Langley Research Center

LPR 1710.40

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Langley Research Center
Pressure Systems Handbook

National Aeronautics and Space Administration

Responsible Office: Safety and Mission Assurance Office

PREFACE

PURPOSE

This Langley Procedural Requirement (LPR) implements the requirements of NASA NPD 8710.5, “NASA Safety Policy for Pressure Vessels and Pressurized Systems,” and is part of the Langley Management System. It establishes requirements and standards for pressurized systems within the framework of Langley Research Center 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.

APPLICABILITY

This LPR is applicable to all Langley employees.

AUTHORITY

NPD 8710.5, “NASA Safety Policy for Pressure Vessels and Pressurized Systems.”

REFERENCE

NPD 8715.4, “Inservice Inspection of Ground-Based Pressure Vessels and Systems.”

LPR 1710.10, “Safety Clearance Procedures for the Control of Hazardous Energy (Lockout/Tagout).”

LPR 1710.15, "Wind-Tunnel Model Systems Criteria.”

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

LPR 1710.42, “Safety Program for Maintenance of Ground-Based Pressure Vessels and Pressurized Systems.”

LPR 1740.2, "Facility Safety Requirements.”

LPR 1740.4, “Facility System Safety Analysis and Configuration Management.”

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

LPR 1740.7, “Process Systems Certification Program.”

LMS-CP-5616, “Computerized Maintenance Management System (CMMS) Change

Request."

LMS-TD-5569, "Performing Visual Inspections."

LF 121, "LaRC Safety Manual Review for Certified Operators."

LF 122, "Facility Safety Awareness and Procedures Review for Certified Operators."

LF 159, "Appointment for Operator Certification."

CANCELLATION

LPR 1710.40, "Safety Regulations Covering Pressurized Systems," dated October 3, 2004.

original signed on file

Roy D. Bridges, Jr.
Director

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Chapter 1

1. INTRODUCTION

1.1 Purpose

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

1.2 Fundamental Premise

This document is written on the premise that the functions listed in Chapter 13 are essential to provide the checks and balances necessary to ensure pressure system safety and functional integrity.

1.3 Applicability and Exclusions

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

Pressurized systems in wind tunnel models shall comply with LPR 1710.15, "Wind-Tunnel Model Systems Criteria."

The following systems are excluded from the requirements of this document:

(a) AIR-PAK Rescue Equipment or Other Self-Sustaining Breathing Apparatus

These items shall comply with OSHA regulations in 29 CFR Part 1910, Subparts 1910.134 through 1910.140.

(b) Commercial Off-The-Shelf Pressure Systems and Components

Commercial off-the-shelf (COTS) pressure systems and components are exempt from the requirements of this document provided they are:

- Used, maintained, and repaired in accordance with the manufacturer's recommendations.
- Furnished with an ASME Code Stamp, unless determined by the SPE that code stamping is not applicable.

Modifications to COTS systems and components shall be approved by the SPE.

(c) Fire Extinguishers

These items are covered by OSHA regulations in 29 CFR Part 1910, Subpart L, and include:

- Portable extinguishers,
- Stand pipe and hose systems,

- Automatic sprinkler systems,
- Fixed dry and wet chemical extinguishing systems,
- Carbon dioxide extinguishing systems, and
- Alternative gas (environmentally friendly) extinguishing systems.

(d) Low Energy Systems

The following systems are excluded from the requirements of this document provided they are installed and maintained in accordance with standard practices using code acceptable materials:

- Water vessels or systems operating at pressures less than 125 psig and temperatures less than 130 °F.
- Vessels or systems containing air or inert gases, with a volume less than 40 cubic feet water volume, operating at less than 125 psig and 130 °F (equates to an energy content less than 5000 psi-ft^3).
- Vacuum vessels or systems with volumes not exceeding 100 cubic feet water volume.

(e) Over-the-Road Trailers

Over the road trailers shall comply with the Department of Transportation (DOT) regulations, 49 CFR Parts 171 through 180.

2. GENERAL REQUIREMENTS

2.1 Codes and Standards

All pressure systems and components owned by or used at Langley Research Center shall be designed, fabricated, modified, repaired, and/or recertified, as a minimum, in accordance with the following codes and standards as applicable:

(a) American Society of Mechanical Engineers (ASME)

- Boiler and Pressure Vessel Code
- B31.1, “Power Piping” (for steam piping)
- B31.3, “Process Piping” (for all piping other than steam systems)
- B31.5, “Refrigeration Piping and Heat Transfer Components”

(b) National Board of Boiler and Pressure Vessel Inspectors (NBBI)

- NB-23, “National Board Inspection Code”

(c) American Institute of Aeronautics and Astronautics (AIAA)

- S-080 “Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components”
- S-081 “Space Systems - Composite Overwrapped Pressure Vessels (COPV)”

(d) Langley Research Center (LaRC)

- LPR 1710.41, “Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds”
- LPR 1710.42, “Safety Program for Maintenance of Ground-Based Pressure Vessels and Pressurized Systems”
- LPR 1710.15, "Wind-Tunnel Model Systems Criteria”

2.2 Approvals

Ground-based pressure systems shall be approved, as a minimum, by the Standard Practice Engineer (SPE) for Pressure Systems. Flight rated pressure systems shall be approved by the Standard Practice Engineer (SPE) for Flight Systems. The SPE's may waive specific requirements of this document on a case-by-case basis. The Pressure Systems Committee must approve deviations from the requirements in the codes and standards listed above.

3. DEFINITIONS

Change Notification Sheet (CNS) – An electronic form available through the Configuration Management On Line (CMOL) website initiated with the intent to document changes to systems under configuration control.

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 – NBBI Pressure Vessel Repair

VR – NBBI Valve Repair

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

PP – ASME Power Piping

Cognizant Engineer – a person who understands the design and operation of a pressure system and is responsible for monitoring the progress of pressure systems work.

Commercial Off-The-Shelf Pressure Systems and Components - Commercial off-the-shelf (COTS) pressure systems and components are systems and components routinely produced by a reputable manufacturer. COTS pressure systems and components are typically furnished with a recommended pressure rating, temperature rating, and/or life expectancy.

Configuration Management On Line (CMOL) – A LaRC website for processing CNS's or to obtain copies of Configuration Controlled Documents (CCD's) (http://cmol).

Design pressure – the value of the maximum difference in pressure across the pressure retaining boundary of a pressure component used in its design calculations.

Inert gas – refers to any non-reactive, non-toxic gaseous media, e.g., gaseous nitrogen, helium, and argon.

Maximum Allowable Working Pressure (MAWP) – the maximum allowable working pressure of a system, subsystem, or component as permitted by the applicable code. In general, the MAWP is taken to be equal to the design pressure, unless it 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 working 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.

Owner – as used in this document, the owner of a pressure system refers to the Organizational Unit Manager (OUM), or his/her 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 shall be 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.

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 CMOL web site.

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, 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.

Standard Practice Engineer (SPE) for Pressure Systems – An agent of the Pressure Systems Committee responsible for ensuring ground based pressure systems comply with this document.

Standard Practice Engineer (SPE) for Flight Systems – An agent of the Pressure Systems Committee responsible for ensuring pressure components on flight rated systems comply with this document.

Working pressure – the pressure at which a pressurized system operates under normal conditions.

4. DESIGN OF NEW PRESSURE SYSTEMS

4.1 General

All new pressure systems owned by or used at LaRC shall be designed in accordance with the applicable codes and standards, as outlined in Chapter 2, and shall include documentation to verify that they are in accordance with these codes. Documentation examples include drawings or sketches, calculations, catalog cuts, and manufacturer certifications.

