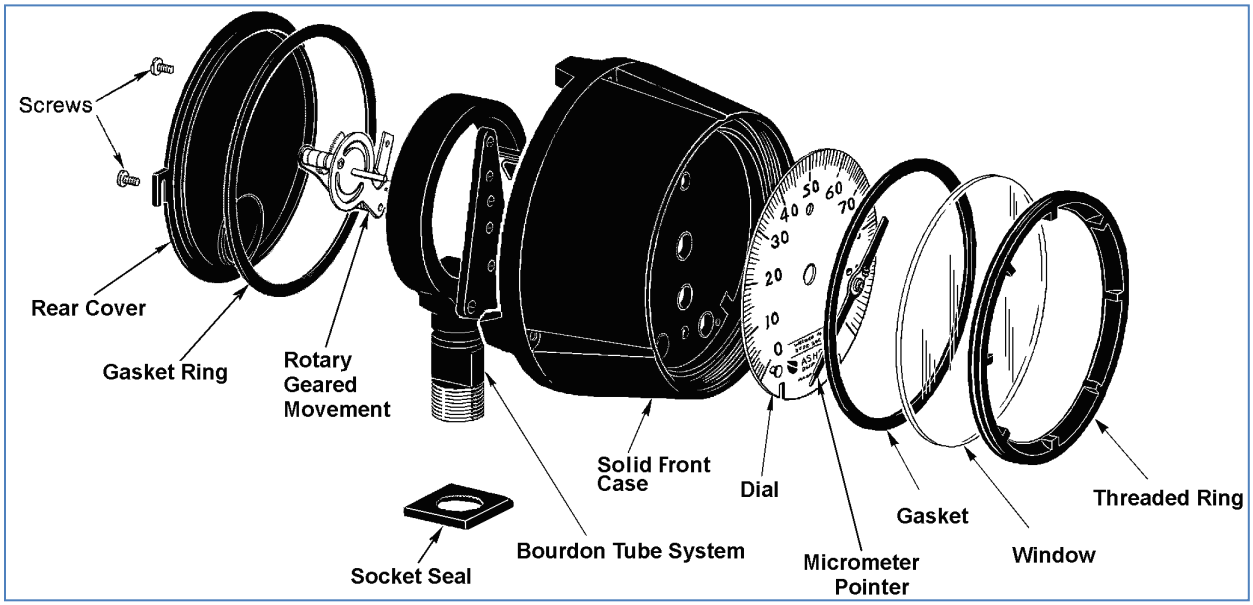


Figure 15-2, View of a bourdon-tube gauge with a solid front case and a full-area blow-out back

Figure 15-3, View of a bourdon-tube gauge lacking a solid front case and having a blow-out plug

15.15 Pressure Relieving and Venting

15.15.1 Relief valves shall be ASME code stamped. The SPE for Pressure Systems has the authority to determine when the use of code stamped relief valves is impractical for a specific application.

15.15.2 When a single pressure relief device is used, the set pressure marked on the device shall not exceed the MAWP of the system being protected. When the total required capacity is provided by utilizing more than one pressure relief device, only one pressure relief device need be set at or below the MAWP. The additional pressure relief devices may be set to open at higher pressures but in no case at a pressure higher than 105 percent of the MAWP, except as provided in the applicable code.

15.15.3 Relief valves shall be periodically tested to check for proper operation and the accuracy of the set point.

15.15.3.1 Relief valves shall be properly tagged after testing. The maximum intervals for re-testing are listed in LPR 1710.42.

15.15.3.2 Relief valve tags shall include the valve number, set pressure, and the test date.

15.15.4 New ASME code stamped relief valves shall be tested and certified by a National Board Valve Repair (VR) code stamp certified shop or by the Component Verification Facility prior to initial use to ensure proper relief setting. Non-code stamped relief valves are exempt from this requirement.

15.15.5 A rupture disk shall be used in parallel with a relief valve in cryogenic systems wherever liquid cryogen entrapment could occur.

15.15.6 Rupture disk/holder shall be rated for desired burst pressure at the coincident design temperature of the system.

15.15.7 Rupture disk/holder shall be of the same manufacturer.

15.15.8 Rupture disk installed in new systems and/or rupture disk used to replace preexisting disks should be properly tagged after installation such that the disk manufacturer, model number, and material can be identified outside of the assembly.

