Corporate Process Requirement No: CPR400.1.1.27
Sponsor: Dori Ellis, 4000, Acting

Revision Date: September 29, 2006
Replaces Document Dated: June 6, 2006

Sandia National Laboratories
Environment, Safety & Health

Pressure Safety Manual

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
Revision Date: September 29, 2006; Replaces Document Dated: June 6, 2006
Administrative Changes: October 16, 2006, November 20, 2006, April 2, 2007, April 19, 2007, and May 17, 2007

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* Indicates a substantive change

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Sandia National Laboratories
Environment, Safety & Health

Pressure Safety Manual Change History

Administrative Changes Only
May 17, 2007

[Chapter 6, "Testing and Evaluating Pressure Systems"]

This chapter was revised to:

- Under topic, “Periodic Reevaluations of Pressure Systems,” under subtopic “Manager Activities,” and under “Guidance”:
    - **Change:** The last sentence under the topic “Inspection” **from** “This could be as often as daily, prior to use, or as part of the annual audit, depending on the type of component or system and the hazards involved” **to** “This could be as often as daily, prior to use, or as part of the Periodic Evaluation, depending on the type of component or system and the hazards involved.”
- Under topic, “When to Reevaluate Pressure Systems,” and under “Guidance”:
    - **Delete:** The first sentence after the topic “All other Systems,” which states “Line Pressure Advisors should consider all pressure systems for a formal re-evaluation as part of the annual Audit,” and move up the next sentence to take its place.

Administrative Changes Only
April 19, 2007

[Appendix H, "Suppliers of Quality Pressure Hardware"]

This appendix was revised to:

- Under topic, “Where to Obtain Catalogs and Information”:
    - **Remove:** The invalid department number “9615” associated with the “Information Desk at the Technical Library.”
    - **Change:** The link **from** “Industrial Hygiene and Safety Engineering Programs Department” **to** “Pressure Safety – Resources.”

Appendix J, “Pressure-Relief Valve Test Procedures and Policies”

This appendix was revised to:

- **Replace:** The invalid link, “Materials Mechanics Engineering Department (9123),” found throughout Appendix J, with the link “ Onsite Calibration & Maintenance Department (2541-1).”
- Under topic, “Designated PRV Testing Stations at SNL,” and under subtopic “New PRVs”:
    - **Delete:** The following Note: “Pressure relief valves are Category A devices.”

Administrative Changes Only
April 2, 2007

Chapter 2, "The Pressure Safety Program"

This chapter was revised to:

- In Form SF 2001-PAD (Pressure Advisor Designation Form), which can be accessed via a hyperlink under topic “Organization of Sandia’s Pressure Safety Program,” under the subtopic “Pressure Advisors,” and under the heading “Qualifications for PAs include”:
    - **Change:** “to: Safety Department 10322, MS 1094” **to** “to: S. Page, Safety Engineering (10322), New Mexico operations, MS 1093.”
    - **Delete**: The following: “Copy to:
        - 10322 S. Page (Safety Engineering, New Mexico operations)
        - 8517 D. A. Wright (Health and Safety, California operations) “

- In Form SF 2001-PAQ (Pressure Advisor Qualification Form), which can be accessed via a hyperlink under topic "Organization of Sandia's Pressure Safety Program," under the subtopic "Pressure Advisors," under the heading "Qualifications for PAs include," and also via a hyperlink under the topic "Pressure Safety Training Program," under the subtopic "Training Requirements":
    - **Change:** "(optional)" **to** "(as applicable)," in the listing of course PRS115, Cryogen Safety.
    - **Change**: "(or equivalent)" **to** "(required)," in the listing of course PRS150, Pressure Safety Orientation.
    - **Clarify:** That course PRS160, Pressure Advisor Training, is required.
    - **Change:** "(or equivalent)" **to** "(required)," in the listing of course PRS250, Advanced Pressure Safety.
    - **Clarify:** That there is no equivalent course for Commercial Hardware Training by removing "or equivalent."
- In Form SF 2001-PQF (Pressure System Operator Qualification Form), which can be accessed via a hyperlink under the topic "Pressure Safety Training Program," under the subtopic "Training Requirements":
    - Change: "(optional)" **to** "(as applicable)," in the listing of course PRS115, Cryogen Safety.
    - Change: "(or equivalent)" **to** "(required)," in the listing of course PRS150, Pressure Safety Orientation.
- In Form SF 2001-PIQ (Pressure Installer Qualification Form), which can be accessed via a hyperlink under the topic "Pressure Safety Training Program," under the subtopic "Training Requirements":
    - **Change:** "(optional)" **to** "(as applicable)," in the listing of course PRS115, Cryogen Safety.
    - **Change:** "(or equivalent)" **to** "(required)," in the listing of course PRS150, Pressure Safety Orientation.
    - **Change:** "(or equivalent)" **to** "(required)," in the listing of course PRS250, Advanced Pressure Safety.