All drawings/sketches shall include the following information:

(a) Date

(b) Facility name

(c) Building number

(d) Drawing or sketch title

(e) Drawing or sketch number

(f) Salient engineering data, as applicable, such as

- Fluid Service
- Design pressure
- Design temperature
- Material specification
- Nondestructive examination (NDE) and inspection requirements
- Testing requirements
- Set pressure of relief valves
- Set points of all interlocks and protection devices

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

4.2 Review and Acceptance

All designs of pressure systems owned by or used at LaRC shall be reviewed and accepted (signed off) by the following (in order):

(a) The Facility Coordinator

(b) The Standard Practice Engineer

(c) The Facility Safety Head

5. FABRICATION OF NEW PRESSURE SYSTEMS

5.1 General

New pressure systems owned by or used at LaRC shall be fabricated in accordance with an approved design as defined in Chapter 4.

5.2 Pressure Vessels

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

5.3 Welded or Brazed Piping Systems

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, as appropriate. 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.

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

(a) Welding or brazing procedure specification (WPS/BPS)

(b) Procedure Qualification Records (PQR)

(c) Welder or brazer Performance Qualifications (WPQ/BPQ)

(Note: these documents are not submitted for Government approval with ASME code stamped pressure vessels)

5.4 Non-welded or Non-Brazed Piping Systems

Non-welded or non-brazed piping systems shall be fabricated by persons experienced in the fabrication method being utilized.

6. MODIFICATIONS AND REPAIRS TO PRESSURE SYSTEMS

6.1 General

Pressure systems owned by or used at LaRC shall be modified or repaired in accordance with an approved design as defined in Chapter 4.

6.2 Pressure Vessels

Modifications and repairs to pressure vessels shall be performed by organizations that are holders of an applicable National Board Certificate of Authorization such as the “R”, “VR”, or “NR” stamps. Deviations from this requirement must be approved by the LaRC Pressure Systems Committee (see Chapter 14, “Deviations”).

6.3 Welded or Brazed Piping Systems

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”.

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

(a) Welding procedure specification (WPS)

(b) Procedure Qualification Records (PQR)

(c) Welder Performance Qualifications (WPQ)

6.4 Non-Welded or Non-Brazed Piping Systems

Modifications and repairs to non-welded or non-brazed piping systems may be performed by organizations that are not holders of an ASME or National Board stamp but that are experienced in the fabrication method used.

7. PROCUREMENT OF PRESSURE SYSTEMS

7.1 General

All pressure systems and components procured for use in systems owned by or used at LaRC shall comply with the requirements of this document and shall be reviewed by the Standard Practice Engineer.

7.2 New Pressure Vessels

All contracts or orders requiring the purchase of new pressure vessels shall require the vessel to be ASME code stamped and shall contain the following note:

> "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 greatly facilitated 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."

7.3 Welded or Brazed Piping Systems and Existing Pressure Vessels

All contracts requiring fabrication, modification, or repair of welded or brazed piping systems and existing pressure vessels shall require the fabricator to be a holder of an ASME code stamp and shall contain the following note:

> "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 greatly facilitated 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. INSPECTION AND TESTING OF PRESSURE SYSTEMS

8.1 General

Inspection and testing of pressure systems to be owned by or used at LaRC shall meet, as a minimum, the requirements of the applicable design code listed in Chapter 2 of this document.

8.2 Supplemental Inspection Requirements

In addition to the minimum code requirements, the Cognizant Engineer shall ensure that the following supplemental requirements are met:

(a) Non-destructive evaluation (NDE) shall be done in accordance with Table 8-1 (LaRC Supplemental NDE Requirements).

(b) All NDE shall be performed by inspectors certified to the American Society for Nondestructive Testing (ASNT) Level II or Level III requirements.

(c) When heat treatment or stress relieving of a pressure retaining component is required, a magnetic particle examination (MT) or a dye penetrant examination (PT) of the heat-affected-zone shall be conducted after all other required examinations are complete.

(d) Inspection and acceptance criteria for socket welds and branch connection welds shall be in accordance with LPR 1710.41, “Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds.”

(e) Acceptance criteria for butt welds in pressure systems shall be in accordance with ASME B31.3 “Process Piping” for severe cyclic conditions.

(f) Radiographic inspection of piping girth butt welds shall utilize tangential techniques wherever possible (elliptical techniques should be avoided).

(g) Final interpretation and acceptance of radiographs of pressure systems will be by the SPE or his/her designated representative.

(h) All radiographic film of pressure systems shall be submitted by the Cognizant Engineer to the LaRC recertification contractor’s COTR or his/her designated representative for final filing and storage. The LaRC recertification contractor shall retain the radiographic film in a controlled environment repository for a minimum of 5 years.

(i) All hydrostatic and pneumatic tests conducted on site at Langley Research Center shall be performed using written and approved test plans and operating procedures. Test plans shall be approved by the cognizant engineer and the SPE. When hydrostatic testing is conducted at the Component Verification Facility (Building 1284B), the development of test plans is not required.

(j) Hydrostatic or pneumatic testing is used to establish the ability of new, modified, or repaired pressure systems to withstand the design pressure of the system.

Both methods of testing are potentially hazardous. Adequate safety precautions shall be taken to ensure the safety of personnel and equipment. Pneumatic testing should be conducted only when hydrostatic testing is not feasible. A gas complying with cleanliness requirements of the pressure vessel and system shall be used. A hazard zone shall be established by engineering analysis and all personnel must be excluded from the hazard zone. The pneumatic test procedure must be approved by the SPE; the Chairperson of the Pressure Systems Committee; the Director of the Safety and Mission Assurance Office (SMAO); and the cognizant Facility Safety Head (FSH).

(k) Hydrostatic or pneumatic testing of pressure systems shall be witnessed by the Standard Practice Engineer or his/her designated representative. The fabricator shall provide a hydrostatic or pneumatic test certificate, signed and dated by the fabricator's testing personnel. The fabricator's certificate shall include a description of the tested system, the test pressure, holding time, and any other pertinent test parameters.

(l) As a minimum, acceptance criteria for the evaluation of visual inspections on pressure components shall be in accordance with LMS-TD-5569, "Performing Visual Inspections."

Table 8 - 1, LaRC Supplemental NDE Requirements

		Joint Type				
		Butt Weld	**Socket Weld**	**Branch Weld**	**Fillet Weld**	**Threaded / Tubing**
Pressure Vessels	**Code Stamped** (all pressures, all volumes)	Per ASME Boiler and Pressure Vessel Code				
	Not Code Stamped (P > 15 psig, all volumes)	100% VT 100% RT	100% VT 100% RT	100% VT 100% RT	100% VT 100% MT or PT	100% VT
	Not Code Stamped (P ≤ 15 psig, V > 340 ft^3)	100% VT 100% MT or PT	100% VT 100% MT or PT	100% VT 100% MT or PT	100% VT 100% MT or PT	100% VT
	Not Code Stamped (P ≤ 15 psig, V ≤ 340 ft^3)	100% VT	100% VT	100% VT	100% VT	100% VT
Process Piping (except steam piping)	**Air, Water, or Inert Gas** (P ≤ 125 psi, T > 130 °F)	100% VT 5% RT	100% VT 5% RT	100% VT 5% RT	100% VT 5% MT or PT	100% VT
	Air, Water, or Inert Gas (P > 125 psi, T > 130 °F)	100% VT 100% RT	100% VT 100% RT	100% VT 100% RT	100% VT 100% MT or PT	100% VT
	Other Media (all pressures and temperatures)	100% VT 100% RT	100% VT 100% RT	100% VT 100% RT	100% VT 100% MT or PT	100% VT
Steam Piping	**P ≤ 125 psig**	100% VT 10% RT	100% VT 10% RT	100% VT 10% RT	100% VT 10% MT or PT	100% VT
	P > 125 psig	100% VT 100% RT	100% VT 100% RT	100% VT 100% RT	100% VT 100% MT or PT	100% VT

VT – Visual Inspection, MT – Magnetic Particle Inspection, PT – Liquid Penetrant Inspection, RT – Radiographic Inspection

The SPE has the authority to waive inspection or test requirements on a case-by-case basis. The Pressure Systems Committee shall approve deviations from the minimum requirements in the design code.