15.15.9 Piping downstream of relief valves and vent valves shall:

a. Have a nominal diameter equal to or larger than the valve outlet size.

b. Be designed and routed such as to minimize exposure of personnel to vented media and to excessive noise levels as required in LPR 1800.1. The vent release shall also be clear of any equipment and other obstructions that could alter its flow path.

c. Incorporate means of reacting thrust loads, including the use of equalizing tees and structural supports.

d. Be designed for the MAWP of the system to which they are connected unless engineering calculations are made to justify a lower design pressure. For example, calculations may be performed in accordance with API STD 521.

15.16 Seam-Welded Pipe and Tubing

15.16.1 Seam-welded pipe and tubing shall not be used in pressure systems within the scope of this LPR.

15.17 Steam and Condensate Piping and Fittings

15.17.1 Threaded piping and fittings shall be avoided in steam and condensate systems, except where required to facilitate maintenance.

15.18 Torque Values

15.18.1 Torque values shall be provided for all bolted connections in pressure systems and shall be designated on the system's drawings.

15.19 Langley Research Center Identification (LaRC ID) Locator Numbering

15.19.1 Permanently installed pressure system component locations at LaRC shall be numbered and tagged in accordance with Appendix E, "LaRC Location ID" of LPR 7123.2, and the additional requirements herein.

15.19.2 Personnel performing maintenance on a valve with a suffix listed in LPR 7123.2, or disassembling a system identified by this suffix, shall positively identify the system's media before maintenance or disassembly operations begin.

15.19.3 In addition to the requirements listed in LPR 7123.2, the four digit valve number and the one digit media identifier (3142J in the example in Figure E-1 in LPR 7123.2) found on the valve tag shall be of at least 1/2 inch in height (36 point size) so as to be readable from a distance of 6 feet.

15.20 Orifice Plates:

a. Orifice plates installed in new systems or used to replace preexisting plates shall be properly tagged after installation such that the plate manufacturer, model number, size and material can be identified outside of the assembly.

b. Orifice plates used as flow meters and restriction orifices shall be designed for the maximum flow rate of the system and full pressure drop across the plate.

c. Restriction orifice plates, i.e., plates designed for sonic flow, shall be approved by the SPE for Pressure Systems prior to use.

15.21 Viewports and Windows in Pressure Systems:

a. All viewports and windows in pressure and vacuum vessels shall be approved by the appropriate SPE.

b. A minimum safety factor of 10 shall be used for window designs.

c. Window frames shall be designed in accordance with the applicable code and will preclude metal contact with glass surfaces.

15.22 Pipe Plugs

a. Square and Hex Head Pipe Plugs installed in Pressure systems within the scope of this document shall be solid; Plug material and dimensions should conform to ASME B16.11.

15.23 Clamp Hub-End Connectors

Note: Clamp hub-end connectors are those composed of a metal seal ring, two hubs, and a clamp assembly (e.g., Grayloc flanges).

a. Clamp hub-end connector components shall be of the same manufacturer.

16. RESPONSIBILITIES

16.1 The responsibilities listed below are essential to provide the checks and balances necessary to ensure pressure system safety.

16.2 The LaRC Center Director (or designee) is responsible for:

a. Granting waivers from the requirements of this LPR (Chapter 4).

16.3 The Cognizant Engineer is responsible for:

a. Ensuring that new pressure system designs include documentation to verify that the pressure systems are in accordance with the required codes and standards (Chapter 5).

b. Supervising the progress of the procurement, fabrication, modifications, or repairs to pressure systems (Chapters 6, 7, and 8).

c. Ensuring that pressure systems are inspected and tested in accordance with this LPR (Chapter 10).

d. Performing or overseeing the performance of the verification process of pressure systems and certifying that new construction, modifications, and repairs are completed in accordance with this LPR (Chapter 11).

e. Performing or overseeing the performance of shakedown of pressure systems (Chapter 11).

f. Initiating a FCR to update all configuration controlled documentation of a pressure system (Chapter 11).

g. Ensuring that pressure system documentation is field verified, redlined, and filed following construction or installation work (Chapter 14).

16.4 The Director of Safety and Mission Assurance Office (SMAO) is responsible for:

a. Appointing an individual or individuals to serve as official radiographic interpreters for LaRC (Chapter 10).

b. Serving as “Accepter” in reviewing and signing requests for waivers, form LF 51 (Chapter 4).