Appendix F, "Pressure Safety Assistance Index"

This appendix was revised to:

- Under topic, "SNL Pressure Safety Committee Roster":
    - **Change:** The committee function for A. J. Lopez **from** "Facilities Operations Representative" **to** "Facilities Operations Representative, Division 1000."
    - **Change:** The committee function for M. A. Cooper **from** "Division 1000 Representative" **to** "Division 2000 Representative Alternate."
    - **Change:** The committee function for C. E. Yagow **from** "Division 2000 Representative" **to** "Design Drawing Representative."
    - **Change:** The committee function for D. Vortolomei **from** "Division 2000 Representative" **to** "Design Drawing Representative."
    - **Change:** The committee function for W. R. Olson **from** "Division 2000 Representative" **to** "Division 2000 Representative Alternate."
    - **Change:** The committee function for W. L. Teague **from** "Division 6000 Representative" **to** "Division 5000 Representative Alternate."
    - **Change:** The committee function for W. L. King **from** "Division 6000 Representative" **to** "Division 6000 Representative Alternate."
    - **Replace:** D. A. Wright with P. G. Fugarri as the Division 8000 Representative.
    - **Change:** The committee function for J. A. Orsbun **from** "Division 8000 Representative" **to** "Division 8000 Representative Alternate."
    - **Add:** L. R. Shapanek as the Division 5000 Representative.
    - **Change:** The order in this list so that the "Division Representative Alternate" appears directly under the associated "Division Representative."
- Under topic, "Pressure Safety Assistance Index – New Mexico Personnel":
    - **Change:** The subject order by moving and making "Brittle Materials/Mechanical Properties/Failure Analysis," "Materials Properties," and "Plastic Materials/ Mechanical Properties," a subset of "Materials."

- **Replace:** J. B. Kelly with G. W. Wellman as the contact responsible for the subject "Materials Properties."
- **Delete:** The subject " Design Information Center," and associated contact name "R. L. Josephson."
- **Delete:** The name and phone number, "Scientific Sales Associates 266-7861," associated with the subject "Vacuum Hardware (JIT Contact)."

- Under topic, "Pressure Safety Assistance Index – California Personnel":
    - **Replace:** J. D. Larsen with J. A. Orsbun as the contact responsible for the subject "Safety Engineering."
    - **Delete:** D. A. Wright as the contact responsible for the subject " SNL, CA: Chairmen," and replace it with the word "Vacant."

Administrative Changes Only
November 20, 2006

Appendix F, "Pressure Safety Assistance Index"

This appendix was revised to:

- Under topic, "Pressure Safety Assistance Index – New Mexico Personnel":
    - **Add:** The subject "Plastic Materials/ Mechanical Properties," and list "F.R Gruner" as the contact.

October 16, 2006

Appendix F, "Pressure Safety Assistance Index"

Note: (*) indicates a substantive change

This section has been revised to:

- Under "New Mexico Personnel":

- ***Change:** Contact information for "Facilities Engineering" from "M.J. Quinlan" to "A. J. Lopez."
- ***Add:** "Fire Marshall" and the contact, "G. Earhart."
- ***Change:** Contact information for "Pressure Relief Valve Testing" from "N.D. Roberts" to "K.L. Robbins"

September 29, 2006

Chapter 2, "The Pressure Safety Program"

Note: (*) asterisk denotes substantive change

This chapter was revised to:

- Under topic, "Pressure Safety Program Support Organizations":
  - **Change:** The first bullet listed under the subtopic "Pressure Safety Committee" **from** "A Chairman who is appointed by the Manager, Industrial Hygiene & Safety Programs Department (10327)" **to** " A Chairman who is appointed by the Director, Integrated Safety and Security Center."
  - **Replace:** The subtopic "Industrial Hygiene Program Department (10327)" **with** "Safety Engineering Department (10322)."
  - **Change:** The first sentence under the subtopic "Safety Engineering Department (10322)" **from** "Department 10327 pressure safety personnel are responsible for" **to** "Department 10322 pressure safety personnel are responsible for."
  - **Change:** The first bullet listed under the subtopic "Hardware Procurement Support Organizations" **from** "Industrial Hygiene Program Department (10327) and Health & Safety Department (8517)" **to** "Safety Engineering Department (10322) and Health & Safety Department (8517)."
- Under topic "Pressure Safety Training Program":
  - ***Add:** The following requirement under the subtopic "Training Requirements":
    - Managers shall verify that individuals responsible for developing and

conducting job-specific pressure systems training and pressure safety training have the appropriate education, training, and skills to discharge this responsibility. See CPR400.1.1/MN471001, *ES&H Manual*, Chapter 11, “ES&H Training” for instructor qualification requirements.

June 6, 2006

Chapter 2, "The Pressure Safety Program"

Note: (*) asterisk denotes substantive change

This chapter was revised to:

- Under topic, “Elements of the Pressure Safety Program,” and under the subtopic “Individual Knowledge”:
  - **Change:** “employees” to “MOWs” in three places.
- Under topic, “Elements of the Pressure Safety Program,” and under the subtopic “Documentation and Accountability,” in the fourth bullet:
  - **Change:** “audits” to “assessments”.
- Under topic, “Organization of Sandia’s Pressure Safety Program,” and under the subtopic “Pressure Advisors,” in the fifth bullet:
  - **Change:** “serve” to “serving”.
- Under topic, “Organization of Sandia’s Pressure Safety Program,” under the subtopic “Pressure Advisors,” and under the heading “Qualifications for PAs include” in Item 1:
  - ***Change:** “Center Director” to “Senior Manager”.
- Under topic, “Pressure Safety Program Support Organizations,” under subtopic “Pressure Safety Committee,” in the third bullet:
  - ***Delete:** “nominated by the vice president”.
- Under topic “Pressure Safety Program Support Organizations”:
  - **Change:** the subtopic “Industrial Hygiene & Safety Programs Department,” to

"Industrial Hygiene Program Department".