9. VERIFICATION AND SHAKEDOWN OF PRESSURE SYSTEMS

9.1 General

All new, modified, or repaired pressure systems owned by or used at LaRC shall undergo verification and shakedown prior to being placed in operational service.

9.2 Verification

The cognizant engineer shall verify that the system has been constructed, repaired, or modified in accordance with the approved design documentation (as described in Chapter 4) and shall verify that:

(a) All nondestructive examinations have been completed and accepted.

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

(c) All safety and interlock devices have current calibrations, have been installed, and are operating properly.

(d) All other system devices (e.g., valves, actuators, gages, traps) have been properly installed and are operable (without pressure).

(e) A shakedown plan has been developed.

Once verified, the cognizant engineer shall document the verification in a letter (or e-mail) to the Owner, or his/her designated representative, for concurrence, certifying that:

(a) All work has been completed and complies with LPR 1710.40, “Pressure Systems Handbook.” Deviations from ASME and ANSI codes and standards, if any, were approved by the Pressure Systems Committee.

(b) The installation was completed in accordance with the engineering design, specifications, and drawings.

(c) Any changes to the original design were approved by the Standard Practice Engineer.

(d) The Pressure Systems Committee, a formal design review committee, or the Standard Practice Engineer has reviewed the plans for shakedown.

(e) The system is ready to be pressurized.

For systems under configuration control, the letter shall identify the appropriate CNS number for the change.

9.3 Shakedown

Shakedown may be performed after the system has been verified, and shall validate

system performance and operator training. The Cognizant Engineer shall oversee shakedown. During shakedown:

(a) The operators shall be properly trained and certified.

(b) The operating procedures shall be completed and signed off in accordance with the configuration management process.

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

10. OPERATIONS AND MAINTENANCE OF PRESSURE SYSTEMS

10.1 General

Pressure systems under configuration control shall be operated in accordance with Standard Operating Procedures developed and approved in accordance with LPR 1740.4, “Systems Safety Analysis and Configuration Management.”

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

10.2 Operator Certification

All pressure systems used at LaRC shall be operated by personnel who have received training in the operational characteristics of the system and understand the operational procedures, checklists, and inherent hazards associated with the system. The operator of a pressure system owned by LaRC shall be certified in accordance with LPR 1740.7, “Process System Certification Program.” The Facility Safety Head shall ensure that Langley Form (LF) 121, “LaRC Safety Manual Review for Certified Operators,” and LF 122, “Facility Safety Awareness and Procedures Review for Certified Operators,” include the appropriate documents to ensure the operator has read and understands the operational procedures, checklists, and inherent hazards associated with the system. The certification of the operator shall be documented on LF 159, “Appointment for Operator Certification.”

10.3 Personnel Protection

When any maintenance operation could result in injury to personnel or serious damage to equipment, the system shall be locked/tagged out in accordance with LPR 1710.10, “Safety Clearance Procedures for the Control of Hazardous Energy (Lockout/Tagout).”

Any system containing toxic fuel or other potentially dangerous media shall be purged with an appropriate agent such as fresh air, water, inert gas, or a neutralizing agent prior to disassembly of components or opening up the system. The purge shall be performed in accordance with written procedures approved by the Facility Safety Head.

11. DOCUMENTATION

11.1 General

The cognizant engineer shall provide records to the Facility Safety Head that document the as-built configuration of the system. Documentation shall include:

(a) As-built drawings or sketches for incorporation into the Configuration Control System.

(b) NDE records.

(c) Test reports.

(d) Shakedown records.

The owner of a pressure system shall maintain a file copy of:

(a) Current certifications of calibrated devices

(b) Test reports

(c) Non-destructive examination reports

(d) Inspection records

(e) Shakedown records

(f) Process and instrumentation diagram (PID)

11.2 Process and Instrumentation Diagrams

The owner of a pressure system shall maintain a file copy of a current process and instrumentation diagram (P&ID) for each pressure system at his/her facility. These P&ID drawings shall be made available to the system operators. The P&ID drawing shall identify all safety devices and their set points. For pressure systems under configuration management, the P&ID shall be a configuration controlled document.

12. RECERTIFICATION

12.1 General

Pressure systems owned by or used at LaRC shall be periodically inspected and recertified in accordance with the guidelines in NPR 8715.4 "*Inservice Inspection of Ground-Based Pressure Vessels and Systems*" and LPR 1710.42, "Safety Program for Maintenance of Ground-Based Pressure Vessels and Pressurized Systems."

Pressure systems at LaRC shall be documented in a Pressure System Document (PSD) including a description of the system, an overall system schematic, detailed system sketches, a listing of all the components, a listing of components recommended for replacement (if any), references to the system's inspection plans, and information on the status of the pressure system. PSD's are available electronically through the CMOL website.

12.2 Active and Inactive Pressure Systems

The owner is responsible for establishing the operational status of a pressure system. A pressure system designated as "ACTIVE" will be subject to the periodic inspections required by the LaRC Recertification Program and by the guidelines in NPR 8715.4 and LPR 1710.42. An "INACTIVE" pressure system will not be subject to periodic inspection and shall not be operated. In order to change a pressure system's operational status from "INACTIVE" back to "ACTIVE", the pressure system shall be thoroughly inspected and/or tested as required by the Standard Practice Engineer prior to re-pressurization.

13. RESPONSIBILITIES

The functions listed below are essential to provide the checks and balances necessary to ensure pressure system safety and functional integrity.

13.1 Cognizant Engineer

The Cognizant Engineer shall:

(a) Monitor the progress of pressure systems work.

(b) Ensure that all performance and safety requirements for pressure systems are documented.

(c) Ensure that all fabrication, modifications, repairs, and inspections are in compliance with the approved design.

(d) Ensure that completed pressure systems meet documented project requirements.

(e) Provide written notification to the Facility Safety Head that the system has met the requirements of this document and is ready to be placed in operation.

(f) Ensure that all radiographs and weld maps are submitted to the Recertification contractor's COTR or his/her designated representative.

(g) Oversee pressure system shakedown activities.

13.2 Facility Coordinator (FC)

Facility Coordinators shall:

(a) Ensure that all pressure-retaining equipment (e.g., relief valves, control valves, gages, transmitters) in pressure systems within their facility shall be included in the Computerized Maintenance Management System (CMMS) in accordance with LMS-CP-5616.

(b) Review and accept pressure system designs for their facility.

(c) Maintain records of valve numbers in their facility pressure systems.

13.3 Facility Safety Head (FSH)

Facility Safety Heads shall:

(a) Ensure that all new pressure vessels, piping, associated equipment, and all modifications thereto are approved by the Standard Practice Engineer and/or the LaRC Formal Design Review process before commencing site work.

(b) Ensure that each employee is familiar with and complies with the provisions of this handbook and other related LaRC safety regulations.

(c) Possess written verification that a pressure system is ready to be re-energized as described in Chapter 9.

(d) Ensure that new operational procedures and/or revision of existing operational procedures for changes, additions, or alterations are completed.

(e) Ensure that a complete set(s) of final drawings, design specifications, design analysis manuals, and schematic drawings required for safe and proper operation is available.

(f) Ensure safeguarding, inspection, and testing of flex hoses that are not permanently installed.

(g) Approve pneumatic test procedures.

(h) Review and accept pressure systems designs for their facility.

13.4 Owner

The owner of a pressure system shall:

(a) Maintain a file copy of a current process and instrumentation diagram (P&ID) for each pressure system at his/her facility.

(b) Maintain a file copy of all relevant pressure system documentation.

(c) Establish operational status of pressure systems.

13.5 Pressure Systems Operator

The Pressure Systems Operator shall:

(a) Be knowledgeable of the operational procedures, checklists, and inherent hazards of the system.

(b) Be certified in accordance with LPR 1740.7, “Process Systems Certification Program.”

13.6 Standard Practice Engineer (SPE) For Pressure Systems

The Standard Practice Engineer for Pressure Systems (ground-based) shall:

(a) Review and approve all new designs, modifications, and repairs to pressure systems and shall certify their compliance with existing codes and standards.