16.5 Facility Coordinators are responsible for:

a. Reviewing and approving new designs, fabrication plans, modifications, and repairs to pressure systems in their facilities, as well as certifying that the pressure systems comply with facility requirements (Chapter 3).

b. Ensuring that all pressure-retaining equipment such as relief valves, control valves, gauges, and pressure transmitters in pressure systems within their facilities are included in CMMSin accordance with LMS-CP-5616 (Chapter 13).

c. Ensuring that Safety Operators performing LOTO at their facilities are certified to perform work on the systems needing to be serviced or maintained (Chapter 13).

16.6 Facility Safety Heads are responsible for:

a. Reviewing and approving new designs, fabrication plans, modifications, and repairs to pressure systems in their facilities, as well as certifying that the pressure systems comply with facility safety requirements (Chapter 3).

b. Approving pneumatic test procedures (Chapter 10).

c. Approving shakedown procedures (Chapter 11).

d. Ensuring that pressure system operators are properly trained and certified (Chapter 12).

e. Approving procedures for purging pressure systems prior to the performance of service or maintenance activities (Chapter 13).

f. Ensuring that critical safety interlocks are tested as required by LPR 1740.4 (Chapter 15).

g. Approving blowdown procedures (Appendix C.4.1).

16.7 The Authority Having Jurisdiction (AHJ) is responsible for:

a. Reviewing and approving new designs, fabrication plans, modifications, and repairs to pressure systems containing flammable or combustible liquids, flammable gases, cryogenic liquids, oxidizers, pyrophoric substances, highly reactive substances, or toxic substances (Chapter 3).

b. Providing interpretation of the applicability requirements in this LPR related to code compliance in matters of fire protection, personnel safety, and the protection of LaRC assets (Chapter 4).

16.8 The LaRC Safety Manager is responsible for:

a. Approving pneumatic test procedures (Chapter 10).

b. Serving as a member of the ORR board that certifies new pressure systems for operation (Chapter 12).

c. Authorizing the appropriate SPE to perform the certification function of an ORR board (Chapter 12).

16.9 Owners of pressure systems are responsible for:

a. Serving as “Accepter” in reviewing and signing requests for waivers, form LF 51 (Chapter 4).

b. Ensuring duplicate valve numbers are not used in a pressure system (Chapter 15).

c. Keeping a current copy of all relevant pressure system documentation at the facility (Chapter 12).

16.10 The Chairman of the Pressure Systems Working Groupis responsible for:

a. Reviewing and approving pneumatic test procedures (Chapter 10).

b. Serving as “Recommending Authority” in reviewing and signing requests for waivers, form LF 51 (Chapter 4).

16.11 The Pressure Systems Manager is responsible for:

a. The recertification of pressure systems, as defined in LPR 1710.42.

16.12 Pressure Systems Operators are responsible for:

a. Reading and understanding the operational procedures and checklists of the pressure systems with which they work (Chapter 13).

b. Understanding the inherent hazards of the pressure systems with which they workand the engineering solutions and safety controls used to mitigate those hazards (Chapter 13).

c. Maintaining current certification in accordance with LPR 1740.6.

16.13 The Official Radiograph Interpreter is responsible for:

a. Serving as LaRC’s authority in the interpretation of radiographs of pressure system welds and signing for their final acceptance (Chapter 10).

16.14 Safety Operators are responsible for:

a. Locking and tagging out a pressure system prior to the performance of any service or maintenance activity that could result in the unexpected release of hazardous energy from the system (Chapter 13).

16.15 The Standard Practice Engineer for Pressure Systems (ground-based) is responsible for:

a. Reviewing and approving new designs, fabrication plans, modifications, and repairs to pressure systems, certifying their compliance with required codes and standards (Chapter 3).

b. Providing interpretation of the applicability of the requirements of this LPR (Chapter 4).

c. Approving procurement of pressure systems and pressure system components (Chapter 8).

d. Establishing the required technical qualifications of the Official Radiograph Interpreters (Chapter 10).

e. Reviewing and approving plans for hydrostatic testing and for pneumatic testing (Chapter 10).

f. Witnessing hydrostatic and pneumatic tests (Chapter 10).

g. Establishing additional NDE required whenever hydrostatic testing or pneumatic testing is deemed impractical (Chapter 10).

h. Reviewing and approving independent hazard analysis in lieu of low pressure leak tests (Chapter 10).

i. Reviewing and approving pressure system shakedown plans (Chapter 11).

j. Reviewing and approving changes to approved pressure system designs (Chapter 11).

k. Certifying new pressure systems for operation, in conjunction with the LaRC Safety Manager (Chapter 12).

l. Determining when the use of flexible hose in lieu of rigid piping is acceptable (Chapter 15).

m. Determining the need to restrain flexible hoses in systems containing pressurized liquids (Chapter 15).

n. Reviewing and approving the use of glass viewports in pressure systems (Chapter 15).

o. Approving blowdown procedures (Appendix C.4.1).

