



*Langley Research Center*  
**Directives Management**  
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**Material Transmitted**

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*Superseded*

LPR 1710.42 / Safety Program for the Maintenance of Ground-Based Pressure Vessels and Pressurized Systems

**Summary**

120307-Superseded by Revision D

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***Reason***

Superseded by Revision D

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**Langley Research Center**

**LPR 1710.42**

**Effective Date: March 23, 2007**

**Expiration Date: March 23, 2012**

**SAFETY PROGRAM FOR THE MAINTENANCE OF  
GROUND-BASED PRESSURE VESSELS  
AND PRESSURIZED SYSTEMS**

**National Aeronautics and Space Administration**

**Responsible Office: Safety and Mission Assurance Office****P.1 PURPOSE**

This Langley Procedural Requirement (LPR) implements NPD 8710.5, "NASA Safety Policy for Pressure Vessels and Pressurized Systems," in conjunction with LPR 1710.40, "Langley Research Center Pressure Systems Handbook." This LPR provides details for maintaining pressure system safety through the use of documentation, inservice inspection, maintenance, operation procedures, and training.

**P.2 APPLICABILITY**

This procedural requirement applies to all persons performing work at Langley Research Center (LaRC), including civil servants, contractors, research associates, and others. Non-compliance with this LPR will result in appropriate disciplinary action that may include termination for a civil servant employee or exclusion from the Center for a contractor employee, research associate or others.

**P.3 AUTHORITY**

- a. NPD 8710.5, "NASA Safety Policy for Pressure Vessels and Pressurized Systems."

**P.4 REFERENCE**

- a. LPR 1710.40, "Langley Research Center Pressure Systems Handbook"
- b. LPR 1710.41, "Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds."
- c. LPR 1740.4, "Facility System Safety Analysis and Configuration Management."
- d. LPR 1740.7, "Process Systems Certification Program."
- e. LMS-TD-5569, "Performing Visual Inspections."
- f. OSHA 29 CFR Part 1910, Subparts 1910.134 through 1910.140.
- g. OSHA 29 CFR Part 1910, Subpart L.
- h. Department of Transportation (DOT) regulations, 49 CFR Parts 171 through 180.
- i. ASME Boiler and Pressure Code, Sections VI, VII and VIII.
- j. LAPD 1150.2, "Councils, Boards, Panels, Committees, Teams, and Groups."

## **P.5 CANCELLATION**

LPR 1710.42, "Safety Program for Maintenance of Ground Based Pressure Vessels and Pressurized Systems," dated July 22, 2004.

*Original signed on file*

Lesa B. Roe  
Director

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**Chapter 1****1. INTRODUCTION****1.1. PURPOSE**

The purpose of this LPR is to establish the procedural requirements to document LaRC's approach to ensuring the safety of ground-based pressure vessels and systems. This pressure system safety program consists of five elements: documentation, inservice inspection, maintenance, operation, and training, as depicted in Figure 1-1. The first three of these elements, documentation, inservice inspection, and maintenance, make up the LaRC Pressure Systems Recertification Program (RECERT).

**1.2. APPLICABILITY**

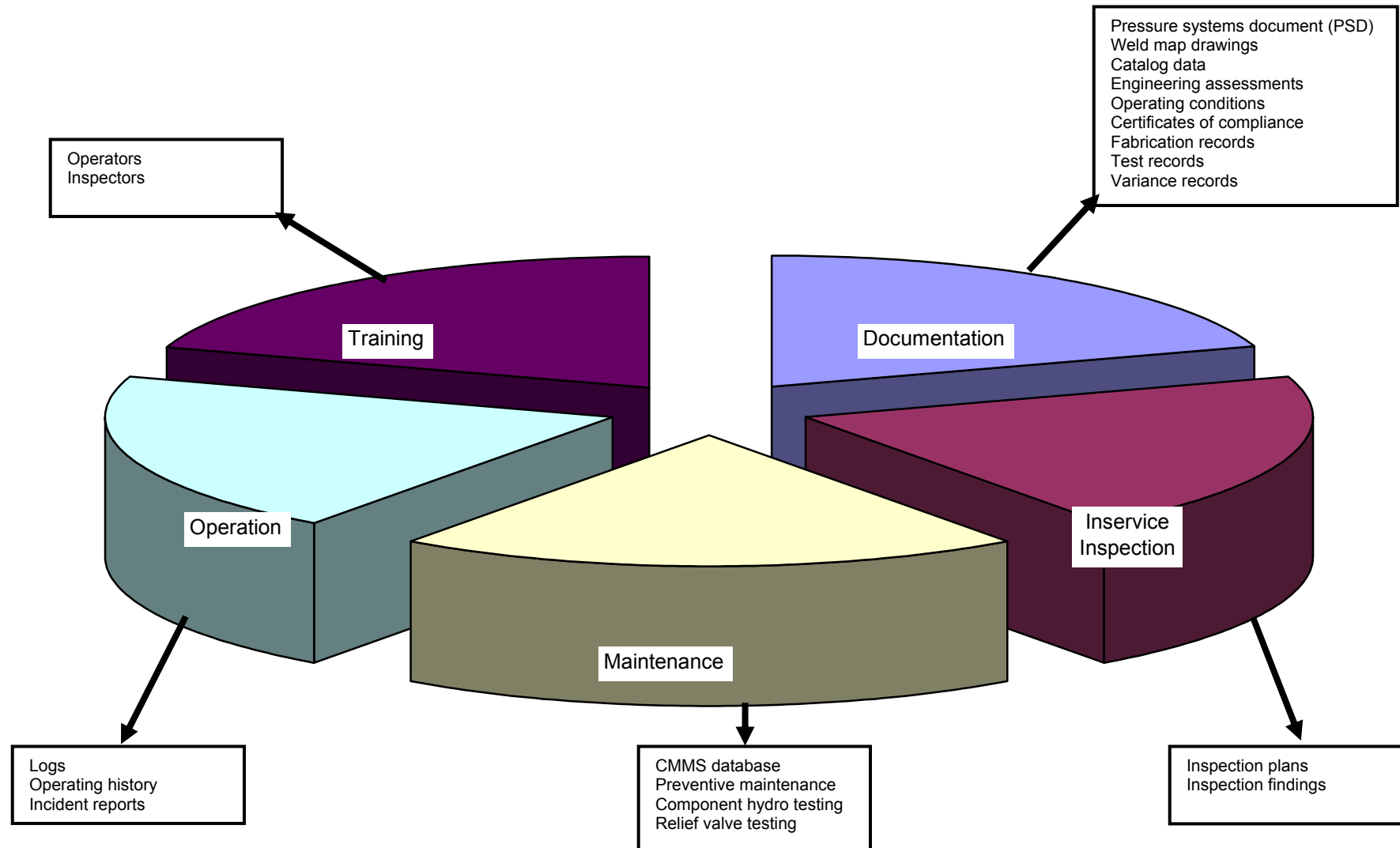
- a. This LPR is applicable to all pressurized systems at LaRC.
- b. The following systems are excluded from the documentation and inservice inspection requirements described in this LPR because they do not present sufficient risk to warrant other than normal maintenance, operation, and training practices:
  - (1) **Low Energy Systems** – The following categories of systems are excluded provided they are installed and maintained in accordance with standard practices using code acceptable materials:
    - (a) Water vessels or systems operating at pressures less than 125 psig and temperatures less than 130°F.
    - (b) 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<sup>3</sup>).
    - (c) Vacuum vessels with volumes not exceeding 100 cubic feet water volume and vacuum piping systems with nominal diameter less than 20 inches.
  - (2) **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.
  - (3) **Fire Extinguishers** – These items are covered by OSHA regulations in 29 CFR Part 1910, Subpart L, and include (1) portable extinguishers, (2) stand pipe and hose systems, (3) automatic sprinkler systems, (4) fixed dry and wet chemical extinguishing systems, (5) carbon dioxide extinguishing systems, and (6) alternative gas (environmentally friendly) extinguishing systems.



- (4) **Over-the-Road Trailers** – Over the road trailers shall comply with the Department of Transportation (DOT) regulations, 49 CFR Parts 171 through 180.
- (5) **Heating and Power Boilers** – Heating boilers shall comply with the ASME Boiler and Pressure Code, Section VI. Power boilers shall comply with the ASME Boiler and Pressure Code, Section VII.
- (6) **Refrigeration Systems** – Refrigeration systems with energy content<sup>1</sup> less than 500 psi-in<sup>2</sup> are excluded. Maintenance and operation shall follow the practices recommended by the manufacturer.

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<sup>1</sup> The energy content of a refrigeration system is defined as the product of the maximum operating pressure, in pounds per square inch gage, times the square of the pipe diameter, in inches squared.



**Figure 1-1 The Five Elements of LaRC's Pressure Systems Safety Program**

### **1.3. RESPONSIBILITIES**

#### **1.3.1. Executive Safety Council (ESC)**

- a. The Executive Safety Council (ESC) reviews and approves/disapproves written requests for variances or deviations from established NASA policy on pressure systems that have been recommended for approval by the Pressure Systems Committee (PSC).

#### **1.3.2. Pressure Systems Committee (PSC)**

The membership of the PSC is documented in LAPD 1150.2, "Councils, Boards, Panels, Committees, Teams, and Groups." Among its members, the committee shall include the Pressure Systems Manager and a representative from the Safety and Facility Assurance Branch (SFAB), Safety and Mission Assurance Office (SMAO). The PSC:

- a. Reviews and recommends for approval or disapproval requests for deviation from the requirements of NPD 8710.5, "NASA Safety Policy for Pressure Vessels and Pressurized Systems," LPR 1710.40, "LaRC Pressure Systems Handbook," and this LPR.
- b. Identifies specific pressure systems or categories of pressure systems that need not be subject to the requirements of NPD 8710.5 and documents the rationale for the exclusion.
- c. In concert with the SFAB, SMAO, provides oversight of the LaRC Pressure Systems Recertification Program and conducts quarterly progress reviews of the scheduled in-service inspections. Delinquent inspections shall be highlighted to the PSM and plans for completing the delinquent inspections and/or removing the lapsed system(s) from service shall be developed. The PSC Chair shall provide a summary status of the quarterly reviews to the ESC on a semi-annual basis.