(b) Evaluate requests for deviations from the requirements of this document.

(c) Interpret and accept, or designate a representative to interpret and accept, radiographs of pressure systems.

(d) Approve all designs of glass windows to be installed in pressure systems.

(e) Witness, or designate a representative to witness, hydrostatic or pneumatic tests.

13.7 Standard Practice Engineer (SPE) For Flight Systems

The Standard Practice Engineer for Pressurized Flight Systems shall

(a) Review and approve drawings, test plans, operational procedures, checkout procedures, purchase requests, specifications, and statements of work.

(b) Evaluate requests for deviations from the requirements of this document.

14. DEVIATIONS

14.1 General

Deviations from the requirements of the codes and standards listed in Chapter 2 must be approved by the LaRC Pressure Systems Committee (PSC).

A request for deviation to the PSC shall include full justification for the deviation and the supporting data and analyses to demonstrate that safe operation can be achieved. The PSC will review the request and forward its recommendation to the LaRC Executive Safety Board for final approval.

Deviations from other requirements of this document require approval by the Standard Practice Engineer.

Appendix A - Additional Requirements and Best Practices

Appendix A – Additional Requirements and Best Practices

This Appendix contains additional requirements and best practices associated with pressure systems. Whenever the word “shall “ is used in this Appendix, the text is understood to be mandatory. Whenever the word “should “ is used, the text is interpreted as being a recommended practice.

A-1 Anchoring

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

(b) Pipe, tubing, and flexible hoses should be firmly secured to a stable structure at or near joints and bends to prevent violent displacement in case of joint failure.

A-2 Bladder Accumulators

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

A-3 Bushings

(a) Single-step bushings conforming to ANSI/ASME B16.11 shall not be used in systems with pressures above 125 psig. All transitions of this type should be made using concentric reducer sections or reducing couplings.

A-4 Cleaning

(a) Pressurized components shall be cleaned internally before use to the extent necessary to be compatible with their intended use. For example, use of oxygen gas, liquid oxygen, or high pressure air (high concentration of oxygen) in a system containing oil or other hydrocarbon-rich residues will form a flammable or explosive mixture, which may result in an explosion.

(b) Systems requiring cleanliness to 10 parts per million or less of hydrocarbons shall be cleaned in accordance with LPR 1740.5, "Procedures for Cleaning of Systems and Equipment for Oxygen Service.”

(c) Hydrostatically tested pressure systems should be dried using air or nitrogen gas.

A-5 Color Coding and Marking

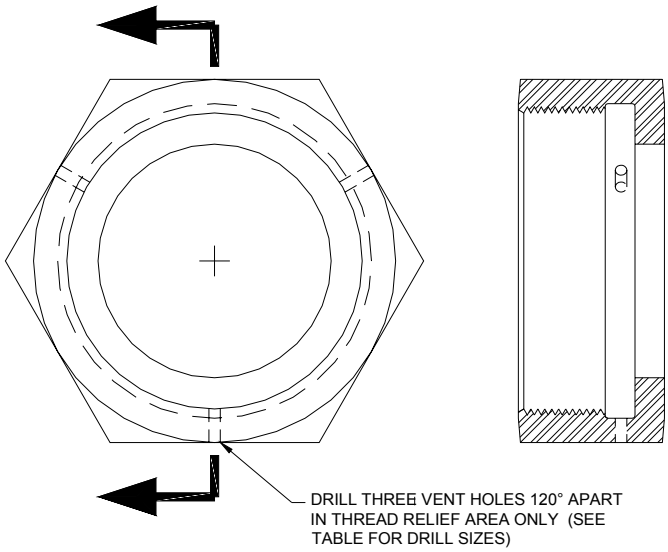
(a) All pressure systems shall have identification of media type, flow direction, and use the color coding scheme specified in LPR 1740.2, "Facility Safety Requirements."

A-6 CPV-Type Union Nuts

(a) CPV type union nuts subject to pressures above 3000 psi shall have vent holes and be torqued to the values listed in the figure below. CPV type unions 1 1/4" and larger

in size shall not be used in compressed gas systems above 2400 psi.

SIZE	TORQUE (FT-LB)	VENT HOLE DIAMETER
1/8"	10 - 25	1/16"
1/4"	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"
1 1/4"	30 - 75	1/8"
1 1/2"	35 - 90	1/8"
2"	45 - 120	1/8"



A-7 Filter Regulators

(a) Filter regulators with glass bulbs shall not be used in pressure systems unless the glass bulb is made of impact-resistant glass.

A-8 Flexible Hoses

(a) Flex hoses shall not be used in a system in lieu of rigid piping or tubing unless the use of rigid piping or tubing has been determined to be impractical, or where vibration isolation, motion allowance, or component flexibility requires their use.

(b) Fabrication and testing of flex hoses for use in LaRC ground-based facilities shall be performed by certified personnel at the Component Verification Facility (Building 1284B) or by flex hose manufacturers/providers.

(c) Flex hoses in pneumatic systems with working pressure above 125 psig shall be secured at both ends and at intermediate connections using Kellems or similar type restraints. Hose restraints in liquid systems shall be evaluated by the SPE.

(d) Procurements of flex hose assemblies shall require the following:

- the maximum allowable working pressure (MAWP) of the flex hose shall be marked on the outside surface
- the manufacturer shall provide a signed pressure test certificate
- the manufacturer shall provide a tag affixed to the flex hose indicating the date and pressure of the pressure test

(e) All flex hoses shall be tested prior to initial use to 150% of the hose material's MAWP if hydrostatically tested or 110% of the MAWP if pneumatically tested.

(f) Flex hoses shall be periodically retested if (a) the flex hose is subject to periodic disconnection and reconnection, (b) the flex hose is subject to constant flexing, twisting, or stretching (c) the flex hose contains a pressurized liquid that is known to be corrosive or damaging to the hose material, or (d) the hose is exposed to external agents or conditions that deteriorate its outer layer. Under these conditions, flex hoses shall be retested hydrostatically or pneumatically to 100% of the hose MAWP every 2 years.

(g) A pressure test tag or band shall be placed on all flex hoses indicating the date and pressure of the last test. Flex hoses with missing test tags shall be retested or replaced.

(h) Flex hoses that are permanently installed in a pressure system shall be periodically inspected using a visual external inspection technique by a certified ASNT Level II or Level III inspector. Inspection intervals shall be as required by the LaRC pressure systems recertification program.

(i) It is the responsibility of the Facility Safety Head to ensure that any flex hoses which are not a part of a permanent installation, or hoses which are used for multiple purposes are appropriately labeled and safeguarded. The FSH shall ensure that these flex hoses are entered in the Computerized Maintenance Management System (CMMS), and that they are visually inspected and pressure tested at least every two years.

(j) A flex hose with leaks, or has 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 not be used.

(k) Flex hoses shall not be subjected to normal (or sustained) operating pressures greater than the manufacturer's recommended MAWP. Additionally, due to the probability of plastic yielding, any flex hose that experiences momentary pressures in excess of 2 times its MAWP shall be immediately removed from service and destroyed.

A-9 Glass Windows in Pressure Systems

(a) 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.

(b) All windows in pressure and vacuum vessels must be approved by the SPE.

(c) A minimum safety factor of 10 shall be used for all glass window designs. Window frames shall be designed in accordance with the applicable code.

(d) Special consideration should be given to vacuum systems and implosion effects whereby viewing windows present potential hazards to personnel.

Appendix A – Additional Requirements and Best Practices

A-10 Heat Sources

(a) Care should be taken to ensure that pressure systems are not subject to extraneous heat sources since heat raises gas pressure and reduces metal strength.

(b) Glass windows in pressure systems should not be subjected to extraneous heat sources such as ultraviolet lamps, infrared lamps, or other lighting/heat sources, which could cause cracking and/or breakage due to thermal expansion of glass and/or frame.