16.16 The responsibilities of the Standard Practice Engineer for Pressurized Flight Systems parallel those of the SPE for Pressure Systems, but as applicable to flight-grade systems.

16.17 The SPE for Welding is responsible for:

a. Reviewing and approving new designs, fabrication plans, modifications, and repairs to pressure systems, certifying their compliance with welding and quality assurance requirements (Chapter 3).

b. Providing interpretation of the applicability of the requirements of this LPR (Chapter 4).

c. Reviewing and approving welding documentation, i.e., WPS/BPS, PQR, and WPQ/BPQ (Chapters 6 and 7).

16.18 The SPE for Wind Tunnel Models is responsible for:

a. Reviewing and approving pressurized models to be tested in LaRC wind tunnels in accordance with NASA STD-8719.28.

APPENDIX A. DEFINITIONS

Abandoned. Refers to when a system is no longer in use or maintained and no provision for long term storage has been made.

Authority Having Jurisdiction (AHJ). An individual appointed by the Center Director to ensure regulatory and code compliance on matters involving the safety of personnel and protection of LaRC assets from fire hazards.

Category 1 Pressure Sensing and Indicating Devices. Callibration is performed atan established interval.

Category 2 Pressure Sensing and Indicating Devices. Calibration is performed before use.

Code Stamp. A marking applied to a pressure component by a certified manufacturer to indicate compliance with a national consensus code. Available stamps include:

U – ASME B&PV Code Section VIII, Div 1 (Pressure Vessels)

U2 – ASME B&PV Code Section VIII, Div 2 (Pressure Vessels)

R – NBIC Pressure Vessel Repair

VR – NBIC Valve Repair

N – ASME B&PV Code Section III (Nuclear Facility Components)

PP – ASME Power Piping

Cognizant Engineer. The individual who is responsible for sponsoring, executing, or implementing the construction of a new pressure system or modifications to an existing pressure system. In this context, the word “engineer” is used to mean an individual with a degree in engineering or engineering technology, or an engineering technician with at least 5 years of experience in design, maintenance, or operations.

Combustible Liquid. A liquid with a flashpoint above 100 °F.

Commercial Off-The-Shelf (COTS) Pressure Systems and Components. COTS pressure systems and components are systems and components routinely produced in quantity by an industrial manufacturer and adhere to one or more published national consensus standards or to manufacturer’s association standards. COTS pressure systems and components are typically furnished with a recommended pressure rating and temperature rating.

Critical Interlock. An interlock that is designed specifically to mitigate an undesired event.

Demolished. Refers to when a system has been physically removed from a facility.

Design Pressure. The maximum difference in pressure across the pressure retaining boundary of a pressurized component used in its design calculations.

Engineering Drawing Files. The electronic repository for LaRC drawings.

Excluded Pressure System. A pressure system not required to meet the requirements of this LPR and NASA-STD-8719.17.

Facility Change Request (FCR). An FCR is an electronic form processed via the FCM website. A FCR is initiated to obtain approval for changes to systems under configuration control.

Facility Configuration Management (FCM). A LaRC website for processing FCRs or to obtain copies of Configuration Controlled Items (CCIs).

Flammable Liquid. A liquid with a flashpoint below 100 °F.

Flash Point. The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with the air, near the surface of the liquid or within the vessel used.

Inactive. Refers to when a system is not currently in an operational status.

Inert Gas. Refers to any non-reactive, non-toxic gaseous media, e.g., gaseous nitrogen, helium, and argon.

Interlock. A device (or devices) designed with the purpose of preventing a system from crossing a specified threshold or entering an undesirable mode of operation.

Maximum Allowable Working Pressure (MAWP). The maximum pressure in a system, subsystem, or component as permitted by the applicable code. In general, the term “MAWP” is synonymous to the term “design pressure,” unless the MAWP is explicitly determined by calculations, testing, or recertification.