#### **1.3.3. Pressure Systems Manager (PSM)**

The Pressure Systems Manager (PSM) is designated by the LaRC Center Director as required by NPD 8710.5. The PSM:

- a. Serves as a member of the PSC, acting as the committee's primary advisor on matters relating to the applicability of National Consensus Codes to LaRC pressure systems.
- b. Ensures referral to the PSC when a pressure system does not comply with the code requirements in LPR 1710.40.
- c. Evaluates requests for variances and forwards them to the PSC for action. See Appendix B for details on variances.
- d. Ensures that all LaRC pressure vessels/systems are certified in compliance with applicable codes, standards, and guidelines.
- e. Evaluates and approves new designs and modifications to pressure systems.
- f. Manages and oversees the implementation of the LaRC RECERT program.

- g. Maintains an inventory of all pressure systems at LaRC. The inventory, among other things, keeps track of the current RECERT program phase (1, 2, or 3) of all pressure systems as well as their current operational status (Active, Inactive, or Standby).
- h. Ensures that necessary documentation to support the recertification program is available for all pressure systems.
- i. Ensures that a Pressure Systems Document (PSD) is prepared for each pressure systems in the LaRC RECERT program.
- j. Controls the retention of all pressure system certification/recertification documents as part of a recertification file for each system.
- k. Assigns priorities to pressure systems for the purpose of field surveys and non-destructive examination (NDE).
- l. Approves disposition (e.g., derate, repair, scrap) of all pressure systems which do not meet the requirements of this LPR.
- m. Submits proposed deviations to the PSC when appropriate.
- n. Prepares and forwards a RECERT Program Status Report annually to the ESC. The status report shall indicate the anticipated inspection/repair time frames for all PHASE 1 or 2 systems.
- o. Reviews/approves all Inspection Plans (IP) for all pressure systems.
- p. Provides guidance to Project Managers (PM's) in the requirements for initial certification of pressure systems.
- q. In the event that a pressure system is transferred from LaRC to another installation, either by physical movement or through transfer of responsibility to an outside agent, the PSM ensures that an appropriate recertification file is forwarded with it.

#### **1.3.4. Contracting Officer's Technical Representative (COTR) for the Research, Operations, Maintenance, and Engineering (ROME) Contract**

In support of the LaRC pressure systems safety program, the ROME COTR shall ensure the ROME Contractor:

- a. Formulates a 3-year pressure systems recertification plan.
- b. Develops a Pressure Systems Document (PSD) for each pressure system covered by this LPR and maintains them under configuration control in the LaRC Configuration Management On-Line (CMOL) system.
- c. Maintains additional supporting documentation for pressure systems, e.g., NDE results, manufacturer's catalog data, analyses, and approved variances.
- d. Performs engineering assessments and provides the PSM with recommendations regarding the disposition of pressure system components.
- e. Prepares an Inspection Plan (IP) to ensure continued system integrity through periodic inspections based on the guidance provided by this LPR.
- f. Performs non-destructive evaluation (NDE) of existing pressure systems to assess their structural integrity.
- g. Performs inspections as required by the IP.
- h. Performs preventive maintenance on pressure systems in accordance with the Computerized Maintenance Management System (CMMS).
- i. When directed, repairs major deficiencies discovered during non-destructive

- examinations and analyses.
- j. Enters information into the CMMS from maintenance input data sheets completed by either the FC or by ROME contractor personnel.
  - k. Tests, tags, and maintains logs of relief valves. The logs keep track of the date tested, valve number, pressure set-point, and any adjustments or repairs made to the relief valves.
  - l. Reports to the PSM at the beginning of the last quarter of the calendar year whenever the annual requirements of the RECERT program will not be met.

### **1.3.5. Facility Safety Head (FSH)**

Every facility at LaRC has a Facility Safety Head (FSH) who is nominated by the line organization and approved by the Vice-Chairperson of the ESC. The FSH shall:

- a. Review inservice inspection plans (IP).
- b. Ensure that personnel training and facility operational knowledge of procedures for working with pressure vessels and systems are current. Qualified operators shall be certified in writing per LPR 1740.7, "Process System Certification Program."
- c. Coordinate pressure systems training as required. General pressure system safety training shall be conducted after system modifications and after any extended "down" period.
- d. Maintain pressure system training records for personnel assigned to the facility.
- e. Review operational procedures and ensure that changes, modifications, or alterations are appropriately reflected.
- f. Maintain current log of operations.
- g. Review results of periodic inspections performed by the ROME Contractor and, if necessary, establish a contingency plan for correcting rejectable deficiencies noted in the inspection report.

### **1.3.6. Facility Coordinator (FC)**

Every facility at LaRC has a Facility Coordinator (FC) who is appointed by the line organization and the FSH. The FC shall:

- a. Initiate maintenance requests for repairs and/or facility modifications.
- b. Submit new work requests as required.
- c. Review all applicable computerized maintenance sheets for accuracy and submit changes to the Maintenance Manager.
- d. Coordinate with the PSM and the ROME Contractor for walk-through of pressure systems to verify/update Pressure Systems Documents (PSD's).

### **1.3.7. Project Managers (PM)**

Project Managers (PM) shall:

- a. Initiate a Change Notification Sheet (CNS) to document changes to pressure systems affected by their project.
- b. Ensure that an inspector is assigned to inspect all new pressure system installations, alterations, repairs, and modifications.
- c. Ensure their projects comply with applicable pressure system standards, codes, and regulations or ensure that deviations have been approved by the PSM or the PSC,

as applicable.

- d. Provide written certification to the FSH that a pressure system installation was performed in accordance with LPR 1710.40, "LaRC Pressure Systems Handbook" prior to re-energizing a pressure system.
- e. Ensure that documentation (see Chapter 2 for types of documentation) regarding the components used in the modification, alteration, or construction of pressure systems is obtained during the course of the project. The PM shall turn over this documentation to the PSM after the completion of Operational Readiness Review (ORR) or the final Systems Operations Committee (SOC) review.
- f. Obtain guidance from the PSM regarding the requirements for pressure system documentation.

#### **1.3.8. Center Operations Directorate (COD)**

The Center Operations Directorate (COD) shall designate persons with the following responsibilities:

- a. Managing and overseeing the LaRC Maintenance Program.
- b. Managing and overseeing the LaRC RECERT Program.
- c. Ensuring the information in the CMMS database is accurate.
- d. Maintaining historical maintenance information.

#### **1.3.9. Construction Inspection Contractor**

The COTR for the Quality Assurance and Inspection (QAI) contract shall ensure the Construction Inspector.

- a. Ensures that all new installations, alterations, repairs, and modifications of pressure systems meet the requirements of the specifications.
- b. Witnesses all tests (hydrostatic, pneumatic, or operational) as required by the specifications.
- c. Coordinates with the PM to resolve any problems with the interpretation of the specifications.
- d. Verifies that the calibration of a Contractor's test apparatus is current before use.

**Chapter 2****2. RECERT PROGRAM****2.1. GENERAL**

The RECERT program is an Agency-wide program mandated by NPD 8710.5, "NASA Safety Policy for Pressure Vessels and Pressurized Systems." The main purpose of this NASA safety program is to manage the risk to people, facilities, and the environment posed by pressurized systems. This risk management is accomplished via compliance with national consensus codes, documentation, non-destructive examination (NDE), engineering assessments, repairs, and periodic inspections.

**2.2. METHODOLOGY**

The RECERT program is subdivided into three phases of work. A brief description of what is accomplished in each phase and the risk assessment associated with the pressure system within each phase is provided in Table 2-1.

**Table 2-1, Brief Description of RECERT Phases and Associated Risk Codes.**

| <b>Phase</b> | <b>Existing System</b>   | <b>Typically Associated RAC<sup>(*)</sup></b>   |
|--------------|--|---|
| <b>1</b>     | Available documentation is gathered and a field survey of all components is performed. An engineering assessment of system integrity is conducted, which may include the nondestructive examination of a 10 percent sampling of welds and high stress areas. A PSD and a weld map are developed. | RAC 1 (I-B) for systems not built to a national consensus code<br><br>RAC 3 (I-D) for systems built to a national consensus code  |
| <b>2</b>     | Up to 100 percent NDE is performed, depending on the results of the Phase 1 engineering assessment. Any necessary repairs are conducted. An inspection plan is developed.  | RAC 1 (I-C) for systems not built to a national consensus code if no emergency repairs required. RAC 1 (I-A) if emergency repairs are required.<br><br>RAC 3 (I-D) for systems built to a national consensus code |
| <b>3</b>     | Periodic inspections are performed in accordance with the developed inspection plan.   | RAC 3 (I-D) for all systems   |

<sup>(\*)</sup> Particular conditions of a system may alter the risk assessment codes shown here

### **2.3. SYSTEM PRIORITIZATION**

The PSM determines the order of priority for the recertification of pressure systems based on criteria such as stored energy (pressure times volume), cyclic duty, environmental considerations (susceptibility to erosion/corrosion), number and proximity of personnel, cost of replacement, schedule impact, and age.

### **2.4. RECERT PHASE 1**

a. The primary products of Phase 1 shall be (a) a pressure system component database, (b) a pressure system document (PSD), (c) weld maps, (d) a weld database, and (e) a recertification file. During this Phase, the ROME Contractor shall develop recommendations of actions for each specific system component, such as performing repairs, conducting additional tests, removal from service, de-rating, or recertification.

b. Specific responsibilities for the activities that are performed during Phase 1 depend on whether the system is an existing system or a new/modified system, as follows:

#### **2.4.1. Systems Built to a National Consensus Code**

For pressure systems built to a national consensus code, after the Operational Readiness Review (ORR) or final Systems Operations Committee (SOC) review, the Project Manager (PM) shall send to the PSM all documentation required for the establishment of the Pressure System Document and any other pertinent information to be stored in a recertification file. See section 2.4.8 for a detailed description of the data/documentation required. It shall be the responsibility of each PM to gather the required documentation for the development of the RECERT documentation for new systems. For those cases where original manufacturer's documentation is not available, the PM shall be required to conduct all necessary field surveys, NDE, and/or pressure system analyses to develop equivalent documentation. After the documentation is gathered, it shall be forwarded to the ROME Contractor for inclusion in the system's recertification file. The ROME Contractor shall conduct field surveys as needed to validate the completeness of the provided documentation.

#### **2.4.2. Systems with Uncertain National Consensus Code Compliance**

For existing systems where compliance with national consensus codes is uncertain, the ROME Contractor shall gather any available documentation and evaluate it for completeness. For those cases where original documentation is not available, the ROME Contractor shall additionally conduct field surveys to identify all system components and perform any required analyses to develop equivalent documentation. The ROME Contractor shall then perform a 10 percent-sampling nondestructive examination of welds and high stress areas.