A-11 Isolation and Depressurization

(a) Isolation of pressure systems, or sections of pressure systems, should be accomplished utilizing a double-block and bleed configuration.

(b) Depressurization of systems shall be verified by the opening of vent valves or by other positive means.

(c) Isolation valves shall not be placed upstream of relief valves.

A-12 Materials

(a) Pressure retaining components made of cast iron or ductile iron shall not be used at pressures above 125 psig or where they will be subject to vibration or shock loading.

(b) Non-metallic piping shall not be used in compressed gas service.

A-13 Pressure Gages

(a) Gages used in pressure systems shall meet the requirements shown in Table A-13.

(b) All gages referenced in a system's standard operating procedures (SOP) shall be calibrated at least once every 5 years to ensure accurate measurement.

(c) All pressure gages shall be mounted so that safety features, such as blowout backs, will function properly.

(d) Gages shall be installed on both sides of pressure regulators to ensure proper monitoring of pressures.

Table A-13 – Requirements for Pressure Gages

Requirements	Service Above 125 Psig		Service 125 psig and lower (1)	Instrument gages, 0-30 psig, and vacuum gages
	Type A	Type B	Type C	
Max. Operating Pressure	No Limit	No Limit	125 psig	30 psig
Allow. Working Pressure (% of full scale)	80	60	60	100
Safety Case (2) (5)	Required	Not required	Not required	Not required
Proof Test Pressure	100	100	100	100

(% of full scale)				
Type of Test [3]	Dead Weight	Dead Weight	Dead Weight or N_2	Dead Weight or N_2
Retest Period	5 year	5 year	Not required	Not required
Test Label [4] [6]	Required	Required	Required if tested	Required if tested

Notes:

(1) Gage shall be bourdon-tube type for non-flight applications.

(2) Gages shall have a solid front, glass or plastic pane, with blow out of entire back area. Blowout plugs are not allowed.

(3) Dead weight test media shall be water or oil. Oil shall not be used for gages used with oxygen or other oxidizing agents.

(4) Test label shall include maximum pressure, test date, and initials of testing personnel. Label shall be made of aluminum foil, with pressure sensitive adhesive back, and shall be a different color each year.

(5) An adequate free area shall be provided for discharge of blowout back gages.

(6) A "No certification/calibration required" sticker should be applied to devices used in general service.

A-14 Pressure Relieving and Venting Systems

(a) Relief valves on pressure systems shall be ASME code stamped.

(b) Exhaust piping downstream of relief valves and vent valves shall be equal to or larger than the valve outlet size.

(c) Piping downstream of relief valves and vent valves shall be designed for the maximum system working pressure unless engineering calculations are made to justify a lower design pressure. For example, calculations may be performed in accordance with the American Petroleum Institute (API) RP-521 "Guide for Pressure Relieving and Depressuring Systems".

(d) Piping downstream of relief valves and vent valves should be routed separately to the point of discharge. A properly designed common header may be used when approved by the SPE.

(e) Exhaust piping downstream of relief valves and vent valves should utilize equalization tees and bird screens.

(f) Exhaust piping shall be routed to minimize exposure of personnel to vented media and/or noise.

(g) New relief valves shall be tested and certified by the valve manufacturer or by the LaRC Component Verification Facility prior to initial use to ensure proper relief setting.

(h) A relief valve shall be used in conjunction with a rupture disk in cryogenic systems where liquid cryogen entrapment could occur.

(i) When a single relief device is used, the set pressure shall not exceed the MAWP of the system, subsystem, or component being protected.

A-15 Pressure Testing of Tubing

(a) The required pressure for testing of tubing shall be 1.5 times the system design pressure for hydrostatic tests, and 1.1 times the system design pressure for pneumatic tests. Engraving or marking of test pressure on the tubing fittings is not required, but a test report is required.

A-16 Reclaimed Materials

(a) Reclaimed piping or tubing may be reused provided the reclaimed materials are (1) examined to determine if the minimum wall thickness is greater than that required by the applicable code, (2) hydrostatically tested to 1.5 times the design pressure of the system, (3) inspected for imperfections which would be unacceptable for the new intended use, and (4) cleaned in sufficient measure to ensure compatibility with their intended use (see A-4).

A-17 Seam-Welded Pipe and Fittings

(a) Seam-welded pipe and fittings shall not be used in pressure systems with working pressure above 125 psig unless:

(b) The seam welds are 100% radiographed and accepted, or

(c) An appropriate “joint quality factor”, as defined by the applicable piping design code, is utilized in the design calculations to determine the minimum required wall thickness of the pipe or fitting.

Either alternative shall be approved by the Standard Practice Engineer.

A-18 Torque Values

(a) Torque values for bolted connections in pressure systems shall be designated on the system’s drawings.

A-19 Valve bodies

(a) Valve bodies should be forged for valve sizes 6” or larger or where the flange rating is 600 pound class or above.

A-20 Valve Numbering

(a) System valves shall be numbered in accordance with LPR 1740.2, "Facility Safety Requirements."

(b) The Facility Coordinators shall be responsible for maintaining records of valve numbers in pressure systems at their facility.

A-21 Working Pressure

(a) The *maximum* working pressure should be 5 to 10% below the MAWP of the system or relief device setting.

Appendix B – Pressure Rating of Metallic Seamless Piping

Pressure Rating of Metallic Seamless Piping [Notes 1,5,6,8]

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED[Note 2]		THREADED[Note 2]	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
1/8	10	0.405	0.049	(Note 7)	4641	3000#		
	30	0.405	0.057	0.02963	5479	3000#	2057	2000#
	40	0.405	0.068	0.02963	6723	3000#	3150	2000#
	STD	0.405	0.068	0.02963	6723	3000#	3150	2000#
	80	0.405	0.095	0.02963	7525	3000#	5295	2000#
	XS	0.405	0.095	0.02963	7525	3000#	5295	2000#
1/4	10	0.540	0.065	(Note 7)	4612	3000#		
	30	0.540	0.073	0.04444	5237	3000#	1448	2000#
	40	0.540	0.088	0.04444	6438	3000#	2570	2000#
	STD	0.540	0.088	0.04444	6438	3000#	2570	2000#
	80	0.540	0.119	0.04444	7182	3000#	4561	2000#
	XS	0.540	0.119	0.04444	7182	3000#	4561	2000#
3/8	10	0.675	0.065	(Note 7)	3622	3000#		
	30	0.675	0.073	0.04444	4104	3000#	1152	2000#
	40	0.675	0.091	0.04444	5237	3000#	2164	2000#
	STD	0.675	0.091	0.04444	5237	3000#	2164	2000#
	80	0.675	0.126	0.04444	7496	3000#	4243	2000#
	XS	0.675	0.126	0.04444	7496	3000#	4243	2000#
1/2	5	0.840	0.065	(Note 7)	2870	3000#		
	10	0.840	0.083	(Note 7)	3736	3000#		
	30	0.840	0.095	0.05714	4292	3000#	1270	2000#
	40	0.840	0.109	0.05714	4974	3000#	1877	2000#
	STD	0.840	0.109	0.05714	4974	3000#	1877	2000#
	80	0.840	0.147	0.05714	7003	3000#	3626	2000#
	XS	0.840	0.147	0.05714	7003	3000#	3626	2000#
	160	0.840	0.188	0.05714	7240	6000#	5113	3000#
	XXS	0.840	0.294	0.05714	9808	9000#	8378	6000#
3/4	5	1.050	0.065	(Note 7)	2270	3000#		
	10	1.050	0.083	(Note 7)	2945	3000#		
	30	1.050	0.095	0.05714	3375	3000#	1010	2000#
	40	1.050	0.113	0.05714	4079	3000#	1653	2000#
	STD	1.050	0.113	0.05714	4079	3000#	1653	2000#
	80	1.050	0.154	0.05714	5732	3000#	3159	2000#