Maximum/Minimum Design Temperature. The maximum/minimum metal temperature (averaged through-the-wall) considered in the design calculations.

Modification. An alteration or change to the original configuration of a pressure system, which may affect its pressure retaining capability. Any operational or physical change to a pressure system other than a direct replacement of a component is a modification. Operational changes may include such things as changing the normal operating pressure, temperature, or relief valve settings of the system. Physical changes may include such things as changing relief valves or adding/removing piping or components.

Mothballed. Refers to when a system is placed in a storage mode status, often using an inert gas blanket internally and physical isolation methods such as flanges.

National Consensus Code. A document which (1) has been adopted or distributed by a nationally recognized standards developing organization using procedures such that it can be determined by the Secretary of Labor or by the Assistant Secretary of Labor for Occupational Safety and Health that persons interested and affected by the standard have reached substantial agreement on its adoption; (2) was formulated in a manner that afforded an opportunity for diverse views to be considered; and (3) has been so designated by the Secretary or the Assistant Secretary, after consultation with other appropriate Federal Agencies.

Normal Operating Pressure. The pressure in a piping system or pressure vessel under typical operating conditions.

Owner. The owner of a pressure system refers to the Organizational Director or designated representative who is responsible for the pressure system.

Piping System. An assembly of structural components, which may include pipes, valves, fittings, and other such piping components, with the primary purpose to convey, distribute, mix, separate, discharge, meter, control, or snub the flow of a fluid. For the purpose of this definition, tubing and piping are considered to be interchangeable.

Pressure Vessel. An assembly of structural components, which may include pipes, fittings, and piping components, with the primary purpose to hold, contain, or enclose a finite volume of a fluid under pressure or hold a vacuum.

Pressure System. A collection of piping systems and/or pressure vessels used jointly to convey or contain a pressurized fluid or a vacuum.

Pressure Systems Document (PSD). A configuration controlled document describing the current system configuration, including isometric sketches of the system and a database of components. PSDs are available through the FCM website.

Pressure Systems Manager. An individual responsible for managing the recertification program for pressure systems at LaRC.

Redefined. Refers to when a system undergoes a configuration change that deviates from the original design.

Relief Device Setting. The value of increasing inlet static pressure at which the relief device begins venting fluid. For different relief device types, this value may be called opening pressure, cracking pressure, popping pressure, start-to-leak pressure, burst pressure, or breaking pressure.

Repair. The work necessary to restore a pressure system to a safe and satisfactory operating condition, provided that no deviation from the original design is made.

SPE for Pressure Systems. An individual responsible for ensuring ground-based pressure systems at LaRC comply with this LPR.

SPE for Flight Systems. An individual responsible for ensuring pressure components on flight rated systems at LaRC comply with this LPR.

SPE for Welding. An individual responsible for ensuring that welding on pressure systems at LaRC complies with this LPR.

SPE for Wind Tunnel Models. An individual responsible for ensuring that wind tunnel models comply with NASA STD-8719.28and this LPR as applicable.

Tank. A storage container intended to hold or store liquids, with low pressure gases or vapors in the space above the liquid surface.

Test Article. An object being tested for the sole purpose of obtaining research data.

Test-Specific Pressure System. A pressure system used to perform research testing of a specific test article. Pressure systems used on a permanent basis or on a recurring basis are not considered to be test-specific. Pressure systems built up of components used repeatedly for testing different test articles or test configurations are not considered to be test-specific.

APPENDIX B. ABBREVIATIONS AND ACRONYMS

AHJ	Authority Having Jurisdiction
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
B&PV	Boiler and Pressure Vessel
BPQ	Brazer Performance Qualifications
BPS	Brazing Procedure Specification
CCI	Configuration Controlled Item
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CMMS	Computerized Maintenance Management System
COTS	Commercial Off The Shelf
CP	Center Procedure
CVF	Component Verification Facility
DOT	U.S. Department of Transportation
FCM	Facility Configuration Management
FCR	Facility Change Request
FM	Factory Mutual
FSH	Facility Safety Head
HVAC	Heating, Ventilation, and Air Conditioning
ICC	International Code Council
LAPD	Langley Policy Directive
LaRC	Langley Research Center
LF	Langley Form
LMS	Langley Management System