**2.4.3. Field Surveys for the Development of the Pressure Systems Document**

- a. Detailed field surveys shall generally be accomplished to collect data on pressure system components, such as pipe sizes, wall schedules, flange and valve class ratings, manufacturer's nameplate data, relief valve set point and capacity, and the location of all welds and support structures.
- b. The component information gathered during the field surveys shall be entered into a pressure system component database. After conducting the field surveys, the ROME Contractor shall produce isometric sketches showing each component in the system. Figure 2-2 shows a sample of a component database sheet from a typical PSD. Details of the information that shall be included in each column of a component database sheet are listed in Figure 2-3. The component database and the sketches shall be used to create a Pressure Systems Document (PSD) for each pressure system. In addition to gathering the information in the component database and the isometric drawings, field surveys shall be used to create weld identification drawings for the system, also known as weld maps.
- c. The ROME Contractor shall be responsible for the inclusion of the PSD and the weld maps in the Configuration Management On-Line (CMOL) system.

March 23, 2007

LPR 1710.42

FACILITY: BLDG. 1247E, WAA  
SYSTEM: 6000 PSI AIR  
REFERENCE SKETCH: 60-A-1

SAMPLE

01-6000A-PSCM  
APR 1, 1997

| NO. | Component                   | END | Manufacturer/Description   | Material  | Installation | Inspection | Rated Pressure | Working Pressure | Code | Analysis | NDE | Foot Notes | Reference   | Rec |
|-----|-----------------------------|-----|--|-----------|--------------|------------|----------------|------------------|------|----------|-----|------------|-------------|-----|
| 1   | PIPE ELL                    | SW  | VOGT<br>2", 6000 CWP   | STEEL     | 12/64        | 12/92      | 6000           | 6000             | B11  | MC       | V   | 3          | D1,D4,E3,S1 | RC  |
| 2   | PIPE ELL                    | SW  | BONNY FORGE<br>2', 6000#   | A105      | 12/64        | 12/92      | 6599           | 6000             | B11  | MC       | V   | 62         | D1,D4,E3,S1 | RC  |
| 3   | PRE FILTER                  | BW  | DOLLINGER<br>2', S/N 30781<br>6500 PSI, "U" STAMP                  | STEEL     | 06/76        | 12/92      | 6500           | 6000             | 81   | ES       | V   |            | D1,D4,E3    | RC  |
| 4   | BUSHING                     | TH  | UNKNOWN<br>1/2 X 1/4"  | STEEL     | 06/76        | 12/92      | 12250          | 6000             | B11  | CE/PS    | V   | 3          | D1          | RC  |
| 4A  | MALE ELL                    | TH  | CRAWFORD<br>1/4", 1/8" SS TUBE                                     | STAINLESS | 06/76        | 12/92      | 9352           | 6000             | N/A  | MC/TC    | V   | 40         | D1          | RC  |
| 5   | MALE CONNECTOR              | TH  | UNKNOWN<br>1/4", 1/8" SS TUBE                                      | STAINLESS | 06/76        | 12/92      | 6500           | 6000             | SA5  | CE       | V   | 8          | D1          | RC  |
| 6   | DIFFERENTIAL PRESSURE GAUGE | TH  | ORANGE RESEARCH, INC.<br>1/4", M/N 1202 PG-1-2<br>0-100 PSID RANGE | STEEL     | 06/76        | 12/92      | 9352           | 6000             | N/A  | TC       | V   | 58         | D1          | RC  |
| 7   | MALE CONNECTOR              | TH  | UNKNOWN<br>1/4", 1/8" SS TUBE                                      | STAINLESS | 06/76        | 12/92      | 9352           | 6000             | SA5  | CE       | V   | 8          | D1          | RC  |
| 8   | BUSHING                     | TH  | UNKNOWN<br>1/2 X 1/4"  | STEEL     | 06/76        | 12/92      | 12250          | 6000             | B11  | CE/PS    | V   | 3          | D1          | RC  |
| 8A  | MALE ELL                    | TH  | CRAWFORD<br>1/4", 1/8" SS TUBE                                     | STAINLESS | 06/76        | 12/92      | 9352           | 6000             | N/A  | MC/TC    | V   | 40         | D1          | RC  |
| 8T  | TUBE                        |     | UNKNOWN<br>1/8", T=.028"   | STAINLESS | 06/76        | 12/92      | 7482           | 6000             | B3   | PS       | UT  | 4          | D1,E2       | RC  |
| 9   | COUPLING                    | SW  | BONNY FORGE<br>3/4', 6000#   | A105      | 06/76        | 12/92      | 8466           | 6000             | B11  | MC/PS    | V   |            | D1,D4       | RC  |
| 10  | PIPE ELL                    | SW  | BONNY FORGE<br>3/4', 6000#   | A105      | 06/76        | 12/92      | 8466           | 6000             | B11  | MC/PS    | V   |            | D1,D4       | RC  |

Figure 2-2, Sample Component Database Sheet in a Pressure System Document (PSD)

### Figure 2-3, Key To Component Database Sheets.

UPPER LEFT: Facility Name and Building Number. System Name. Reference Sketch for Recertification Status Sheet. Date of latest computer printout. Page Number.

UPPER RIGHT: System Designation.

#### Fifteen Columns - Read Left to Right

- (1) NO: Component number which can be found on the sketch referred to in the upper right of the recertification status sheet. (Example: REF SK. 60-A-1)
- (2) COMPONENT: Component name. The names are derived from ANSI and SAE.
- (3) END: End connection. It is listed by abbreviation: TH = threaded; SW = socket weld; BW = butt weld; FL = flanged; CW = connection weld; SO = slip on (flange only); WN = weld neck (flange only).
- (4) MANUFACTURER/DESCRIPTION: Consists of the information which shall be gathered in the field. The first line gives the manufacturer (if known). The second line lists the line size of the component and also any information such as model number, class or type. The last line contains any additional information.
- (5) MATERIAL: Material the component is made of or is assumed to be made of.
- (6) INSTALLATION: Component's installation date.
- (7) INSPECTION: Inservice inspection date.
- (8) RATED PRESSURE: Maximum allowable working pressure (APRES) of the component. This number is arrived at by: information found on the component; information found in the manufacturer's catalog; comparing the components dimensions to dimensions given in the applicable code or standard; by making contact with the manufacturer by phone or by letter; or by using the pipe pressure formula from ANSI B31.
- (9) WORKING PRESSURE: Working pressure (WPRES) of the system at the component's location.
- (10) CODE: Code or standard that the component is designed to. These codes are abbreviated. The abbreviations are explained on the Definition of Symbols page. Entries in the CODE column come from the Manufacturer's catalogs, crossing the component's dimensions with dimensions listed in the code, or by contacting the manufacturer. ASMD in this column means assumed.
- (11) ANALYSIS: Method of analyzing or evaluating the component. Abbreviations are explained on the Definition of Symbols page.
- (12) NDE: Method of non-destructive examination used to evaluate the component. Abbreviations are explained on the Definition of Symbols page.
- (13) FOOTNOTES: Footnotes which further explain or clarify the information for the component. Footnotes are by system and can be found on the Footnotes page.
- (14) REFERENCE: NASA specifications, NASA drawings, Engineering Analysis, and Non-Destructive Examination. These can be referenced on the Recertification Document Reference List.
- (15) REC: Recommendation for each component. The component is either recertified or recommended for removal, repair, derating, or waived.

#### 2.4.4. Evaluation Issues

a. After the initial field surveys are conducted, each component shall be analyzed to determine if they are in compliance with the applicable national consensus code. From time to time, unusual issues are encountered while evaluating the integrity of system components. Table 2-2 lists typical evaluation problems and possible solutions.

**Table 2-2, Typical Evaluation Problems With Possible Solutions.**

| <b>Problem</b>   | <b>Possible Solution</b>  |
|--|---|
| Material specification unknown                                       | <p>a) Whenever feasible, a small sample of the material shall be removed for chemical identification.</p> <p>b) When obtaining a sample is not practical, the component shall be assumed to be fabricated of the lowest strength material that has similar chemistry and is used for the same application (e.g., pipes, forgings, castings, or plates)</p>                          |
| Component cannot be reasonably analyzed using code provided formulas | <p>a) Use other known engineering analysis methods (closed form equations or finite element analysis) and compare calculated global stresses to code allowables.</p> <p>b) The MAWP for components can be established by proof testing per Section UG-101, "Proof Tests to Establish Maximum Allowable Working Pressure," of Section VIII Division 1 of the ASME B&amp;PV Code.</p> |
| Component made of known, but not Code-approved materials             | For these components, equivalent Code allowable stresses to be used in analysis shall be calculated using the "Basis for Establishing Stress Values" section for the applicable Code. A variance request from the Pressure Systems Committee shall be required.   |

b. When the engineering evaluation indicates that all components are adequate for the system's maximum operating pressure (relief valve setting), the analysis portion of recertification shall be considered complete. Otherwise, the system shall be listed as requiring repairs under Phase 2.