- Under topic "Pressure Safety Program Support Organizations," under subtopic "Hardware Procurement Support Organizations," in the third bullet:
    - **Change:** "Purchasing organizations (e.g. Procurement Operations Department (10258) and Logistics & Procurement Department (8523))" to "Buyers supporting Center purchasing operations".

- In Form SF 2001-PAD (Pressure Advisor Designation Form), which can be accessed via a hyperlink under topic "Organization of Sandia's Pressure Safety Program," under the subtopic "Pressure Advisors," and under the heading "Qualifications for PAs include" in Item 1:
    - **Change:** "Department 3122" to " Safety Department 10322" after "to".
    - **Change:** "MS 1037" to "MS 1094" after "to".
    - ***Change:** "Director" to "Senior Manager" following the "from" signature line.
    - **Change:** "3122" to "10322" after "Copy to" in "subject" area.

Administrative Changes Only
April 27, 2006

Chapter 1, "Introduction"

This document was administratively revised to:

Under the topic "Objectives":

- Under the second bullet, in the second sub-bullet:
    - **Add**: "Pressure Safety Committee" before "PSC" and place parentheses around PSC.
- Under the third bullet, in the fifth sub-bullet:
    - **Add:** "are established (or in place)" after "Measures" and before "to protect".

Chapter 3, "Pressure Safety Practices"

This document was administratively revised to:

Under the topic “Selecting the Factor of Safety,” sub-topic “Requirements”:

- In the fourth bullet:
    - **Add:** “is required” after “(See Ch. 9)” and before “for all systems”.

Administrative Changes Only
April 14, 2006

Appendix F, "Pressure Safety Assistance Index"

This appendix was revised to:

- **Replace:** B. R. Rogillo with N.D. Roberts as the Pressure Testing Representative for the Sandia National Laboratories Pressure Safety Committee.
- **Delete:** The Division 10000 representation (K. K. Miles) from the Sandia National Laboratories Pressure Safety Committee.
- **Delete:** K.K. Miles as a contact for National Codes from the Pressure Safety Assistance Index – New Mexico Personnel.
- **Replace:** B. R. Rogillo with N.D. Roberts as the Pressure Testing contact on the Pressure Safety Assistance Index – New Mexico Personnel.
- **Replace:** B. R. Rogillo with N.D. Roberts as the Pressure Relief Valve Testing contact on the Pressure Safety Assistance Index – New Mexico Personnel.
- **Replace:** P.D. Walkington with S.J. Younghouse as the Ultrasonics contact on the Pressure Safety Assistance Index – New Mexico Personnel.
- **Replace:** K.K. Miles with R.D. Shrouf as the Pressure Safety Library contact on the Pressure Safety Assistance Index – New Mexico Personnel.
- **Replace:** P. Salgado and J.A. Price with J.J. Coots and J.A. Jojola as the Purchasing (JIT Contracts) contacts on the Pressure Safety Assistance Index – New Mexico Personnel.
- **Delete:** K.K. Miles as a contact for Safety Engineering from the Pressure Safety Assistance Index – New Mexico Personnel.

Administrative Changes Only
June 29, 2005

Pressure Safety Manual

This document was administratively revised to:

Change: Executive Policy Sponsor from Les Shephard to Frank Figueroa

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May 19, 2005

Chapter 5, "Selecting and Assembling Pressure Hardware"

This chapter was revised to:

- **Add:** The topic "Suppliers and their Products," after "Compressed Air Systems."
- **Add:** The topics, "Manifolds" and "Regulators," to the beginning of the document.
- **Change:** Throughout the document, the spelling of "gage(s)" to "gauge(s)."
- **Change:** The topics, "Manifolds" and "Regulators," completely.
- **Delete:** The topic "Suppliers and their Products," from the beginning of the document.
- **Delete:** The topics, "Manifolds" and "Regulators," from after the topic, "Common Compressed Gases."
- Under the topic, "Gas Cylinders":
    - **Change:** Under the subtopic "Storage," the requirement that "cylinders stored in the open *must* be shaded" to "*should* be shaded."
- Under the topic, "Suppliers and their Products":
    - **Add:** Information on suspect/counterfeit items, including a link to the SNL Suspect/ Counterfeit Items Program under the Requirements for the sub-topic, "Non-JIT Purchases."

ES&H Manual Glossary:

Add: Additional wording to "Pressure system" definition.

Appendix J, "Pressure Relief Valve Test Procedures and Policies"

This appendix was revised to:

- **Change:** Defined the acronym PRV (pressure-relief valve) at first use, then used the acronym PRV consistently throughout document.
- Under the topic, “Pressure Indicators,” under “Hardware for PRV Test Stations”:
  - **Delete:** The requirement for all pressure indicators to be calibrated by a source approved by SNL’s Primary Standards Laboratory.
- Under the topic, “Tagging,” under “Data Recording and Record-Keeping”:
  - **Delete:** Note giving minimum tag requirements.
- Under the topic, “Inspection and Replacement Intervals,” under “Special Cases – Nonroutine Testing Procedures”:
  - **Add:** The words, “in the Pressure Data Package” to the requirement that the user will state inspection and replacement information

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Administrative Changes Only
June 2, 2004

Introduction

This section was revised to:

- **Add.** The topic, “Applicability.”