LOTO	Lock Out / Tag Out
LPR	Langley Procedural Requirement
M&TE	Measurement and Test Equipment
MAWP	Maximum Allowable Working Pressure
MT	Magnetic particle examination
NASA	National Aeronautics and Space Administration
NBIC	National Board Inspection Code
NDE	Non Destructive Examination
NPR	NASA Procedural Requirements
OSHA	Occupational Safety and Health Administration
O&M	Operations & Maintenance
ORR	Operational Readiness Review
P&ID	Process and Instrumentation Diagram
PPE	Personal Protective Equipment
PQR	Procedure Qualification Record
PSD	Pressure Systems Document
PSM	Pressure Systems Manager
PSIG	Pounds per square inch gauge
PSID	Pounds per square inch differential
PT	Dye penetrant examination
PVS	Pressure Vessels and Pressurized Systems
RT	Radiographic examination
RTS	Return To Service
SAE	Society of Automotive Engineers
SCBA	Self-Contained Breathing Apparatus
SFAB	Safety and Facility Assurance Branch
SMAO	Safety and Mission Assurance Office
SPE	Standard Practice Engineer
STD	Standard

TD	Task Description
UL	Underwriters Laboratories
VR	Valve Repair stamp
VT	Visual Testing
WPQ	Welder Performance Qualifications
WPS	Welding Procedure Specification

APPENDIX C. BEST PRACTICES FOR PRESSURE SYSTEM DESIGN, INSTALLATION, AND OPERATION

C.1 Bladder Accumulators

C.1.1 Bladder accumulators should be pre-charged with nitrogen gas rather than air or other gases to prevent adverse reaction or combustion.

C.2 Deactivated Pressure Systems

C.2.1 When a pressure system is deactivated or placed in standby mode, it should be pressurized up to 15 psig with a dry, inert gas to prevent contamination and internal corrosion. Positive isolation using blind flanges is the preferred method of isolation. Deactivation of pressure systems shall be reviewed and approved as required in Chapter 3 of this LPR.

C.2.2 When a pressure system is abandoned in place, the piping should be completely removed when appropriate, or the piping where exposed should be left open or cut open and fully identified with tags or labels to indicate that the pipe is abandoned. Abandonement of pressure systems shall be reviewed and approved as required in Chapter 3 of this LPR.

C.3 Double Block and Bleed Isolation

C.3.1 Isolation of sections of a pressure system for the purpose of performing maintenance or for performing work requiring opening the system to atmosphere should be accomplished utilizing a double-block and bleed valve configuration. See LPR 1710.10 for additional requirements for the use of double block and bleed valve configurations.

C.4 Drying of Pressure Systems

C.4.1 Following hydrostatic testing, internal surfaces in pressure systems should be dried using mechanical means, vacuum, or by blowdown with inert gas. If blowdown is to be performed, a written procedure should be developed and approved by the FSH and the SPE for Pressure Systems. As a minimum, the procedure should address the following hazards:

a. Noise,

b. High velocity air, water, and debris,

c. Movement due to unbalanced thrust at the discharge end,

d. Asphyxiation hazard if using an inert gas, and

e. Contamination of oxygen systems, where applicable.

C.5 Filters and Filter Elements

C.5.1 Filters should use ultrasonically-cleanable metallic filter elements whenever possible.

C.5.2 Filter elements should be designed to withstand full differential pressure without collapse. In the absence of this feature, the differential pressure across the filter element should be monitored to prevent collapse.

C.5.3 Whenever a filter housing contains threaded filter elements, the filter elements should be threaded into a removable tubesheet instead of threading directly into the filter housing. This is to prevent damage to the housing in the event the threads become galled or cross-threaded. Lifting lugs should be provided for removal of the elements/tubesheet.

C.5.4 Welds in filter elements should be VT examined and PT examined after fabrication. Criteria for rejection of filter element welds include (a) cracks in the weld area, (b) surface porosity, (c) excessive weld reinforcement, (d) undercut, and (e) lack of fusion.

C.5.5 The filter housing should allow for an annular area between the housing and the filter elements of at least 1.5 times the inlet piping cross sectional area.

C.5.6 The design of T-type filters should not produce direct flow impingement on the filter media.

C.5.7 Manufacturers of new custom-built filters should provide calculations of the filter element's maximum allowable differential pressure, a certified as-built drawing of the filter housing, and a certified as-built drawing of the filter element and tubesheet, including part numbers.