#### 2.4.5. Nondestructive Examination

a. During Phase 1, nondestructive examination (NDE) shall be used to assess the integrity of pressure system components. The selection of the NDE technique to be used shall depend on several issues, such as a component's material, geometry, fabrication method, and service conditions. In addition, NDE technique selection shall consider the type of defects being sought (e.g., laps and laminations in forgings and plates, voids and shrinkage in castings, slag inclusions in welds, surface cracks.)

| NDE Technique             | Use for   | Don't use for   |
|---------------------------|---|---|
| X-ray (RT) <sup>(*)</sup> | <ul style="list-style-type: none"> <li>Looking for internal inclusions, voids, incomplete fusion, porosity, incomplete penetration, and improper joint fit-up</li> </ul>  | <ul style="list-style-type: none"> <li>Finding small cracks</li> </ul>  |
| Ultrasonic (UT)           | <ul style="list-style-type: none"> <li>Looking for inclusions, voids, incomplete fusion, and incomplete penetration</li> <li>Finding and characterizing sub-surface cracks and plate laminations</li> <li>Determining wall thickness</li> </ul> | <ul style="list-style-type: none"> <li>Examination of complex geometries</li> </ul>                                     |
| Eddy Current (ET)         | <ul style="list-style-type: none"> <li>Finding surface or slightly below surface defects on smooth painted surfaces</li> </ul>  | <ul style="list-style-type: none"> <li>Finding deep subsurface defects</li> </ul>                                       |
| Dye penetrant (PT)        | <ul style="list-style-type: none"> <li>Finding surface cracks and other defects open to the surface on clean, paint-free surfaces (e.g., surface porosity and weld undercut)</li> </ul>   | <ul style="list-style-type: none"> <li>Finding subsurface defects</li> </ul>  |
| Magnetic particle (MT)    | <ul style="list-style-type: none"> <li>Finding surface cracks, other linear surface defects, and weld undercut on clean, paint-free surfaces</li> </ul>   | <ul style="list-style-type: none"> <li>Inspecting non-magnetic materials</li> <li>Finding subsurface defects</li> </ul> |
| Visual (VT)               | <ul style="list-style-type: none"> <li>Finding surface defects (e.g., open cracks, corrosion, weld undercut)</li> </ul>   | <ul style="list-style-type: none"> <li>Finding subsurface defects</li> </ul>  |

<sup>(\*)</sup> Radiography is the preferred method of NDE for most generic applications because of the wide range of internal defects that can be detected and the fact that a permanent record (the film) is retained.

b. For the purpose of the initial engineering evaluation, nondestructive examination of non-code-stamped pressure system components shall generally consist of:

- (1) Visual inspection of the entire system to look for signs of cracks, corrosion, wear, leakage, vibration, missing fasteners, broken supports, or welds with surface cracks, etc.
- (2) Initial x-ray inspection of 10 percent of all welds and high stress areas. If unacceptable welds are found during the initial RT, up to 100 percent of all welds may be radiographed, at the discretion of the PSM.

c. Similarly, the initial nondestructive examination of code-stamped pressure system components shall generally consist of:

- (1) Visual inspection of the component to look for signs of corrosion, wear, leakage, support deterioration, etc.

d. The acceptance criteria that is used for evaluating NDE performed on pressure system components shall be as follows:

| Type of weld                              | Acceptance criteria  |
|---|--|
| All pressure vessel welds                 | Use the acceptance criteria of the applicable Division of the ASME Boiler and Pressure Vessel Code, Section VIII   |
| Piping butt welds                         | Use the acceptance criteria for "Severe Cyclic Conditions" in the ASME B31.3 Process Piping code. For steam systems, use the criteria in ASME B31.1 Power Piping code. |
| Piping socket and branch connection welds | Use the acceptance criteria in LPR 1710.41, "Langley Research Center Standard for the Evaluation of Socket and Branch Connection Welds."                               |

#### 2.4.6. Pressure Vessel Evaluation

a. The procedures for evaluating pressure vessels shall be:

- (1) **Code-Stamped Vessels:** Code stamping of a vessel by its manufacturer certifies that the vessel complies with all the design requirements and is fabricated following the quality control measures of the ASME Boiler and Pressure Vessel Code. No additional analysis is performed in recertifying Code-stamped vessels.
- (2) **Non-Code-Stamped Vessels:** These vessels shall be analyzed using the criteria of the current edition of the ASME Code Section VIII, Division 1. Use of the more rigorous criteria in ASME Section VIII, Division 2 is allowed for vessels that do not meet the safety factor requirements of Division 1. In the event the vessel being evaluated does not meet the requirements of the current edition of the code, it is permissible to use the edition of the ASME code that was current at the time of the fabrication of the vessel.

#### 2.4.7. Piping Component Evaluation

All piping components, except for steam piping components, shall be evaluated using the ASME B31.3 Process Piping code. All steam piping components shall be evaluated using the ASME B31.1 Power Piping code. Refrigeration piping components shall be evaluated using the ASME B31.5 "Refrigeration Piping and Heat Transfer Components" code.

#### 2.4.8. Recertification File

- a. The ROME Contractor shall be responsible for creating and maintaining a recertification file for each pressure system to serve as the repository for supporting documentation and information that is not part of a Pressure Systems Document (PSD).
- b. Typical documentation in the recertification file shall include, but not limited to:
  - (1) Stress calculations
  - (2) Engineering assessments

- (3) Vendor catalog sheets
- (4) Manufacturer's drawings
- (5) Certificates of compliance
- (6) Manufacturer's U-1 or U-2 data reports for pressure vessels
- (7) Special welding procedures and procedure qualifications
- (8) Inspection reports
- (9) Test reports
- (10) Records of modifications
- (11) Incident reports
- (12) Record of approved variances
- (13) Recertification letter

c. The engineering evaluation report shall become a part of the recertification file for the pressure system. It shall be referenced within the PSD on the document reference sheet (see Figure 2-2).

## **2.5. RECERT PHASE 2**

The primary objectives of Phase 2 shall be to repair or replace any defective components found during the engineering evaluation part of Phase 1 and to prepare an inspection plan (IP).

### **2.5.1. Systems Built to a National Consensus Code**

In general, repairs are not necessary for pressure systems built to a national consensus code, because they meet the requirements of LPR 1710.40, "LaRC Pressure Systems Handbook." Phase 2 for these systems shall simply consist of the preparation of an inspection plan.

### **2.5.2. Repairs to Systems With Uncertain National Consensus Code Compliance**

- a. The following actions shall be conducted during Phase 2 on these systems:
- (1) If a significant number of unacceptable welds were identified in the Phase 1, up to 100 percent of all welds shall be radiographed, at the discretion of the PSM.
  - (2) All unacceptable welds shall be repaired.
  - (3) All recommended system corrective actions, such as, removal, repair, or derating of components, shall be performed.
  - (4) An IP shall be developed for the system.

### **2.5.3. Recertification letter**

When all components and welds in the system satisfy the requirements of the applicable National Consensus Codes, a recertification letter shall be issued to the cognizant Facility Safety Head by the PSM or his/her designated representative. See Figure 2-4 for a sample recertification letter.

#### 2.5.4. Emergency Repairs

If components are identified that are not in compliance with the applicable national consensus code, the ROME Contractor shall make an assessment in conjunction with the PSM to determine whether or not the non-compliance requires emergency repair action or not. Generally, the presence of cracks or wall thicknesses below code required levels shall qualify the non-compliance for emergency repair. In these cases, an Emergency Trouble Call shall be initiated by the ROME Contractor.

#### 2.5.5. Non-emergency Repairs

a. If non-compliant components are identified, and emergency repairs are not warranted, the non-compliant components shall be placed in a list of components to be replaced. The PSM shall then make an assessment of whether the system maximum operating pressure needs to be reduced (i.e., system is de-rated), or if additional analysis or NDE needs to be performed to ensure the non-compliant system's integrity while repair plans are advocated, designed, and implemented. In the event of a de-rating action, a letter shall be sent by the PSM to the Facility Coordinator (FC) and the Facility Safety Head (FSH) indicating the new limits of operation for the pressure system.

b. For non-emergency repairs not exceeding \$50,000 in estimated value, the ROME Contractor shall initiate maintenance work orders and shall include photographs and/or sketches as necessary to describe the scope of the required repairs.

c. For non-emergency repairs exceeding \$50,000 in estimated value, the ROME Contractor shall prepare a repair package including any photographs and sketches necessary to describe the scope of the required repairs. The PSM shall then be responsible for initiating any necessary funding advocacy, design, and procurement actions to accomplish the repairs.

d. A copy of the repairs conducted as a result of RECERT activities shall be kept in the recertification file.

#### 2.5.6. Inspection Plan Development

a. The purpose of the Inspection Plan (IP) shall be to minimize risk to personnel by ensuring system integrity is maintained. Specific guidelines and recommendations for the development of inspection plans are listed in Appendix F. Guidance and recommendations from the manufacturer of a pressure system component can also be used to supplement the guidelines presented there. At the discretion of the PSM, the recommended inspection intervals in Appendix F can be shortened or lengthened based on a system's inspection history, repair history, and operating environment. As a minimum, an IP shall contain the following information:

- (1) **Inspection frequency:** If the inspection plan is based on years of operation as its basis, the IP shall present at least a 10 year schedule of required inspections. If the inspection plan is based on cycles of operation, the IP shall



present (a) the maximum number of pressure and/or thermal cycles between inspections and (b) the current cycle count. It shall be the responsibility of the owner of the pressure system to maintain a log of the pressure and thermal cycles incurred by the pressure system. The current cycle count shall be updated by the ROME Contractor at the end of each calendar year.

- (2) **Inspection Procedure:** The IP lists which applicable procedure shall be followed to perform the inspections, such as LMS-TD-5569, "Performing Visual Inspections", or Section V, "Nondestructive Examination" of the ASME Boiler and Pressure Vessel Code.
- (3) **Qualifications:** The IP shall clearly identify the minimum required qualifications of the personnel that will be performing the inspection, such as an ASNT Level I, II, or III.

b. The IP shall be a configuration controlled document maintained in the CMOL system.

#### **2.5.7. Updates to the Documentation**

After repairs and modifications are complete, the ROME Contractor shall be responsible for updating the applicable PSD, component database, weld maps, weld database, and recertification file. The ROME Contractor shall then issue the modified CCD documents in the CMOL system.

### **2.6. RECERT PHASE 3 – INSERVICE INSPECTION**

The primary goal of inservice inspection shall be to verify the continued structural integrity of a pressure system. A secondary goal shall be to field verify the current Pressure System Document (PSD).

#### **2.6.1. Performing Inservice Inspection**

The ROME Contractor shall be responsible for performing the periodic inspections required by the IP's and for coordinating with the affected Facility Coordinators to schedule the required inspections.