Pressure Rating of Metallic Seamless Piping Notes 1,5,6,8

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
3/4	XS	1.050	0.154	0.05714	5732	3000#	3159	2000#
	160	1.050	0.219	0.05714	6887	6000#	5158	3000#
	XXS	1.050	0.308	0.05714	8812	9000#	7455	6000#
1	5	1.315	0.065	(Note 7)	1796	3000#		
	10	1.315	0.109	(Note 7)	3067	3000#		
	30	1.315	0.114	0.06957	3239	3000#	930	2000#
	40	1.315	0.133	0.06957	3796	3000#	1472	2000#
	STD	1.315	0.133	0.06957	3796	3000#	1472	2000#
	80	1.315	0.179	0.06957	5280	3000#	2794	2000#
	XS	1.315	0.179	0.06957	5280	3000#	2794	2000#
	160	1.315	0.250	0.06957	7686	6000#	4984	3000#
	XXS	1.315	0.358	0.06957	8377	9000#	6969	6000#
1-1/4	5	1.660	0.065	(Note 7)	1412	3000#		
	10	1.660	0.109	(Note 7)	2399	3000#		
	30	1.660	0.117	0.06927	2585	3000#	808	2000#
	40	1.660	0.140	0.06927	3151	3000#	1311	2000#
	STD	1.660	0.140	0.06927	3151	3000#	1311	2000#
	80	1.660	0.191	0.06927	4376	3000#	2479	2000#
	XS	1.660	0.191	0.06927	4376	3000#	2479	2000#
	160	1.660	0.250	0.06957	5900	6000#	3868	3000#
	XXS	1.660	0.382	0.06957	7423	9000#	6186	6000#
1-1/2	5	1.900	0.065	(Note 7)	1230	3000#		
	10	1.900	0.109	(Note 7)	2083	3000#		
	30	1.900	0.125	0.06957	2405	3000#	857	2000#
	40	1.900	0.145	0.06957	2825	3000#	1230	2000#
	STD	1.900	0.145	0.06957	2825	3000#	1230	2000#
	80	1.900	0.200	0.06957	3977	3000#	2313	2000#
	XS	1.900	0.200	0.06957	3977	3000#	2313	2000#
	160	1.900	0.281	0.06957	5777	6000#	4002	3000#
	XXS	1.900	0.400	0.06957	6941	9000#	5812	6000#
2	5	2.375	0.065	(Note 7)	979	3000#		
	10	2.375	0.109	(Note 7)	1653	3000#		
	30	2.375	0.125	0.06957	1906	3000#	683	2000#

Pressure Rating of Metallic Seamless Piping [Notes 1,5,6,8]

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
2	40	2.375	0.154	0.06957	2382	3000#	1119	2000#
	STD	2.375	0.154	0.06957	2382	3000#	1119	2000#
	80	2.375	0.218	0.06957	3438	3000#	2124	2000#
	XS	2.375	0.218	0.06957	3438	3000#	2124	2000#
	160	2.375	0.344	0.06957	5641	6000#	4219	3000#
	XXS	2.375	0.436	0.06957	7384	9000#	5872	6000#
2-1/2	5	2.875	0.083	(Note 7)	1037	3000#		
	10	2.875	0.120	(Note 7)	1505	3000#		
	30	2.875	0.188	0.1	2406	3000#	921	2000#
	40	2.875	0.203	0.1	2606	3000#	1109	2000#
	STD	2.875	0.203	0.1	2606	3000#	1109	2000#
	80	2.875	0.276	0.1	3610	3000#	2057	2000#
	XS	2.875	0.276	0.1	3610	3000#	2057	2000#
	160	2.875	0.375	0.1	5022	(Note 3)	3387	3000#
	XXS	2.875	0.552	0.1	6456	(Note 3)	5333	6000#
3	5	3.500	0.083	(Note 7)	848	3000#		
	10	3.500	0.120	(Note 7)	1230	3000#		
	30	3.500	0.188	0.1	1960	3000#	754	2000#
	40	3.500	0.216	0.1	2258	3000#	1038	2000#
	STD	3.500	0.216	0.1	2258	3000#	1038	2000#
	80	3.500	0.300	0.1	3198	3000#	1923	2000#
	XS	3.500	0.300	0.1	3198	3000#	1923	2000#
	160	3.500	0.438	0.1	4797	(Note 3)	3458	3000#
	XXS	3.500	0.600	0.1	6818	(Note 3)	5380	6000#
3-1/2	5	4.000	0.083	(Note 7)	741	3000#		
	10	4.000	0.120	(Note 7)	1073	3000#		
	30	4.000	0.188	0.1	1706	3000#	659	2000#
	40	4.000	0.226	0.1	2062	3000#	1000	2000#
	STD	4.000	0.226	0.1	2062	3000#	1000	2000#
	80	4.000	0.318	0.1	2944	3000#	1846	2000#
	XS	4.000	0.318	0.1	2944	3000#	1846	2000#
	XXS	4.000	0.636	0.1	6256	(Note 3)	5030	6000#

Pressure Rating of Metallic Seamless Piping Notes 1,5,6,8

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
4	5	4.500	0.083	(Note 7)	657	3000#		
	10	4.500	0.120	(Note 7)	951	3000#		
	30	4.500	0.188	0.1	1511	3000#	585	2000#
	40	4.500	0.237	0.1	1910	3000#	970	2000#
	STD	4.500	0.237	0.1	1910	3000#	970	2000#
	80	4.500	0.337	0.1	2767	3000#	1796	2000#
	XS	4.500	0.337	0.1	2767	3000#	1796	2000#
	120	4.500	0.438	0.1	3653	(Note 3)	2649	2000#
	160	4.500	0.531	0.1	4506	(Note 3)	3470	3000#
	XXS	4.500	0.674	0.1	5859	(Note 3)	4771	6000#
5	5	5.563	0.109		693	(Note 3)		(Note 4)
	10	5.563	0.134		856	(Note 3)		(Note 4)
	40	5.563	0.258		1680	(Note 3)		(Note 4)
	STD	5.563	0.258		1680	(Note 3)		(Note 4)
	80	5.563	0.375		2475	(Note 3)		(Note 4)
	XS	5.563	0.375		2475	(Note 3)		(Note 4)
	120	5.563	0.500		3361	(Note 3)		(Note 4)
	160	5.563	0.625		4269	(Note 3)		(Note 4)
	XXS	5.563	0.750		5208	(Note 3)		(Note 4)
6	5	6.625	0.109		580	(Note 3)		(Note 4)
	10	6.625	0.134		717	(Note 3)		(Note 4)
	40	6.625	0.280		1524	(Note 3)		(Note 4)
	STD	6.625	0.280		1524	(Note 3)		(Note 4)
	80	6.625	0.432		2391	(Note 3)		(Note 4)
	XS	6.625	0.432		2391	(Note 3)		(Note 4)
	120	6.625	0.562		3158	(Note 3)		(Note 4)
	160	6.625	0.719		4110	(Note 3)		(Note 4)
	XXS	6.625	0.864		5023	(Note 3)		(Note 4)
8	5	8.625	0.109		444	(Note 3)		(Note 4)
	10	8.625	0.148		610	(Note 3)		(Note 4)
	20	8.625	0.250		1037	(Note 3)		(Note 4)
	30	8.625	0.277		1148	(Note 3)		(Note 4)
	40	8.625	0.322		1343	(Note 3)		(Note 4)