Administrative Changes Only
June 2, 2004

Pressure Safety Manual

This manual was revised to:

- **Change.** The title of Attachment A and Form SF 2001-CPA from, “Pressure System Checklist for Pressure Advisors” to, “Pressure System Checklist.”
- **Change.** References throughout the manual from the Solid Mechanics Engineering Department

to Materials Mechanics Engineering Department.

November 10, 2003

General Changes to Chapters 2, 5, 8, and 9:

- **Change:**
  - The function title from "Pressure System Operator(s)" to "Pressure Operator(s)." (Also on SF 201-PQF, Pressure Operator Qualification Form.)
  - Update organization numbers and names.

Chapter 2, "The Pressure Safety Program"

- **Add:**

  In the topic, "Organization of Sandia's Pressure Safety Program, Managers," a new requirement for managers to be responsible for ensuring that "each identified pressure system is represented by a responsible individual (e.g., Pressure Advisor, Pressure Installer or Pressure Operator)."

- **Change:**
  - In the topic, "Organization of Sandia's Pressure Safety Program," emphasize that use of the qualification forms (Pressure Advisor, Pressure Installer, and Pressure Operator) is optional by noting the forms in "notes."
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Advisors," state that responsibilities are "based on the types of system applications they are assigned to oversee."
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Advisors," change statement numbers to bullets.
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Advisors," clarify that the second group of numbered statements are "qualifications for PAs."
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Advisors," clarify the wording of the qualifications.
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Operators," that designation is based on the needs of the job task and a Job Task Analysis form is no

longer needed.

- **Delete:**
  - In the topic, "Organization of Sandia's Pressure Safety Program, Managers," Statement 1, "the PA is cognizant of, and has a list of, all pressure systems in the assigned area of responsibility."
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Advisors, Statement 2" the entire statement, "maintaining an up-to-date list of the type and location of all pressure systems in the PA's area of responsibility. The PA is required to audit these systems annually, together with the manager, to assure the proper adherence to the PSM, guard against hazardous installations, and update the pressure system list. (See SF 2001-CPA, audit checklist [Word file/Acrobat file].)"
  - In the topic, "Organization of Sandia's Pressure Safety Program, Pressure Advisors," in the statement previously numbered 3, the responsibility to "enter initials in the 'special approvals' box of Purchase Requisitions for pressure hardware."
  - In the topic, "Pressure Safety Training Program, Training Requirements," the footnotes that include a reference to the deleted course PRS102 and to events whose implementation dates have passed.

Chapter 5, "Selecting and Assembling Pressure Hardware"

- **Add:**
  - To the topic, "Suppliers and Their Products," a paragraph, "Non-JIT Purchases," that requires Pressure Installers to ensure that that non-JIT purchases for vacuum and pressure hardware meet the requirements of Chapter 4 and to be aware of the information in CPR500.2.1, *Quality Significant Procurement*.
- **Change:**
  - In the topic, "Suppliers and Their Products," the content of the guidance in paragraph, "Just-In-Time Procurement."
- **Delete:**
  - From the topic, "Suppliers and Their Products," paragraphs, "Manufacturer's Claims," "Levels of Quality Control," "Quality Requirements," and "Other Hardware."

Chapter 8, "Servicing Pressure Vessels and Components"

- **Change:**

- In the topic, "Maintenance of Components, Guidance" that Table 8-2 is a "Summary of Relief Valves by System Use, Inspection and **Recommended** Testing Intervals, and Responsible Organizations," to agree with the content.

Chapter 9, "Documenting the Operational Safety of Pressure Systems"

- **Change:**
  - In the topic, "Data Package, Requirements" move the conditions under which managers shall not require that a Data Package be created to the end of the topic.
  - In the topic, "Pressure Safety Analysis Report (PSAR)," expand the content of the introductory "note."
- **Delete:**
  - From the topic, "Data Package, Requirements" the requirement that the Data Package managers approve "reflects the categories of components used for R&D, laboratory-type systems that undergo many modifications and changes."
  - From the topic, "Pressure Safety Analysis Report (PSAR), Guidance " the "note" and the last bullet.

Administrative Changes Only
May 30, 2003

Chapter 2, "The Pressure Safety Program" was revised to:

- **Add:**
  - Under the topic, "Pressure Installer," a note that the Pressure Installers act as the lead point of contact for issues related to the pressure system.

Administrative Changes Only
May 12, 2003

Chapter 2, "The Pressure Safety Program" was revised to:

- **Add:**
  - Under the topic, "Training," a note that personnel who have completed PRS102 are strongly encouraged to take PRS150.

- **Delete:**
    - Under the topic, "Training," the note that addresses Members of the Workforce who took PRS102 prior to 4/01/1999 and the need to complete PRS115.

September 5, 2002

This document was reformatted to clearly distinguish “requirements” from “guidance” and to indicate who is responsible for what activities. In addition to the reformat, the following substantive changes were made.