#### **2.6.2. Findings by the Inservice Inspections**

a. The ROME Contractor shall develop a report including the results of the inservice inspections that shall be forwarded to the cognizant Facility Safety Head, the Facility Coordinator, and to the PSM. In addition, a copy of this report shall be placed in the recertification file. The inspection report shall include sufficient descriptions, redlined sketches, and/or photographs to clearly convey the findings.

b. If the results of the inservice inspections indicate that repairs are required, the affected pressure system shall be reverted to Phase 2 and the procedures for dealing with non-compliant systems in Phases 2 shall be utilized.

|  |   |
|--|---|
| National Aeronautics and<br>Space Administration   |   |
| Langley Research Center<br>Hampton, VA 23681-0001  |   |
| Date _____   |   |
| 447  |   |
| TO:  | XXX/Facility Safety Head, Building _____  |
| FROM:  | 447/Pressure Systems Manager, Center Operations Directorate   |
| SUBJECT:   | Recertification of the _____  |
| REF:   | (1) NPD 8710.5, "NASA Safety Policy for Pressure Vessels and Pressurized Systems"<br>(2) LPR 1710.40, "Langley Research Center Pressure Systems Handbook" |
| <p>The recertification analysis and inspection of the subject system is complete. All components now satisfy the requirements of References 1 and 2.</p> <p>The pertinent RECERT documentation has been entered into the Pressure Systems Configuration Management system. With your assistance, this documentation will be maintained up to date.</p> <p>The inspection plan for the subject system is given in the attached plan number _____.</p> <p>Based upon the successful completion of the recertification analyses and inspections, the subject system is recertified for continued use.</p> <p>(SIGNED)<br/>Pressure System Manager (PSM)</p> |   |

**Figure 2-4, Sample Recertification Letter**

**Chapter 3****3. PRESSURE SYSTEMS MAINTENANCE****3.1. GENERAL**

Preventive and predictive maintenance are tools used to preserve the structural integrity of a pressure system. This chapter outlines the parts of the LaRC Maintenance program that shall work together with the RECERT program to maintain pressure system integrity.

**3.2. PREVENTIVE MAINTENANCE (PM) PROGRAM**

a. The preventive maintenance program consists of a time-based schedule of maintenance work orders that are executed with a pre-programmed frequency. The LaRC pressure systems safety program takes advantage of the PM program of the Computerized Maintenance Management System (CMMS) by including in it the requirements for periodic testing of safety relief devices and pressure gages. The ROME Contractor shall be responsible for performing periodic maintenance in accordance with the schedule in the CMMS and for reporting completed actions to the appropriate FC and key COD personnel. The day-to-day management of the CMMS shall be performed by the ROME Contractor. The Center Operations Directorate (COD) manages the CMMS Software Change Control Board and the CMMS Maintenance Change Control Board.

b. Pressure relief valves are the most important safety devices on any pressurized system. These valves are intended to protect equipment and personnel from over pressurization events due to (a) failure of pressure regulators, (b) unexpected combustion of volatile fluids, or (c) evaporation of cryogenic liquids. The ROME Contractor shall be responsible for ensuring periodic testing of safety relief devices is conducted in accordance with the schedule in the CMMS, tagging them after servicing (see Appendix A), and returning them to service.

**3.3. COMPONENT VERIFICATION FACILITY**

a. The Component Verification Facility is a key element of the pressure system maintenance program. In this facility, hydrostatic testing and pneumatic testing is routinely and safely performed for the purpose of establishing the continued suitability of pressure system components.

b. Safety relief valves shall be periodically tested, refurbished, and repaired using OEM parts and procedures to ensure that these safety-critical components are operating as intended. A log of all the maintenance work performed on relief valves in operation at LaRC shall be kept at the Component Verification Facility. This log shall be considered a part of the RECERT documentation. The ROME Contractor shall be responsible for maintaining this log.

### **3.4. INTERFACE WITH PRESSURE SYSTEM DOCUMENTS**

As noted in Chapter 2, the recertification file shall include documentation of the changes that have occurred to a pressure system. Whenever maintenance activities result in changes that affect a configuration controlled pressure system, a Change Notification Sheet (CNS) form shall be prepared by the initiator or requester of the maintenance work. This CNS shall be intended to notify the ROME RECERT Group that updating the pressure systems documents is required.

### **3.5. LOCKOUT / TAGOUT (LO/TO)**

Maintenance operations on pressure systems can result in injury to personnel or in damage to equipment due to the energy they contain. All pressure systems shall be locked/tagged out in accordance with the requirements in LPR 1710.10, "Safety Clearance Procedures for the Control of Hazardous Energy (Lockout/Tagout)," prior to removing components from the system or otherwise performing any maintenance activity that requires opening the system to atmosphere.

**Chapter 4****4. OPERATIONS****4.1. GENERAL**

Operating procedures and operational logs are critical to the operation of pressure systems. Operational records and logs provide a continuous chronological narrative of the facility operation and a history of servicing activities conducted. In addition, these logs are used to determine trends in system performance, cyclic information, and other issues. Critical issues, incidents, or mishaps associated with pressure systems shall be reported to the SFAB, SMAO for further investigation.

**4.2. STANDARD OPERATING PROCEDURES AND CHECKLISTS**

Standard Operating Procedures (SOP's) are essential to the safe operation of any pressure system and shall be developed as specified in LPR 1740.4, "Facility System Safety Analysis and Configuration Management." Checklists shall be developed using the same process as the SOP to cover a particular area of system operation and to ensure that specific steps are always executed prior to, during, and after a pressure system is operated.

**4.3. OPERATIONAL RECORDS AND LOGS**

a. Within any particular facility, based on the judgment of the FSH and the FC, a continuous log of operations shall be maintained. This log shall denote:

- (1) The type of test being conducted,
- (2) The date/time/duration of the test,
- (3) Cause of any delays (e.g. status lights not operating, communication difficulties, clogged filters, filling of tanks, model problems and test equipment failures), and
- (4) Significant items of interest (e.g. car crash, power outage, environmental problems (storm, lightning, snow), acute illness of person(s) and fire).

b. Based on the operational complexity and/or material requirements, records pertaining to a specific component or the entire system operation shall be recorded by the operators and retained at the facility. Information recorded in these records shall include, for example, temperatures, pressures, fluid levels, and component status. The FSH shall coordinate with the PSM to determine if recording specific information is required for maintaining the system's integrity and recertification status.

#### **4.4. ACCIDENTS AND INCIDENTS**

As defined in LPR 1740.4, "Facility System Safety Analysis and Configuration Management," accidents, mishaps, incidents, and close calls shall be documented as specific circumstances dictate. The SFAB, SMAO is responsible for reviewing all accident, mishap, incident and close call reports to determine if pressure systems were involved and if so forward a copy to the ROME Contractor who shall be responsible for placing copies of the reports, if any, in the appropriate recertification file.

**Chapter 5****5. TRAINING****5.1. GENERAL**

The introduction of the human element into a perfectly designed and controlled hardware system brings with it the potential for unexpected results. As depicted in statistics compiled by the National Board of Boiler and Pressure Vessel Inspectors, over the past several years, anywhere from 15 to 40 percent of all accidents that have occurred with unfired pressure vessels took place because of human error. Hence, the only way to minimize the occurrence of "operator error" is by using trained, knowledgeable, and qualified operators. The operator shall be intimately familiar with the pressure system's standard operating procedures, safety analysis report, emergency protection systems, safety devices, and operational limits. Several methods shall be employed to ensure personnel are trained/qualified; both in general pressure system safety, as well as specific system procedures and limits. This chapter outlines general and specific training requirements for operators and installation personnel.

**5.2. HIGH-PRESSURE SYSTEM AWARENESS TRAINING**

The SFAB, SMAO are responsible for periodically providing to all interested LaRC personnel general pressure system awareness training. This training shall cover the basic hazards and controls that are inherent in high-pressure systems. Specifically, the following subjects shall be covered:

- a. Definition of high-pressure systems
- b. Over pressurization protection (safety relief devices)
- c. Relationship between various pressure terms (e.g., maximum expected operating pressure, maximum allowable working pressure, relief pressure, and test pressure)
- d. Programs to maintain operational safety of systems (e.g., national consensus codes, configuration management, inspection plans, preventive maintenance, operator qualifications);
- e. Review of incidents/accidents that have occurred (either at LaRC or at other facilities as appropriate);
- f. Demonstrative illustrations of the potential power that pressurized vessels/systems contain;
- g. Roles and responsibilities of key entities, such as the ESC, PSC, PSM, the FSH, and the FC.

**5.3. HIGH-PRESSURE SYSTEM OPERATOR TRAINING**

a. In addition to attending the high pressure system awareness training offered by SFAB, pressure system operators and handlers shall be certified as required by LPR 1710.40, "Langley Research Center Pressure Systems Handbook," using the procedures in LPR 1740.7, "Process System Certification Program." The FSH and the FC shall be responsible for ensuring that all equipment operators possess the requisite qualifications in the pressure system to be operated. Training shall include:

- (1) An overview of the system's design
- (2) Interrelationship of system components such as valves, control systems, safety devices, interlocks and monitoring equipment
- (3) Special instructions or procedures for specific jobs
- (4) Alarm conditions (visual and audible) and required emergency action/operation
- (5) Specific instruction on handling of potentially dangerous fluid or gas used in the process
- (6) Review of incident and accident reports and the recommendations to prevent reoccurrence
- (7) Review of recent equipment failures and repairs
- (8) Review of any changes in system operation and procedures
- (9) Review of system notes, cautions, and warnings.

b. Along with the list of certified operators, records of training shall be kept by the FSH and include dates of training, subjects discussed, copies of any handouts or lesson plans, and attendance sheets.

#### **5.4. HIGH-PRESSURE SYSTEM INSPECTOR TRAINING**

a. Training shall be in accordance with the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A or ASNT CP-189, "ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel," required for all inspection personnel conducting nondestructive examination of pressure systems at LaRC. ASNT Level II or Level III inspectors shall be required to provide final interpretation of the results of nondestructive examination of pressure systems.

b. Training shall be in accordance with the American Welding Society (AWS) Certified Welding Inspectors or Certified Assistant Welding Inspectors recommended for all inspection personnel conducting general construction inspection of pressure systems.

#### **5.5. HIGH-PRESSURE SYSTEM MAINTENANCE PERSONNEL TRAINING**

Personnel performing maintenance on pressure systems shall attend the high pressure system awareness training offered by SFAB and shall be trained in the use of LaRC lockout/tagout procedures. Maintenance personnel are strongly encouraged to attend training classes offered by OEM's whenever available and as applicable to their assigned work.



## Chapter 6

### 6. TAGGING OF RELIEF VALVES AND FLEXIBLE HOSES

#### 6.1. TAGGING OF RELIEF VALVES

a. Relief valves shall be required to be periodically inspected, tested, and tagged. The ROME Contractor shall be responsible for installing tags on relief valves that contain the following information:

- (1) Valve number
- (2) Set pressure
- (3) Test date.

b. Tagging of relief valves shall be required at initial installation and during any required retesting. The ROME Contractor shall be responsible for checking that relief valves are properly tagged during inservice inspections and field surveys.

#### 6.2. TAGGING OF FLEXIBLE HOSES

a. Flexible hoses are required to be tagged at initial installation and during any required retesting with the following information:

- (1) Test pressure
- (2) Test date.