Pressure Rating of Metallic Seamless Piping Notes 1,5,6,8

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
8	STD	8.625	0.322		1343	(Note 3)		(Note 4)
	60	8.625	0.406		1702	(Note 3)		(Note 4)
	80	8.625	0.50		2117	(Note 3)		(Note 4)
	XS	8.625	0.50		2117	(Note 3)		(Note 4)
	100	8.625	0.594		2534	(Note 3)		(Note 4)
	120	8.625	0.719		3098	(Note 3)		(Note 4)
	140	8.625	0.812		3530	(Note 3)		(Note 4)
	XXS	8.625	0.875		3824	(Note 3)		(Note 4)
	160	8.625	0.906		3970	(Note 3)		(Note 4)
10	5	10.750	0.134		439	(Note 3)		(Note 4)
	10	10.750	0.165		542	(Note 3)		(Note 4)
	20	10.750	0.250		828	(Note 3)		(Note 4)
	30	10.750	0.307		1021	(Note 3)		(Note 4)
	40	10.750	0.365		1216	(Note 3)		(Note 4)
	STD	10.750	0.365		1216	(Note 3)		(Note 4)
	60	10.750	0.50		1685	(Note 3)		(Note 4)
	XS	10.75	0.50		1685	(Note 3)		(Note 4)
	80	10.75	0.594		2013	(Note 3)		(Note 4)
	100	10.75	0.719		2455	(Note 3)		(Note 4)
	120	10.75	0.844		2906	(Note 3)		(Note 4)
	140	10.75	1.000		3483	(Note 3)		(Note 4)
	160	10.75	1.125		3951	(Note 3)		(Note 4)
12	5	12.75	0.156		434	(Note 3)		(Note 4)
	10	12.75	0.180		501	(Note 3)		(Note 4)
	20	12.75	0.250		697	(Note 3)		(Note 4)
	30	12.75	0.330		923	(Note 3)		(Note 4)
	STD	12.75	0.375		1051	(Note 3)		(Note 4)
	40	12.75	0.406		1139	(Note 3)		(Note 4)
	XS	12.75	0.500		1413	(Note 3)		(Note 4)
	60	12.75	0.562		1593	(Note 3)		(Note 4)
	80	12.75	0.688		1963	(Note 3)		(Note 4)
	100	12.75	0.844		2428	(Note 3)		(Note 4)
	120	12.75	1.000		2905	(Note 3)		(Note 4)

Pressure Rating of Metallic Seamless Piping Notes 1,5,6,8

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
12	XXS	12.75	1.000		2905	(Note 3)		(Note 4)
	140	12.75	1.125		3290	(Note 3)		(Note 4)
	160	12.75	1.312		3881	(Note 3)		(Note 4)
14	5	14	0.156		395	(Note 3)		(Note 4)
	10	14	0.250		634	(Note 3)		(Note 4)
	20	14	0.312		792	(Note 3)		(Note 4)
	30	14	0.375		955	(Note 3)		(Note 4)
	STD	14	0.375		955	(Note 3)		(Note 4)
	40	14	0.438		1119	(Note 3)		(Note 4)
	XS	14	0.500		1284	(Note 3)		(Note 4)
	60	14	0.594		1531	(Note 3)		(Note 4)
	80	14	0.750		1947	(Note 3)		(Note 4)
	100	14	0.938		2461	(Note 3)		(Note 4)
	120	14	1.094		2892	(Note 3)		(Note 4)
	140	14	1.250		3334	(Note 3)		(Note 4)
	160	14	1.406		3780	(Note 3)		(Note 4)
16	5	16	0.165		363	(Note 3)		(Note 4)
	10	16	0.250		554	(Note 3)		(Note 4)
	20	16	0.312		692	(Note 3)		(Note 4)
	30	16	0.375		834	(Note 3)		(Note 4)
	STD	16	0.375		834	(Note 3)		(Note 4)
	40	16	0.500		1120	(Note 3)		(Note 4)
	XS	16	0.500		1120	(Note 3)		(Note 4)
	60	16	0.656		1477	(Note 3)		(Note 4)
	80	16	0.844		1916	(Note 3)		(Note 4)
	100	16	1.031		2362	(Note 3)		(Note 4)
	120	16	1.219		2818	(Note 3)		(Note 4)
	140	16	1.438		3356	(Note 3)		(Note 4)
	160	16	1.594		3749	(Note 3)		(Note 4)
18	5	18	0.165		322	(Note 3)		(Note 4)
	10	18	0.250		491	(Note 3)		(Note 4)
	20	18	0.312		614	(Note 3)		(Note 4)
	STD	18	0.375		740	(Note 3)		(Note 4)

Pressure Rating of Metallic Seamless Piping Notes 1,5,6,8

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
18	30	18	0.438		866	(Note 3)		(Note 4)
	XS	18	0.500		993	(Note 3)		(Note 4)
	40	18	0.562		1118	(Note 3)		(Note 4)
	60	18	0.750		1502	(Note 3)		(Note 4)
	80	18	0.938		1894	(Note 3)		(Note 4)
	100	18	1.156		2352	(Note 3)		(Note 4)
	120	18	1.375		2824	(Note 3)		(Note 4)
	160	18	1.781		3720	(Note 3)		(Note 4)
20	5	20	0.188		332	(Note 3)		(Note 4)
	10	20	0.250		442	(Note 3)		(Note 4)
	20	20	0.375		665	(Note 3)		(Note 4)
	STD	20	0.375		665	(Note 3)		(Note 4)
	30	20	0.500		892	(Note 3)		(Note 4)
	XS	20	0.500		892	(Note 3)		(Note 4)
	40	20	0.594		1062	(Note 3)		(Note 4)
	60	20	0.812		1464	(Note 3)		(Note 4)
	80	20	1.031		1872	(Note 3)		(Note 4)
	100	20	1.281		2347	(Note 3)		(Note 4)
	120	20	1.500		2772	(Note 3)		(Note 4)
	140	20	1.750		3262	(Note 3)		(Note 4)
	160	20	1.969		3701	(Note 3)		(Note 4)
22	5	22	0.188		302	(Note 3)		(Note 4)
	10	22	0.250		401	(Note 3)		(Note 4)
	20	22	0.375		604	(Note 3)		(Note 4)
	STD	22	0.375		604	(Note 3)		(Note 4)
	30	22	0.500		809	(Note 3)		(Note 4)
	XS	22	0.500		809	(Note 3)		(Note 4)
	60	22	0.875		1433	(Note 3)		(Note 4)
	80	22	1.125		1855	(Note 3)		(Note 4)
	100	22	1.375		2287	(Note 3)		(Note 4)
	120	22	1.625		2726	(Note 3)		(Note 4)
	140	22	1.875		3173	(Note 3)		(Note 4)
	160	22	2.125		3625	(Note 3)		(Note 4)

Pressure Rating of Metallic Seamless Piping Notes 1,5,6,8

Butt Welding, Socket Welding, and Threaded

Sample Materials: A-53 Gr. B, A-106 Gr. B, A-516 Gr. 60, SE = 20,000 PSIG
A-312 Grades TP304, TP316, and TP347 Max. Temp. = 100 °F

					WELDED(Note 2)		THREADED(Note 2)	
Nominal Pipe Size	Wall Schedule	Outside Diameter	Nominal Wall Thickness	Max. Thread Depth	Allowable Pressure (PSIG)	SW Fitting Pound Class	Allowable Pressure (PSIG)	Thr. Fitting Pound Class
24	5	24	0.218		320	(Note 3)		(Note 4)
	10	24	0.250		368	(Note 3)		(Note 4)
	20	24	0.375		553	(Note 3)		(Note 4)
	STD	24	0.375		553	(Note 3)		(Note 4)
	XS	24	0.500		741	(Note 3)		(Note 4)
	30	24	0.562		834	(Note 3)		(Note 4)
	40	24	0.688		1024	(Note 3)		(Note 4)
	60	24	0.969		1454	(Note 3)		(Note 4)
	80	24	1.219		1844	(Note 3)		(Note 4)
	100	24	1.531		2338	(Note 3)		(Note 4)
	120	24	1.812		2791	(Note 3)		(Note 4)
	140	24	2.062		3199	(Note 3)		(Note 4)
	160	24	2.344		3669	(Note 3)		(Note 4)

Notes for Piping Pressure Rating Table:

(1) Pressure ratings are based on ASME B31.3 “Process Piping” Code, 2002 edition.
(2) Pressure rating is shaded for thick walled pipe (t > OD / 6). The allowable pressure is based on the Mises-Hencky failure criterion instead of the standard ASME code equation. See paragraph 304.1.2(b) in ASME B31.3 for additional requirements.
(3) ANSI B16.11 socket welding fittings not available in sizes over NPS 2, except for 3000# class which is available up to size NPS 4.
(4) ANSI B16.11 threaded fittings not available in sizes over NPS 4.
(5) For sizes NPS 2 and above, the use of ANSI B16.9 butt welding fittings is recommended.
(6) Corrosion allowance used in calculating pressure ratings in this table is C_A = 0.000 inch.
(7) Pipe schedules 5 and 10 do not allow threading per ASME B1.20.1.
(8) Pressure rating for piping made of materials with an allowable stress S_b different from the one used in the table above (S_a = 20,000 psi) can be calculated by multiplying the pressure rating listed in the table by the ratio of allowable stresses, S_b/S_a.