C.6 Glass Windows in Pressure Systems

C.6.1 The use of glass windows exposed to pressure differentials should be avoided. If used, glass surfaces should be shielded or protected by quick-acting closures whenever possible. Indirect viewing using electronic cameras and monitors rather than direct viewing should be employed to the greatest extent possible.

C.6.2 Glass windows in pressure systems should not be subjected to extraneous heating or cooling sources such as ultraviolet lamps, infrared lamps, or other lighting/heat sources, cooling water or cryogenic gases, which could cause cracking and/or breakage due to thermal expansion of glass and/or frame.

C.6.3 Special consideration should be given to vacuum systems and implosion effects whereby viewing windows present potential hazards to personnel.

C.7 Normal Operating Pressure

C.7.1 The normal operating pressure of a system should be at least 10% below the relief device setting.

C.8 Pressure Relieving and Venting Systems

C.8.1 Piping downstream of relief valves and vent valves should be routed separately to the point of discharge. However, a common header that considers the effects of

backpressure on the discharge capacity of the relief valves may be used when approved by the SPE for Pressure Systems.

C.8.2 Gas vent piping of sizes 2 inch nominal and larger shallbe outfitted with screens at the point of discharge to keep out insects and animals.

C.9 Pressure Transmitters and Transducers

C.9.1 The use of pressure transmitters and pressure transducers in lieu of bourdon-tube pressure gauges should be used whenever there is a need to convey pressure data to facility control rooms.

C.10 Reclaimed Materials

C.10.1 Reclaimed piping or tubing may be reused provided the reclaimed materials are:

a. Examined to determine if the minimum wall thickness is greater than that required by the applicable code.

b. Hydrostatically tested to 1.5 times the design pressure of the system.

c. Inspected for imperfections that would be unacceptable for its intended use.

d. Cleaned in sufficient measure to ensure compatibility with their intended use.

e. All welds in reused material should be 100% radiographically examined.

f. The material of the piping or tubing is ascertained through Positive Material Identification (PMI) or material markings.

C.11 Supports

C.11.1 Piping and tubing should be firmly secured to a stable structure at or near mechanical joints and at bends to prevent violent displacement of the piping in event of a joint failure.

C.12 Threaded Piping and Fittings

C.12.1 The use of threaded piping and fittings in nominal sizes greater than 1-1/2 inch is not recommended.

C.13 Valve Body Fabrication

C.13.1 Valves should be of forged construction for sizes 6 inches and larger where the flange rating is 600 pound class or above.

C.14 Valve Numbering

C.14.1 In building complexes where multiple research apparatus or facilities are fed from a common piping system, valves should not be assigned the same four digit valve number and suffix combination even if the three digit prefix is different. This is intended to facilitate proper valve identification when they are being serviced or operated (e.g., 066-3200A and 067-3200A are not allowed, but 066-3200A and 066-3200B are allowed).

C.14.2 When a valve is replaced, its valve number may be assigned to the replacement valve if the replacement valve performs the identical function as the

original valve (e.g., system isolation, pressure control, flow control, venting, or pressure relief) and the replacement valve is in the same functional location as the original valve, as determined from the pressure system's P&ID. If the above conditions are not met, the replacement valve should be assigned a new valve number. Example: a penumatically-operated **isolation** valve is replaced by a pneumatically-operated **control** valve. In this example, the control valve should be assigned a new valve number because the valve function has changed.

Note 1: This section contains best practices for valve numbering and not requirements.

Note 2: For any questions regarding valve numbering, personnel may contact the Pressure Systems Manager.

APPENDIX D. RECOMMENDED PRACTICE FOR THE ESTABLISHMENT OF HAZARD PERIMETERS FOR PNEUMATIC TESTING

D.1 General

D.1.1 The consequences of the sudden failure of a compressed gas system include the release of shock waves and the expulsion of debris. The destructive potential of these failures can be estimated using the TNT-equivalency technique that was developed by the Naval Ordnance Laboratory and documented in the technical report NOLTR 70-208 “Failure-Damage Assessment Technique for High-Pressure Gas Containment Vessels,” by V. C. D. Dawson and A. E. Seigel (1970).

D.1.2 The procedure delineated below is recommended for establishing personnel exclusion perimeters associated with pneumatic testing of pressure systems. The calculated exclusion perimeter is not intended as a means of determining how close personnel can work next to an active pressure system during normal operation.