Chapter 2, "The Pressure Safety Program"

This chapter was revised to:

- **Add:**
    - In the Section, “Organization of SNL's Pressure Safety Program,” add course PRS250, “Advanced Pressure Safety” for pressure advisors and pressure installers.
    - In the Section “ Pressure Safety Training Program, Training Requirements,” add course PRS250, “Advanced Pressure Safety” to the appropriate “Role or Work Activity.”
    - To the footnotes for the training information table in the Section “ Pressure Safety Training Program, Training Requirements,” the requirement for pressure installers and pressure advisors to complete PRS250 by September 1, 2003.
- **Change:**
    - In the Section, “Organization of SNL's Pressure Safety Program,” replace course PRS102 with course PRS150 (title remains “Basic Pressure Safety”) for pressure advisor, pressure installer, and pressure system operators.
    - In the Section “Organization of SNL’s Pressure Safety Program, Pressure Installers,” change “Have one year of experience with pressure systems” to “Qualification to be determined by the line manager with concurrence of the Pressure Safety Program owner.”
    - In the Section “ Pressure Safety Training Program, Training Requirements,” the replace all occurrences of course PRS102 with PRS150.
    - In the Section “Pressure Safety Training Program, Training Requirements,” move the table from the Section “Pressure System Personnel,” and delete all columns except “Role or Work Activity” and “Required” training

- **Delete:**
  - From the Section “Organization of Sandia's Pressure Safety Program, Introduction,” the section on “Pressure Safety Personnel,” and move the table from this section the Section “Pressure Safety Training Program, Training Requirements.”
  - In the Section “Pressure Safety Training Program, Training Requirements,” all course descriptions and link from the table to the TEDS course descriptions.

Chapter 3, "Pressure Safety Practices"

This chapter was revised to:

- **Change:**
  - In Section “Selecting the Factor of Safety, Requirements,” lower the minimum safety factor from 4.0 to 3.5.
  - Following the Section “Designing and Selecting Pressure Vessels,” incorporate the following topics from the deleted Chapter 6, “Considerations for Secondary Containment and Protective Shields”:
    - Types of Protective Measures
    - When To Use Shields
    - Examples of When to Use Shields
    - Design Consideration

Chapter 4, "Procuring Pressure Vessels and Special System Components"

In Section “Standard Checklist, Requirements,” in 2.0, change the factor of safety from 4.0 to 3.5.

Chapter 5, "Selecting and Assembling Pressure Hardware"

In Section “Design Criterion, Requirements,” in “Caution,” change the safety factor from 4.0 to 3.5.

Chapter 6 (previous), "Considerations for Secondary Containment and Protective Shields"

This chapter was deleted and information was incorporated into Chapter 3, “Pressure Safety Practices.”

Chapter 6 (formerly Chapter 7), "Testing and Evaluating Pressure Systems"

In Section “Test Pressures, Requirements,” change the factor of safety from 4.0 to 3.5.

Chapter 9 (formerly Chapter 10), "Documenting the Operational Safety of Pressure Systems"

In Section “Pressure Safety Analysis Report (PSAR), Requirements,” change the factor of safety from 4.0 to 3.5.

Glossary

- **Add** the following terms to the Pressure Safety Manual, Glossary:
  - Capacity
  - Pressure system personnel
  - Rupture disc
  - Vacuum
  - Vacuum system personnel
- **Change:**

  Moved the following definitions from Appendix J to the *Pressure Safety Manual*, Glossary:
  - Relief valve
  - Safety relief valve
  - Safety valve
  - Set pressure

Administrative Changes Only
October 31, 2001

Appendix F - Pressure Safety Assistance Index

Appendix F was revised to:

- **Update:**

- The SNL Pressure Safety Committee Roster.

Administrative Changes Only
August 7, 2001

Appendix F - Pressure Safety Assistance Index

Appendix F was revised to:

- **Update:**
  - The list of California Safety Personnel contacts and to link each contact name.

Administrative Changes Only
July 9, 2001

Appendix F - Pressure Safety Assistance Index

Appendix F was revised to:

- **Update:**
  - The list of pressure safety assistance contacts and to make each contact name "linkable."

Administrative Changes Only
December 6, 1999

Appendix F - Pressure Safety Assistance Index

Appendix F was revised to:

- **Update:**
  - The list of pressure safety assistance contacts and to make each contact name "linkable."

Administrative Changes Only
April 28, 1999

Appendix F - Pressure Safety Assistance Index

Appendix F was revised to:

- **Update:**
  - The list of pressure safety assistance contacts.

April 13, 1999

Chapter 2, "The Pressure Safety Program"

This chapter has been revised to:

- **Add**:
  - The new course PRS115, Cryogen Safety

Chapter 5, "Selecting and Assembling Pressure Hardware"

This chapter has been revised to:

- **Add**:
  - The new course PRS115, Cryogen Safety.
  - A pointer to the new document GN470100, *Safe Handling of Cryogenic Fluids*.

November 2, 1998

Chapter 5, "Selecting and Assembling Pressure Hardware"

This chapter has been changed to:

- **Add**:
  - "Markings" with information about the JIT gas cylinder supplier applying a bar code that will meet the requirements of the SNL Chemical Inventory System to each gas cylinder and SNL personnel actions with respect to the barcode.

- **Update**:
  - "Safe Handling" to replace the last three bullets with two bullets that clarify what is to be done with empty cylinders and the use of barcodes.

Chapter 9, "Servicing Pressure Vessels and Components"

This chapter has been changed to:

- **Update**:
  - "Building Pressure Systems" to delete the use of a distinctive yellow tag for identifying facilities inspected systems and include a more comprehensive list of compressed air systems and cryogenic liquid or gaseous systems.
  - "Maintenance and Inspection" to expand the list of facilities organization responsibilities to include designing, modifying, inspecting, and maintaining cryogenic systems.