Appendix C – Pressure Rating of Metallic Seamless Tubing

A.S.M.E. B31.3, Process Piping Code – 2002 Edition [Notes 1, 3]

Pressure Rating of Metallic Seamless Tubing

Sample Materials: A-312 Grades 304, 316, 347 Max. Temp. = 100 °F SE = 20,000 psig

Tubing Size	Outside Diameter	Nominal Wall Thickness	Minimum Wall Thickness	Maximum Wall Thickness	Minimum Inside Diameter	Maximum Inside Diameter	Allowable Working Pressure (psig) (Notes 2, 4, 5, 6)
1/8	0.125	0.010	0.009	0.011	0.103	0.107	3,056
		0.020	0.018	0.022	0.081	0.089	6,510
		0.028	0.025	0.031	0.063	0.075	7,345
		0.035	0.032	0.039	0.047	0.061	8,751
3/16	0.188	0.020	0.018	0.022	0.144	0.152	4,147
		0.028	0.025	0.031	0.126	0.138	5,952
		0.035	0.032	0.039	0.110	0.124	6,523
1/4	0.250	0.020	0.018	0.022	0.206	0.214	3,056
		0.028	0.025	0.031	0.188	0.200	4,348
		0.035	0.032	0.039	0.172	0.186	5,704
		0.049	0.044	0.054	0.142	0.162	6,698
		0.065	0.059	0.072	0.106	0.132	8,327
5/16	0.313	0.020	0.018	0.022	0.269	0.277	2,411
		0.028	0.025	0.031	0.251	0.263	3,413
		0.035	0.032	0.039	0.235	0.249	4,454
		0.049	0.044	0.054	0.205	0.225	6,335
		0.065	0.059	0.072	0.169	0.195	7,047
3/8	0.375	0.020	0.018	0.022	0.331	0.339	1,997
		0.028	0.025	0.031	0.313	0.325	2,817
		0.035	0.032	0.039	0.297	0.311	3,663
		0.049	0.044	0.054	0.267	0.287	5,180
		0.065	0.059	0.072	0.231	0.257	7,200
1/2	0.500	0.028	0.025	0.031	0.438	0.450	2,083
		0.035	0.032	0.039	0.422	0.436	2,698
		0.049	0.044	0.054	0.392	0.412	3,787
		0.065	0.059	0.072	0.356	0.382	5,212
		0.083	0.075	0.091	0.318	0.350	6,818

A.S.M.E. B31.3, Process Piping Code – 2002 Edition [Notes 1, 3]

Pressure Rating of Metallic Seamless Tubing

Sample Materials: A-312 Grades 304, 316, 347 Max. Temp. = 100 °F SE = 20,000 psig

Tubing Size	Outside Diameter	Nominal Wall Thickness	Minimum Wall Thickness	Maximum Wall Thickness	Minimum Inside Diameter	Maximum Inside Diameter	Allowable Working Pressure (psig) (Notes 2, 4, 5, 6)
5/8	0.625	0.035	0.032	0.039	0.547	0.561	2,135
		0.049	0.044	0.054	0.517	0.537	2,984
		0.065	0.059	0.072	0.481	0.507	4,084
		0.083	0.075	0.091	0.443	0.475	5,310
3/4	0.750	0.035	0.032	0.039	0.672	0.686	1,767
		0.049	0.044	0.054	0.642	0.662	2,462
		0.065	0.059	0.072	0.606	0.632	3,358
		0.083	0.075	0.091	0.568	0.600	4,348
		0.095	0.086	0.105	0.540	0.578	5,050
		0.109	0.098	0.120	0.510	0.554	5,837
7/8	0.875	0.035	0.032	0.039	0.797	0.811	1,507
		0.049	0.044	0.054	0.767	0.787	2,096
		0.065	0.059	0.072	0.731	0.757	2,851
		0.083	0.075	0.091	0.693	0.725	3,681
		0.095	0.086	0.105	0.665	0.703	4,267
		0.109	0.098	0.120	0.635	0.679	4,921
1	1.000	0.035	0.032	0.039	0.922	0.936	1,314
		0.049	0.044	0.054	0.892	0.912	1,824
		0.065	0.059	0.072	0.856	0.882	2,477
		0.083	0.075	0.091	0.818	0.850	3,191
		0.095	0.086	0.105	0.790	0.828	3,694
		0.109	0.098	0.120	0.760	0.804	4,253
		0.120	0.108	0.132	0.736	0.784	4,729
1 1/4	1.250	0.049	0.044	0.054	1.142	1.162	1,449
		0.065	0.059	0.072	1.106	1.132	1,962
		0.083	0.075	0.091	1.068	1.100	2,521
		0.095	0.086	0.105	1.040	1.078	2,912
		0.109	0.098	0.120	1.010	1.054	3,346
		0.120	0.108	0.132	0.986	1.034	3,713

A.S.M.E. B31.3, Process Piping Code – 2002 Edition [Notes 1, 3]

Pressure Rating of Metallic Seamless Tubing

Sample Materials: A-312 Grades 304, 316, 347 Max. Temp. = 100 °F SE = 20,000 psig

Tubing Size	Outside Diameter	Nominal Wall Thickness	Minimum Wall Thickness	Maximum Wall Thickness	Minimum Inside Diameter	Maximum Inside Diameter	Allowable Working Pressure (psig) (Notes 2, 4, 5, 6)
1 1/2	1.500	0.049	0.044	0.054	1.392	1.412	1,202
		0.065	0.059	0.072	1.356	1.382	1,624
		0.083	0.075	0.091	1.318	1.350	2,083
		0.095	0.086	0.105	1.290	1.328	2,404
		0.109	0.098	0.120	1.260	1.304	2,757
		0.120	0.108	0.132	1.236	1.284	3,056
2	2.000	0.065	0.059	0.072	1.856	1.882	1,209
		0.083	0.075	0.091	1.818	1.850	1,546
		0.095	0.086	0.105	1.790	1.828	1,781
		0.109	0.098	0.120	1.760	1.804	2,040
		0.120	0.108	0.132	1.736	1.784	2,258
		0.134	0.121	0.147	1.706	1.758	2,543

Notes for Tubing Pressure Rating Table:

(1) Pressure ratings are based on ASME B31.3 Process Piping Code, 2002 Edition.

(2) Pressure rating is shaded for thick walled tubing (t > OD / 6). The allowable pressure is based on the Mises-Hencky failure criterion instead of the standard ASME code equation. See paragraph 304.1.2(b) in ASME B31.3 for additional requirements.

(3) Corrosion allowance used in calculating pressure ratings in this table is C_A = 0.000 inch.

(4) Pressure rating for soft copper tubing conforming to ASTM B-280 (060 temper) or ASTM B-88 (050 and 060 tempers) is 30% of the corresponding allowable working pressures listed in the table above.

(5) Pressure rating for non-brazed hard copper tubing conforming to ASTM B-88 (H temper) is 60% of the corresponding allowable working pressures listed in the table above. Pressure rating for brazed hard copper tubing conforming to ASTM B-88 is 30% of the corresponding allowable working pressures listed in the table above.

(6) Pressure rating for carbon steel tubing conforming to SAE 1025 (AMS 5075) is 84% of the corresponding allowable working pressures listed in the table above.