## **Chapter 7**

### **7. VARIANCES**

Requests for deviation from the requirements of this LPR shall be submitted to the PSM for approval, with a copy to the SFAB, SMAO. If a request includes a deviation from the requirements of the national consensus codes and standards, the PSM shall forward the request to the Pressure Systems Committee for their consideration. Final approval shall be by the Executive Safety Council.

The PSM shall be responsible for forwarding a copy of the approved deviation request to the ROME Contractor for inclusion in the recertification file.

**Appendix A****A. ACRONYMS**

|      |   |
|------|---|
| ANSI | American National Standards Institute                   |
| ASME | American Society of Mechanical Engineers                |
| ASNT | American Society of Nondestructive Testing              |
| B&PV | Boiler and Pressure Vessel                              |
| CAD  | Computer-Aided Design                                   |
| CCD  | Configuration Controlled Document                       |
| CFR  | Code of Federal Regulations                             |
| CM   | Configuration Management                                |
| CMMS | Computerized Maintenance Management System              |
| CMOL | Configuration Management On-Line                        |
| CNS  | Change Notification Sheet                               |
| COD  | Center Operations Directorate                           |
| CoF  | Construction of Facilities                              |
| DOT  | Department of Transportation                            |
| FBL  | Facility Baseline List                                  |
| FC   | Facility Coordinator                                    |
| FSH  | Facility Safety Head                                    |
| IP   | Inspection Plan   |
| LAPD | Langley Research Center Policy Directive                |
| LPR  | Langley Research Center Procedural Requirements         |
| LaRC | Langley Research Center                                 |
| MAWP | Maximum Allowable Working Pressure                      |
| MT   | Magnetic Particle Testing                               |
| NB   | National Board  |
| NDE  | Nondestructive Evaluation or Nondestructive Examination |
| NPD  | NASA Policy Directive                                   |
| NTS  | NASA Technical Standard                                 |
| ORR  | Operational Readiness Review                            |
| SMAO | Safety and Mission Assurance Office                     |
| SFAB | Safety and Facility Assurance Branch                    |
| OSHA | Occupational Safety and Health Administration           |
| PM   | Project Manager   |
| PSC  | Pressure Systems Committee                              |
| PSCM | Pressure Systems Configuration Management               |
| PSD  | Pressure Systems Document                               |
| PSM  | Pressure Systems Manager                                |
| RT   | Radiographic Testing                                    |
| SOP  | Standard Operating Procedure                            |
| SPE  | Standard Practice Engineer                              |
| UT   | Ultrasonic Testing                                      |
| VT   | Visual Testing  |

**Appendix B****B. DEFINITIONS**

**Alteration** – A change which affects the pressure-retaining capability of a pressure system. Non-physical changes such as an increase in the maximum allowable working pressure or the design temperature are considered alterations. A reduction in minimum temperature such that additional mechanical test(s) are required is also considered an alteration.

**Change Notification Sheet (CNS)** – (LPR 1740.4, “Facility System Safety Analysis and Configuration Management”) An electronic form available through the Configuration Management On Line (CMOL) website initiated with the intent to document changes to systems under configuration control.

**Configuration Controlled Documents (CCD)** – Documents that are part of the Configuration Management system as described in LPR 1740.4, “Facility System Safety Analysis and Configuration Management.”

**Configuration Management On-Line (CMOL):** A LaRC website for initiating and processing CNS's, or to obtain copies of Configuration Controlled Documents (CCD's) (<http://cmol.larc.nasa.gov>).

**De-rating:** The lowering of the maximum allowable working pressure or narrowing of the allowable temperature range of a pressure system.

**Design Pressure:** The pressure used in the design calculations of a pressure system for the purpose of determining the minimum permissible thickness or physical characteristics of the different parts. When applicable, static head is added to the design pressure.

**Design Temperature:** The metal temperature used in the design calculations of a pressure system for determining the minimum required thickness of the components and for selecting the maximum allowable stress for the material used in the vessel or system.

**Facility Coordinator (FC):** An individual who has overall responsibility for the operations of an assigned facility.

**Facility Safety Head (FSH):** An individual who is responsible for the day to day safe operation of a facility.

**Inspection Plan (IP):** A configuration controlled document describing the requirements for periodic inspection of a pressure system.

**Maximum Allowable Working Pressure (MAWP):** The maximum gauge pressure permissible at a designated temperature for a particular vessel or system. The MAWP is the basis for the pressure setting of the pressure relieving devices protecting the system.

**Maximum Expected Operating Pressure (MEOP):** The highest pressure expected during the operation of a system, under normal conditions.

**National Consensus Standard:** Any standard which (1) has been adopted or distributed by a nationally recognized standards producing organization under procedures whereby 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 view to be considered; and (3) has been so designated by the Secretary or the Assistant Secretary, after consultation with other appropriate Federal Agencies.

**Operating or Working Temperature:** The metal temperature that is normally maintained in the part of the vessel or system under consideration during operation.

**Operating Pressure:** The gauge pressure at which a system normally operates.

**Project Manager (PM):** Individual designated to supervise and coordinate the design, fabrication, installation and initial certification of pressure systems.

**Recertification File:** A compendium of all documentation regarding a particular pressure vessel or system that contains inservice inspection reports, special inspections, test results, accident/incident reports, CNS forms, recertification letters, engineering assessments, nameplate data facsimile, any National Board Forms, and other documentation as outlined in Chapter 2.

**PHASE 1:** The engineering evaluation phase of the recertification process where documentation is gathered, components identified, and initial non-destructive examinations performed.

**PHASE 2:** The repair phase of the recertification process where either additional repairs and modifications or more complete NDE are performed before recertification.

**PHASE 3:** The maintenance phase of the recertification process after the pressure system has been recertified and the system is then periodically inspected.

**Piping system** – An assembly of 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 system** – A collection of piping systems and/or pressure vessels used jointly to convey or contain a pressurized fluid or a vacuum.

**Pressure Systems Configuration Management (PSCM)** (LPR 1740.4, “Facility System Safety Analysis and Configuration Management”): A subprogram under the Configuration Management (CM). In this subprogram, the component databases shall be constantly updated as modifications are made to the pressure systems.

**Pressure Systems Document (PSD)**: A Configuration Controlled Document (CCD) that includes isometric sketches of a pressure system and a database of all the components that comprise the pressure system. PSD’s are useful to engineering and facility personnel in preparing design changes and maintenance requests, repairs and system inspections.

**Pressure Systems Manager (PSM)**: A technical expert, designated by the Center Director, responsible for all matters involving pressure systems, their operation, and recertification activities.

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

**Recertification**: The procedure (appropriate tests, inspections, examination, analyses, and documentation) which qualifies a pressure system to continue or be returned to operation for a particular service.

**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.

**Safety-Relief Device Set Pressure**: 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.

**Standard Practice Engineer (SPE)**: Individual designated to review and approve the design and specifications of all pressurized ground systems, and verify compliance with applicable codes, standards, guides, and supplementary requirements of these regulations.

**Variance**: A document used to request acceptance of a design, fabrication, or use of a pressure system which is not in compliance with applicable national consensus codes, standards, guides, or LaRC supplementary requirements. This document is a part of the recertification file. Variances require the approval of the Pressure Systems Committee and the Executive Safety Council.

**Appendix C****C. RECOMMENDED PRACTICES FOR THE DEVELOPMENT OF PRESSURE SYSTEMS INSPECTION PLANS****C.1 General**

a. The tables presented in this Appendix are intended as a guide for the selection of inservice inspection intervals for pressurized systems. Tables are presented for various fluid media. Each table is divided by categories of components and further subdivided by a measure of the energy content of the component.

b. The possible consequences of the failure of a system under positive pressure include the release of pressure shock waves, the expulsion of fragments, explosions, and the release of flammable, toxic, or corrosive fluids. A conservative approach to determine the destructive potential of these failures is the TNT-equivalency technique developed by the Naval Ordnance Laboratory and detailed in Appendix F.

c. The destructive potential of a vacuum vessel is caused by the vessel's implosion and the subsequent drop of pressure in the surrounding area. The consequences of this type of failure depend on the volume contained by the system and include high velocity air movement, equipment and personnel drawn towards the vacuum source, the expulsion of fragments, and the possible collapse of surrounding structures.

**C.2 Construction of Inspection Plans**

a. The inspection tables presented in this Appendix are divided on the basis of the contents of the pressure system (flowing media). Within each listed table, recommendations for time-based inspection intervals are further subdivided by the type of component (e.g., vessels, relief valves, expansion joints, flexible hoses, and piping components) and by a measure of their energy content.

b. The inspection tables do not make any explicit recommendation of nondestructive examination (NDE) techniques to be used. The selection of NDE techniques for a specific system should be based on an engineering evaluation of the suitability of the NDE techniques to detect the development and/or growth of flaws in the pressure retaining walls, for the purpose of reducing the risk of unforeseen system failure.

c. Figures E-1 and E-2 are samples of inspection plans that could result from the application of the guidelines in this Appendix.

**C.3 Variances in Inspection Plans**

a. Variances from the guidelines presented in the tables are allowable to account for special issues such as (a) environment-induced factors (b) cyclic duty, (c) proximity or remoteness of untrained personnel, and (d) past history. Inspection plans for pressure systems shall document the rationale for variances from the inspection tables.

All variances in inspection plans shall be approved by the LaRC Pressure Systems Manager and the cognizant Facility Safety Head.

(1) *Environment-induced factors* – (e.g., corrosion, erosion, UV ray degradation.) Shortening or lengthening of the recommended time-based intervals shown in the inspection tables may be done based on known rates of degradation.

(2) *Cyclic duty* – A fatigue analysis per the rules of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 2 should be conducted whenever the pressure system is subject to pressure and/or thermal cycling. A damage tolerance analysis should be conducted to determine fatigue crack growth behavior and to determine whether a “leak before break” condition exists. The results of these analyses may be used to determine critical areas to be examined and to establish alternate inspection intervals based on pressure and thermal cycles instead of time-based inspection intervals.

(3) *Proximity or remoteness of personnel* – When personnel not trained in the risks associated with high pressure systems are regularly required to work inside the perimeter of Zone 4 from a pressure system (as defined in Appendix F), the recommended inspection intervals may be shortened to mitigate the risk. When a pressure system is located in a remote location such that all personnel are normally outside the perimeter of Zone 1, or when the pressure system is located within a structure designed to contain the potential blast forces, the recommended inspection intervals may be extended in response to the reduced risk.