September 16, 1997

Appendix F, "Pressure Safety Assistance Index"

Appendix F was revised to:

- **Update:**
  - The list of pressure safety assistance contacts.

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Pressure Safety Manual

LIST OF EFFECTIVE SECTIONS

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
Revision Date: September 29, 2006; Replaces Document Dated: June 6, 2006
Administrative Changes: October 16, 2006, November 20, 2006, April 2, 2007, April 19, 2007, and May 17, 2007

* Indicates a substantive change

Title	Issue	Date
List of Effective Sections	N	Sep. 29, 2006
1. Introduction	N	Sep. 29, 2006
*2. The Pressure Safety Program	N	Sep. 29, 2006
3. Pressure Safety Practices	N	Sep. 29, 2006
4. Procuring Vessels and System Components	N	Sep. 29, 2006
5. Selecting and Assembling Pressure Hardware	N	Sep. 29, 2006
6. Testing and Evaluating Pressure Systems	N	Sep. 29, 2006
7. Verifying the Safe Operation of Pressure Systems	N	Sep. 29, 2006
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9. Documenting the Operational Safety of Pressure Systems	N	Sep. 29, 2006
Appendix A - Pressure System Checklist for Pressure Advisors	N	Sep. 29, 2006
Appendix B - Calculations	N	Sep. 29, 2006
Appendix C - Piping and Tubing Notes	N	Sep. 29, 2006
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Corporate Process Requirement No: CPR400.1.1.27
Sponsor: Dori Ellis, 4000, Acting

Revision Date: September 29, 2006
Replaces Document Dated: June 6, 2006

Pressure Safety Manual

1. INTRODUCTION

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
Revision Date: September 29, 2006; Replaces Document Dated: June 6, 2006
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* Indicates a substantive change

APPLICABILITY

For purposes of this document, Members of the Workforce are:

- Sandia employees.
- Sandia contractors as specified in CPR400.1.1/MN471001, Section 1B, "What Is the Scope."

PURPOSE OF THE PRESSURE SAFETY PROGRAM

The Pressure Safety Program at Sandia National Laboratories (SNL) is designed to assure safe pressure systems environments.

OBJECTIVES

The Pressure Safety Program is implemented to meet several overarching objectives, including:

- Provide requirements and guidance for Members of the Workforce who are involved with pressure systems.
- Ensure that the Pressure Safety Program conforms to pressure safety practices of the American Society of Mechanical Engineers (ASME), Section VIII of the *Code for Design and Construction of Unfired Pressure Vessels*. Pressure vessels and/or systems that do not conform to ASME code must be proven to provide equivalent safety through adherence to other widely accepted standards. Examples of these standards are included in the section "Requirements Source Documents" (at the end of this chapter). Some pressure systems and/or components are not directly addressed by a particular code. In these cases, the criteria for design and operation of pressure vessels as contained in the *Pressure Safety Manual* (PSM) must be followed.

  Note: SNL is required to meet local, state, and federal codes and standards for safety and industrial hygiene. It is the intent of the Pressure Safety Program to meet applicable codes or standards. When doubt exists as to the applicability of certain requirements or procedures, or questions of interpretation arise, further investigation and analysis may be necessary and should be undertaken. In such cases, the following actions should be considered:

- Obtain counsel from appropriate pressure safety consultants.
- Seek assistance and guidance from the appropriate Environmental Safety & Health organization.
- When interpretation of the governing directives is at issue, seek guidance from the Pressure Safety Committee (PSC).

- Ensure that the following design and operating criteria are considered and decisions are documented prior to the operation of any pressure system:
  - Materials are appropriate to the application.
  - Manufacturing processes and product quality are adequately controlled.
  - There is adequate testing to verify the integrity of pressure vessels.
  - Appropriate pressure system design criteria are followed, such as adequate margins between operating and rupture pressures.
  - Measures are established (or in place) to protect the system from overpressurization during normal operation.

RESPONSIBILITIES

The Pressure Safety Committee (PSC) is the authority having jurisdiction for administering the Pressure Safety Program.

Organization managers are responsible for:

- Implementing the Pressure Safety Program, including periodic inspections of their pressure systems.
- Seeking and using the advice and help of the principal people and organizations with knowledge about pressure safety. These groups are listed in Chapter 2, “The Pressure Safety Program.”

PRESSURE SAFETY MANUAL (PSM)

The PSM is the Pressure Safety Program implementing document, and is based on extensive experience with pressure activities at SNL, as well as on existing codes, standards, recommended practices, manuals, and guides that are applicable to the types of operations and hardware configurations at SNL. The PSM:

- Defines the Pressure Safety Program used at SNL.
- Disseminates policies, guidance, and requirements that are endorsed by the Pressure Safety Committee to govern pressure operations.
- Provides guidance to Members of the Workforce who work with pressure systems.

Changes or additions to the PSM are reviewed and implemented by the Pressure Safety Committee (PSC). Suggestions for revisions may be made directly to a PSC member or through your Pressure Advisor.

PSM updates will be provided to:

- Disseminate new information or requirements from codes and standards.
- Communicate policies and procedures.
- Continually upgrade the quality and content of the guidance provided in the manual.