D.1.3 The general procedure includes the following steps:

a. Establish the water volume of the vessel or piping system (**V**, cubic feet). For piping systems, use the volume of the longest run of pipe in the system with the largest diameter between mechanical discontinuities (e.g., welded joints, threaded fittings, flanges, or other structural item capable of arresting a moving crack front.)

b. Determine the system’s maximum operating pressure (**P**, pounds per square feet absolute) and temperature (**T**, degrees Rankine)

c. Calculate or look up the standard atmospheric pressure ($\mathbf{P_{atm}}$, pounds per square feet absolute)

d. Look up the specific heat ratio of the test gas ($\boldsymbol{\gamma}$, adimensional, e.g., 1.4 for air, 1.3 for nitrogen)

e. Calculate the potential energy contained in the pressurized gas by using the formula (result is in units of ft-lb_f)

$$E = \frac{PV}{\gamma - 1}\left[1 - \left(\frac{P}{P_{atm}}\right)^{\frac{1-\gamma}{\gamma}}\right]$$

f. Convert the potential energy calculated previously (units of ft- lb_f) to an equivalent mass of TNT (units of lb_m) by using the equation

$$m = \frac{E}{1{,}424{,}033}$$

g. Calculate radii of the different overpressure zones using Table D-1 and the following formula

$$R = \lambda \cdot m^{1/3}$$

Table D - 1, Effects of Blast Overpressure

Zone	ΔP, psid	λ, ft/(lb$^{1/3}$)	Comment
1	< 0.2	147.8	Safe distance for all personnel. During system pressure testing, a personnel exclusion perimeter should be normally set at this distance.
2	0.5 – 1.0	76.7 – 45.8	Slight damage may occur; glass may shatter. The exclusion perimeter may be set in this range with approval from the SPE for Pressure Systems.
3	1.0 – 5.0	45.8 – 14.7	Moderate damage to wood frame structures may occur. Corrugated asbestos siding may shatter. Corrugated steel or aluminum paneling may buckle.
4	5.0	14.7	Eardrums may rupture.
5	7.0 – 8.0	12.1 – 11.2	Non-reinforced brick walls 8 inch to 12 inch thick may shear and fail.
6	10.0	10	Lung damage may occur.

When conducting pneumatic tests above the design pressure or MAWP of a pressure system, all personnel shall be excluded from the perimeter calculated per this procedure, with the exception of the minimum number of personnel required to properly conduct the test. All personnel shall wear appropriate Personal Protective Equipment (PPE) while inside the exclusion perimeter. All personnel shall move outside of the exclusion perimeter during pressure holding times.

Example calculation:

A compressed air piping system consists of mainly 3" schedule 160 piping, operating at 4500 psig. The longest run of piping between two discontinuities is 20 feet.

$$V = \frac{\pi}{4} \cdot \left[\frac{2.624}{12}\right]^2 \cdot (20)$$ → 2.624" is nominal inside diameter of pipe

$$V = 0.751 \cdot ft^3$$ *(cubic feet)*

$$P = (4500 + 15) \cdot (144) = 650{,}160 \cdot psfa$$ *(pounds per square foot, absolute)*

$$P_{atm} = 15 \cdot 144 = 2160 \cdot psfa$$

$$T = 520 \cdot Rankine$$

$$\gamma = 1.4$$

$$E = \frac{(650160)(0.751)}{(1.4-1)}\left[1-\left(\frac{650160}{2160}\right)^{\frac{(1-1.4)}{1.4}}\right] \qquad E \cong 982{,}000 \cdot lb_f \cdot ft$$

$$\therefore \quad m = \frac{982000}{1424033} = 0.69 \cdot lb_m \qquad \textit{(pounds of mass)}$$

Then, the distance from the center to the 0.2 psid perimeter (Zone 1) is

$$R = \lambda \cdot m^{1/3} = 147.8 \cdot (0.69)^{1/3} = 131 feet$$

Similarly, the range of distances defining each zone can be calculated.

APPENDIX E. REFERENCES

a. NASA Procedural Requirements (NPR) 8715.3, NASA General Safety Program Requirements.
b. ASME B1.20.1, Pipe Threads, General Purpose (Inch).
c. ASTM B88, Standard Specification for Seamless Copper Water Tube.
d. ASTM B280, Standard Specificaiton for Seamless Copper Tube for Aid Conditioning and Refrigeration Field Service.
e. SAE AMS5075, Steel Tubing, Seamless 0.22 – 0.28C (SAE 1025) Cold Drawn and Stress Relieved.