(4) *Past history* – When the results of at least three consecutive inservice inspections performed at the intervals specified in the inspection plan show that no defects are present, it is permissible to extend the intervals recommended in the tables. When the results of two consecutive inservice inspections performed at the intervals specified in the inspection plan show signs of degradation in a particular area even though corrective actions have been performed, the recommended inspection interval shall be shortened.



**Figure C-1 Sample Time-based Inspection Plan**

| DESCRIPTION                | INSPECTION SCHEDULE |            |       |            |            |       | SPECIAL REQUIREMENTS  |
|----------------------------|---------------------|------------|-------|------------|------------|-------|---|
|                            | Y2000               | Y2002      | Y2004 | Y2006      | Y2008      | Y2010 |   |
| All Piping Components      |                     |            | VE    | UT - Thick | UT - Thick |       | UT-Thick - Ultrasonic Check for Thickness (Spot Check)<br><br>ASNT Level II or III shall perform all nondestructive examinations.<br><br>VE shall be in accordance with LMS-TD-5569, "Visual Inspections" |
| Elbow #24                  |                     | UT - Thick |       |            | UT - Thick |       |   |
| Valve #3                   | VE                  |            | MT    |            | VI & MT    | VE    |   |
| Valves 1, 2, and 4 thru 14 |                     |            | VE    |            | VI         |       |   |
| Water Pump "A"             | VE                  |            |       |            | VI         | VE    |   |
| Relief Valve               |                     | CRVT & VE  |       | VI         | CRVT & VI  |       |   |

**Figure C-2 Sample Time-based and Cycle-based Inspection Plan**

| DESCRIPTION          | INSPECTION SCHEDULE |                     |            |                            |            | SPECIAL REQUIREMENTS  |
|----------------------|---------------------|---------------------|------------|----------------------------|------------|---|
|                      | Y2000               | Y2002               | Y2004      | Y2006                      | Y2008      |   |
| Complete System      |                     | VE                  |            |                            | VE         | $N_F$ – Number of Equivalent Full Pressure Cycles<br><br>$N_{CURRENT}$ – Current cycle count as of 12/31/2004                               |
| Manifold Joints      |                     |                     |            |                            | UT - Shear |   |
| Manifold Exit Joints |                     |                     | UT - Shear |                            | UT - Shear | ASNT Level II or III shall perform all nondestructive examinations.<br><br>VE shall be in accordance with LMS-TD-5569, "Visual Inspections" |
| Tank #3010           | $N_F = 1000$ cycles | $N_{CURRENT} = 865$ |            | PT (all internal surfaces) |            |   |

**TABLE C-1** Recommended Inspection Intervals (in years) for Systems Containing Inert Gases, such as Argon, Helium, Nitrogen, and Dry Air

|                   | Measure of Energy Content                                      |                 |                       | Recommended Inspection Interval |   |   |     |    |
|-------------------|--|-----------------|-----------------------|---------------------------------|---|---|-----|----|
|                   |  |                 |                       | 1/2                             | 1 | 2 | 5   | 10 |
| Pressure Vessels  | Pressure (psig) times Volume (ft <sup>3</sup> )                | < 5,000         | Psi – ft <sup>3</sup> |                                 |   |   | I   |    |
|                   |  | 5,000 – 500,000 |                       |                                 |   | I |     |    |
|                   |  | ≥ 500,000       |                       |                                 | I |   |     |    |
| Piping Components | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 500,000       | Psi – in <sup>2</sup> |                                 |   |   | I   |    |
|                   |  | ≥ 500,000       |                       |                                 |   | I |     |    |
| Expansion Joints  | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 500,000       | Psi – in <sup>2</sup> |                                 |   | I |     |    |
|                   |  | ≥ 500,000       |                       |                                 | I |   |     |    |
| Flex Hoses        | Pressure   | ≥ 125           |                       |                                 | I | T |     |    |
| Relief Valves     | Outdoors, carbon steel   |                 |                       |                                 | I | T | R   |    |
|                   | All others   |                 |                       |                                 |   | I | T,R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-2** Recommended Inspection Intervals (in years) for Systems Containing Gaseous Oxygen

|                   | Measure of Energy Content                                      |                   |                       | Recommended Inspection Interval |   |   |      |    |
|-------------------|--|-------------------|-----------------------|---------------------------------|---|---|------|----|
|                   |  |                   |                       | 1/2                             | 1 | 2 | 5    | 10 |
| Pressure Vessels  | Pressure (psig) times Volume (ft <sup>3</sup> )                | < 1,000           | Psi – ft <sup>3</sup> |                                 |   |   | I    |    |
|                   |  | 1,000 – 400,000   |                       |                                 |   | I |      |    |
|                   |  | ≥ 400,000         |                       |                                 | I |   |      |    |
| Piping Components | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 100,000         | Psi – in <sup>2</sup> |                                 |   |   | I    |    |
|                   |  | 100,000 – 400,000 |                       |                                 |   | I |      |    |
|                   |  | ≥ 400,000         |                       |                                 | I |   |      |    |
| Expansion Joints  | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 400,000         | Psi – in <sup>2</sup> |                                 |   | I |      |    |
|                   |  | ≥ 400,000         |                       |                                 | I |   |      |    |
| Flex Hoses        | Pressure   | ≥ 125             | Psig                  |                                 | I | T |      |    |
| Relief Valves     | ALL  |                   |                       |                                 |   | I | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-3** Recommended Inspection Intervals (in years) for Systems Containing Gaseous Hydrogen or Natural Gas

|                   | Measure of Energy Content                                      |                  |                       | Recommended Inspection Interval |   |   |     |    |
|-------------------|--|------------------|-----------------------|---------------------------------|---|---|-----|----|
|                   |  |                  |                       | 1/2                             | 1 | 2 | 5   | 10 |
| Pressure Vessels  | Pressure (psig) times Volume (ft <sup>3</sup> )                | < 10,000         | Psi – ft <sup>3</sup> |                                 |   |   | I   |    |
|                   |  | 10,000 – 200,000 |                       |                                 |   | I |     |    |
|                   |  | ≥ 200,000        |                       |                                 | I |   |     |    |
| Piping Components | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 20,000         | Psi – in <sup>2</sup> |                                 |   |   | I   |    |
|                   |  | 20,000 – 400,000 |                       |                                 |   | I |     |    |
|                   |  | ≥ 400,000        |                       |                                 | I |   |     |    |
| Expansion Joints  | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | ALL              | Psi – in <sup>2</sup> |                                 | I |   |     |    |
| Flex Hoses        | Pressure   | < 125            | psig                  |                                 | I |   | T   |    |
|                   |  | ≥ 125            |                       |                                 | I | T |     |    |
| Relief Valves     | Outdoors, carbon steel   |                  |                       |                                 | I | T | R   |    |
|                   | All others   |                  |                       |                                 |   | I | T,R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-4** Recommended Inspection Intervals (in years) for Systems Containing Gaseous Fluorine

|                   | Measure of Energy Content             |                  |           | Recommended Inspection Interval |   |   |     |    |
|-------------------|---------------------------------------|------------------|-----------|---------------------------------|---|---|-----|----|
|                   |                                       |                  |           | 1/2                             | 1 | 2 | 5   | 10 |
| Pressure Vessels  | Pressure (psig) times Volume (ft³)    | < 13,000         | Psi – ft³ |                                 |   |   | I   |    |
|                   |                                       | 13,000 – 67,000  |           |                                 |   | I |     |    |
| Piping Components | Pressure (psig) times Diameter² (in²) | < 13,000         | Psi – in² |                                 |   |   | I   |    |
|                   |                                       | 13,000 – 100,000 |           |                                 |   | I |     |    |
|                   |                                       | ≥ 100,000        |           |                                 | I |   |     |    |
| Expansion Joints  | Pressure (psig) times Diameter² (in²) | ALL              | Psi – in² |                                 | I |   |     |    |
| Flex Hoses        | Pressure                              | < 125            | psig      |                                 | I |   | T   |    |
|                   |                                       | ≥ 125            |           |                                 | I | T |     |    |
| Relief Valves     | Outdoors, carbon steel                |                  |           |                                 | I | T | R   |    |
|                   | All others                            |                  |           |                                 |   | I | T,R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-5** Recommended Inspection Intervals (in years) for Systems Containing Liquid Water, Nonflammable Hydraulic Fluids, or Nonflammable refrigerants

|                   | Measure of Energy Content                                      |          |                       | Recommended Inspection Interval |   |   |     |    |
|-------------------|--|----------|-----------------------|---------------------------------|---|---|-----|----|
|                   |  |          |                       | 1/2                             | 1 | 2 | 5   | 10 |
| Tanks             | Capacity (gallons)   | < 50,000 | gal                   |                                 |   |   |     | I  |
|                   |  | ≥ 50,000 |                       |                                 |   |   | I   |    |
| Piping Components | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 50,000 | Psi – in <sup>2</sup> |                                 |   |   |     | I  |
|                   |  | ≥ 50,000 |                       |                                 |   |   | I   |    |
| Expansion Joints  | Diameter (in)  | ALL      | in                    |                                 |   | I |     |    |
| Flex Hoses        | Pressure   | ≥ 125    |                       |                                 |   | I |     |    |
| Relief Valves     | Outdoors, carbon steel   |          |                       |                                 | I | T | R   |    |
|                   | All others   |          |                       |                                 |   | I | T,R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-6** Recommended Inspection Intervals (in years) for Systems Containing Cryogenic Liquids of Argon, Helium, or Nitrogen

|                   | Measure of Energy Content |          |      | Recommended Inspection Interval |   |      |      |    |
|-------------------|---------------------------|----------|------|---------------------------------|---|------|------|----|
|                   |                           |          |      | 1/2                             | 1 | 2    | 5    | 10 |
| Tanks             | Capacity (gallons)        | < 50,000 | gal  |                                 |   |      | I    |    |
|                   |                           | ≥ 50,000 |      |                                 |   | I    |      |    |
| Piping Components | Diameter (in)             | < 36     | in   |                                 |   |      | I    |    |
|                   |                           | ≥ 36     |      |                                 |   | I    |      |    |
| Expansion Joints  | Diameter (in)             | < 36     | in   |                                 |   | I    |      |    |
|                   |                           | ≥ 36     |      |                                 | I |      |      |    |
| Flex Hoses        | Pressure                  | < 125    | psig |                                 |   | I, T |      |    |
|                   |                           | ≥ 125    |      |                                 | I | T    |      |    |
| Relief Valves     | ALL                       |          |      |                                 |   | I    | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-7** Recommended Inspection Intervals (in years) for System Components Containing Liquid Oxygen (LOX)

|                   | Measure of Energy Content |          |      | Recommended Inspection Interval |   |      |      |    |
|-------------------|---------------------------|----------|------|---------------------------------|---|------|------|----|
|                   |                           |          |      | 1/2                             | 1 | 2    | 5    | 10 |
| Tanks             | Capacity (gallons)        | < 20,000 | gal  |                                 |   |      | I    |    |
|                   |                           | ≥ 20,000 |      |                                 |   | I    |      |    |
| Piping Components | Diameter (in)             | < 24     | in   |                                 |   |      | I    |    |
|                   |                           | ≥ 24     |      |                                 |   | I    |      |    |
| Expansion Joints  | Diameter (in)             | < 24     | in   |                                 |   | I    |      |    |
|                   |                           | ≥ 24     |      |                                 | I |      |      |    |
| Flex Hoses        | Pressure                  | < 125    | psig |                                 |   | I, T |      |    |
|                   |                           | ≥ 125    |      |                                 | I | T    |      |    |
| Relief Valves     | ALL                       |          |      |                                 |   | I    | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing



**TABLE C-8** Recommended Inspection Intervals (in years) for Systems Containing Liquid Hydrogen (LH2) or Liquid Natural Gas (LNG)

|                   | Measure of Energy Content |               |      | Recommended Inspection Interval |   |   |      |    |
|-------------------|---------------------------|---------------|------|---------------------------------|---|---|------|----|
|                   |                           |               |      | 1/2                             | 1 | 2 | 5    | 10 |
| Tanks             | Capacity (gallons)        | < 1,300       | gal  |                                 |   |   | I    |    |
|                   |                           | 1,300 – 6,500 |      |                                 |   | I |      |    |
|                   |                           | ≥ 6,500       |      |                                 | I |   |      |    |
| Piping Components | Diameter (in)             | < 18          | in   |                                 |   | I |      |    |
|                   |                           | ≥ 18          |      |                                 | I |   |      |    |
| Expansion Joints  | ALL                       |               | -    |                                 | I |   |      |    |
| Flex Hoses        | Pressure                  | < 125         | psig |                                 |   | I |      |    |
|                   |                           | ≥ 125         |      |                                 | I | T |      |    |
| Relief Valves     | ALL                       |               |      |                                 |   | I | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-9** Recommended Inspection Intervals (in years) for Systems Containing Liquid Fluorine

|                   | Measure of Energy Content |               |      | Recommended Inspection Interval |   |   |      |    |
|-------------------|---------------------------|---------------|------|---------------------------------|---|---|------|----|
|                   |                           |               |      | 1/2                             | 1 | 2 | 5    | 10 |
| Tanks             | Capacity (gallons)        | < 1,300       | gal  |                                 |   |   | I    |    |
|                   |                           | 1,300 – 6,500 |      |                                 |   | I |      |    |
|                   |                           | ≥ 6,500       |      |                                 | I |   |      |    |
| Piping Components | Diameter (in)             | < 6           | in   |                                 |   |   |      | I  |
|                   |                           | ≥ 6           |      |                                 |   |   | I    |    |
| Expansion Joints  | ALL                       |               | -    |                                 | I |   |      |    |
| Flex Hoses        | Pressure                  | < 125         | psig |                                 |   | I |      |    |
|                   |                           | ≥ 125         |      |                                 | I | T |      |    |
| Relief Valves     | ALL                       |               |      |                                 |   | I | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-10** Recommended Inspection Intervals (in years) for Systems Containing Furfuryl Alcohol or Kerosene (RP-1)

|                   | Measure of Energy Content |             |      | Recommended Inspection Interval |   |   |      |    |
|-------------------|---------------------------|-------------|------|---------------------------------|---|---|------|----|
|                   |                           |             |      | 1/2                             | 1 | 2 | 5    | 10 |
| Tanks             | Capacity (gallons)        | < 380       | gal  |                                 |   |   | I    |    |
|                   |                           | 380 – 3,800 |      |                                 |   | I |      |    |
|                   |                           | ≥ 3,800     |      |                                 | I |   |      |    |
| Piping Components | Diameter (in)             | < 10        | in   |                                 |   |   | I    |    |
|                   |                           | ≥ 10        |      |                                 |   | I |      |    |
| Expansion Joints  | ALL                       |             | -    |                                 | I |   |      |    |
| Flex Hoses        | Pressure                  | < 125       | psig |                                 |   | I |      |    |
|                   |                           | ≥ 125       |      |                                 | I | T |      |    |
| Relief Valves     | ALL                       |             |      |                                 |   | I | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-11** Recommended Inspection Intervals (in years) for Vacuum Systems

|                   | Measure of Energy Content   |                  |                 | Recommended Inspection Interval |   |   |      |    |
|-------------------|-----------------------------|------------------|-----------------|---------------------------------|---|---|------|----|
|                   |                             |                  |                 | 1/2                             | 1 | 2 | 5    | 10 |
| Vacuum Vessels    | Capacity (ft <sup>3</sup> ) | 100 – 15,000     | ft <sup>3</sup> |                                 |   |   | I    |    |
|                   |                             | 15,000 – 100,000 |                 |                                 |   | I |      |    |
|                   |                             | ≥ 100,000        |                 |                                 | I |   |      |    |
| Piping Components | Diameter (in)               | < 24             | in              |                                 |   |   |      | I  |
|                   |                             | ≥ 24             |                 |                                 |   |   | I    |    |
| Expansion Joints  | ALL                         |                  | -               |                                 | I |   |      |    |
| Flex Hoses        | Pressure                    | < 125            | psig            |                                 |   | I |      |    |
|                   |                             | ≥ 125            |                 |                                 | I | T |      |    |
| Relief Valves     | ALL                         |                  |                 |                                 |   | I | T, R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

**TABLE C-12** Recommended Inspection Intervals (in years) For Steam Systems (Excluding Boilers and Boiler External Piping)

|                   | Measure of Energy Content                                      |                |                       | Recommended Inspection Interval |   |      |     |    |
|-------------------|--|----------------|-----------------------|---------------------------------|---|------|-----|----|
|                   |  |                |                       | 1/2                             | 1 | 2    | 5   | 10 |
| Pressure Vessels  | Pressure (psig) times Volume (ft <sup>3</sup> )                | < 5,000        | Psi – ft <sup>3</sup> |                                 |   |      | I   |    |
|                   |  | 5,000 – 50,000 |                       |                                 |   | I    |     |    |
|                   |  | ≥ 50,000       |                       |                                 | I |      |     |    |
| Piping Components | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 50,000       | Psi – in <sup>2</sup> |                                 |   |      | I   |    |
|                   |  | ≥ 50,000       |                       |                                 |   | I    |     |    |
| Expansion Joints  | Pressure (psig) times Diameter <sup>2</sup> (in <sup>2</sup> ) | < 50,000       | Psi – in <sup>2</sup> |                                 |   | I    |     |    |
|                   |  | ≥ 50,000       |                       |                                 | I |      |     |    |
| Flex Hoses        | Pressure   | < 125          | psig                  |                                 | - | -    | -   | -  |
|                   |  | ≥ 125          |                       |                                 | I | T    |     |    |
| Relief Valves     | Outdoors, carbon steel   |                |                       |                                 | I | T, R |     |    |
|                   | All others   |                |                       |                                 | I |      | T,R |    |

**Notes:**

I = Inspection

T = Testing (Note: some flex hoses may be exempt from testing, see LPR 1710.40). For relief valves, testing means checking its setpoint through pressure testing.

R = Refurbishing

## Appendix D

## D. RECOMMENDED PRACTICE FOR THE ASSESSMENT OF FAILURE DAMAGE PRODUCED BY HIGH PRESSURE GAS SYSTEMS

### D.1 General

a. The consequences of the sudden failure of a gaseous system subject to internal pressure include the release of pressure shock waves and the expulsion of debris. The destructive potential of these failures can be established 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). The procedure delineated below is recommended for establishing personnel exclusion perimeters associated with pneumatic testing of pressure systems and for determining the potential need to increase or decrease inservice inspection intervals (see LPR 1710.40 for additional requirements for pneumatic testing at LaRC and Appendix E of this LPR for additional requirements for inspection plans). 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.

b. The general procedure includes the following steps:

- (1) Establish the water volume of the vessel or system (**V**, cubic feet). For piping systems, use the volume of the longest run of pipe in the system between welded joints, threaded fittings, flanges, or other structural discontinuity capable of arresting a moving crack front.
- (2) Determine the system's maximum operating pressure (**P**, pounds per square feet absolute) and temperature (**T**, degrees Rankine.)
- (3) Calculate or look up the standard atmospheric pressure (**P<sub>atm</sub>**, pounds per square feet absolute.)
- (4) Look up the specific heat ratio of the gas (**γ**, non-dimensional, 1.4 for air.)
- (5) Calculate the potential energy contained in the pressurized gas by using the formula (result is in units of ft-lb<sub>f</sub>)

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

- (6) Convert the potential energy calculated previously (in ft- lb<sub>f</sub>) to an equivalent mass of TNT (units of lb<sub>m</sub>) by using the equation

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

- (7) Calculate radii of the different overpressure zones using Table F-1 and the following formula

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

**Table D-1 Effects of Blast Overpressure by Zone Number**

| Zone | $\Delta P$ , psi | $\lambda$ , ft/(lb <sup>1/3</sup> ) | 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 windows may shatter. During system pressure testing, and under space critical conditions, the exclusion perimeter may be set in this zone. |
| 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" to 12" thick may shear and fail.  |
| 6    | 10.000           | 10                                  | Lung damage may occur.  |

Example:

*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.*

$$V = \frac{\pi}{4} \cdot \left[ \frac{2.624}{12} \right]^2 \cdot (20) \quad \rightarrow 2.624" \text{ is nominal ID of pipe}$$

$$V = 0.751 \cdot ft^3$$

$$P = (4500 + 15) \cdot (144) = 650,160 \cdot psfa$$

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

$$T = 520 \cdot \text{Rankine}$$

$$\gamma = 1.4$$

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

$$\therefore m = \frac{982000}{1424033} = 0.69 \cdot lb_m$$

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

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

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