SPECIAL CONSIDERATIONS

The following systems involve special considerations that are not covered by this manual:

- Use of fired pressure vessels (e.g., boilers).
- Systems involving explosive or chemical reactions.

- Systems intentionally exposed to fires or extreme temperatures.
- Intentional destructive tests.

REQUIREMENTS SOURCE DOCUMENTS

In addition to the American Society of Mechanical Engineers (ASME), Section VIII of the *Code for Design and Construction of Unfired Pressure Vessels*, the following codes and references are applicable to assure the safe design and operation of pressure systems:

- American Society of Mechanical Engineers (ASME), B31.1 and B31.3 that provide the code for pressure piping design.
- American Petroleum Institute (API). Drum type containers.
- *California Code of Regulations, Title 8 (California OSHA).*
- Compressed Gas Association publications.
- DG 10210, *(Sandia) Reservoir Design and Certification Development Reservoirs for Nuclear Weapons.*
- *DOE Pressure Safety Guidelines*, M-089.
- *National Fire Protection Association (NFPA)*.
- OSHA, Title 29 CFR.
- SAND90-8220, *Pinto Criteria - Production of Gas Transfer System for Nuclear Weapons.*
- Title DOT 49 CFR (Code of Federal Regulations). This contains design rules relating to pressure vessels shipped in interstate commerce.

See Appendix F for sources for obtaining copies of these codes.

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Corporate Process Requirement No: CPR400.1.1.27
Sponsor: Dori Ellis, 4000, Acting

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Pressure Safety Manual

2. THE PRESSURE SAFETY PROGRAM

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
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* Indicates a substantive change

ELEMENTS OF THE PRESSURE SAFETY PROGRAM

Introduction

The Pressure Safety Program consists of five elements:

1. Providing required pressure safety **policies and procedures** through CPR400.1.1.27, *Pressure Safety Manual* (PSM)

2. Providing knowledgeable people as members of the Pressure Safety Committee (PSC) and designating consultants to furnish advice and assistance in pressure safety

3. Developing individual knowledge of a safe pressure environment at Sandia through **personnel who are trained and qualified**

4. Providing for the **documentation and accountability for each pressure vessel and system**

5. Providing for the **control of the selection and the use of pressure hardware**.

Policies and Procedures

The PSM states the policies and procedures established by the PSC as part of the SNL Pressure Safety Program. The PSM is a supplemental manual to CPR400.1.1, *ES&H Manual*.

Advice and Assistance

The PSC provides oversight at SNL for the safety of pressure systems and has the responsibility for administering the Pressure Safety Program. The PSC:

- Establishes pressure safety requirements.
- Addresses unusual problems and occurrences.
- Provides advice and assistance in pressure safety. Other people and organizations are available to consult about pressure safety requirements and issues. Appendix F contains a pressure safety assistance index arranged alphabetically by subject.

Pressure Safety Program support organizations are further discussed later in this chapter.

Individual Knowledge

The manager provides oversight for the implementation requirements of the PSM and ensures that all Members of the Workforce (MOWs) who work with pressure systems develop an individual awareness of pressure hazards. The following measures are taken to promote this awareness.

- MOWs are responsible for implementing appropriate safeguards to require safe performance of pressure systems.
- Managers must consider the training and experience of MOWs, the complexity of tasks to be performed and equipment to be used, and whether the task is routine or unusual.
- Training is provided for personnel who design, fabricate, install, operate, or maintain pressure systems.
- At least one Pressure Advisor (PA) is assigned to each center that deals with

pressure systems.

Adequate PA coverage and involvement in their areas of responsibility enhance individual awareness.

- Qualification of various levels of pressure users is based on required training, knowledge, assignments, and experience.

Documentation and Accountability

Accountability for pressure safety is provided through the following requirements:

- The design meets the requirements of the appropriate standards (see Ch. 4).

  Pressure systems have proper documentation (see Ch. 7 and Ch. 9).

- Procedures for safe operations will be documented in technical work documents (TWDs) (see Ch. 7).

- Periodic assessments will be conducted by line organizations, ES&H organizations, and self-assessment groups.

Hardware Control

The selection and use of pressure hardware is controlled by the following:

- Oversight of the just-in-time suppliers of pressure hardware and industrial and specialty gases by the purchasing contracting representative and the SNL Pressure Safety Committee.

- Guidance for and review of purchases of pressure equipment by each organization's assigned PA.

- Periodic site visits to commercial vendor facilities.

- Review of the JIT contracts for types and quality of pressure hardware.

ORGANIZATION OF SANDIA'S PRESSURE SAFETY PROGRAM

Introduction

The following individuals and groups are key elements of the Pressure Safety Program at SNL:

- Managers
- Pressure Advisors
- Pressure Installers
- Pressure Operators
- Hardware procurement support organizations
- Pressure Safety Committee (PSC)
- Self-appraisal groups
- ES&H Organizations
- Technical Consulting groups

Figure 2-1 is a flowchart showing the organization of the SNL Pressure Safety Program. This section discusses the membership and major responsibilities of the groups listed.

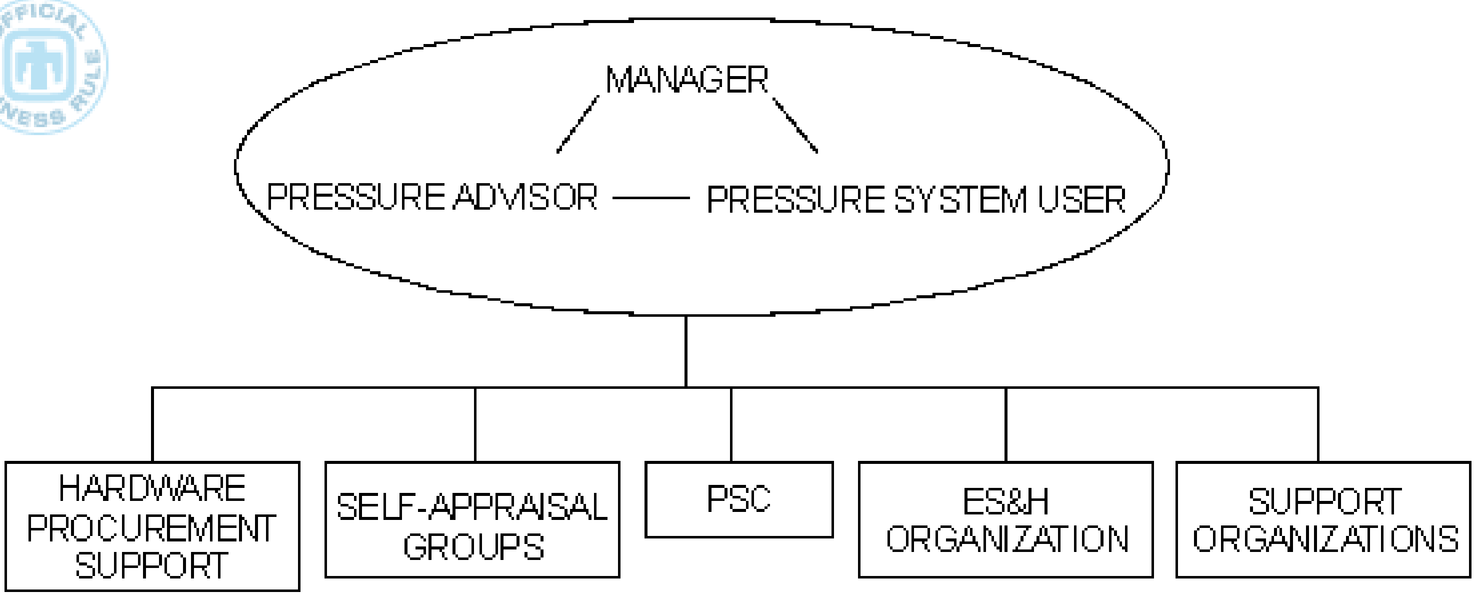

Figure 2-1. Organization of SANDIA's Pressure Safety Program

Managers

Managers have the primary responsibility and accountability for controlling work activities to ensure that pressure safety requirements are met, including ensuring that:

1. Each identified pressure system is represented by a responsible individual (e.g., Pressure Advisor, Pressure Installer, or Pressure Operator).
2. All pressure systems comply with the PSM.
3. Oversight is provided through periodic pressure system reevaluations (see Ch. 8 and Annual Pressure System Assessment Checklist for Pressure Advisors [Word file/Acrobat file]) and safety meetings. These serve as reminders for pressure safety.
4. Equipment operators and maintenance personnel in the organization are properly trained and qualified (see Ch. 2 and Appendix A).
5. Copies of all pressure system documentation are maintained by the organization traceable to the applicable pressure system (see Ch. 7 and Ch. 9).
6. Pressure equipment in the organization is properly maintained (see Ch. 8).
7. Safety relief valves within the organization are monitored for proper inspection,

operational checks, testing and replacement intervals (see Ch. 8 for required intervals).

These requirements and intervals should be incorporated into the line organization's pressure system documentation (see Ch. 7 and Ch. 9).

Pressure Advisors

Pressure Advisors are the first point of contact for questions or guidance regarding any aspect of pressure system safety (e.g., configuration, ratings, procurement, and documentation). Every research and development or service organization working with pressure systems should have its own PA. Facilities engineering also appoints one or more PAs. As a minimum, each center that deals with pressure systems must have at least one PA.

PAs are responsible for (based on the types of system applications they are assigned to oversee):

- **Developing and maintaining knowledge of:**
  - Pressure systems - proper assembly and setup
  - Typical pressure safety hazards
  - Standard practices as set forth in the Sandia PSM
  - Basic pressure system design.
- **Providing guidance** in the purchase of pressure equipment.
- **Reviewing** new pressure systems; review PSARs and ES&H Technical Work Documents (TWDs) dealing with pressure systems.
- **Assisting** in conducting pressure system reviews.
- **Consulting** with end user and serving as **liaison** between the end user and the PSC, Safety Engineering, or any other expert consultant (e.g., nondestructive testing, materials, stress analysis).

- **Maintaining visibility**: Make themselves known to the personnel in their area of responsibility as a reminder for the personnel to use their services. Participate in organization safety meetings.
- **Validating that the documentation requirements of the PSM are met**: Make sure that all of the proper documentation exists (e.g., Data Packages, and PSARs when required), that it contains the appropriate data and is current.
- **Advising** on pressure-related issues.
- **Serving as conscience**: Create an awareness of the intent of the Pressure Safety Program. Recognize and eliminate unsafe practices.

*Qualifications for PAs include:

1. Recommendation by the Senior Manager. (See Pressure Advisor Designation Form [Word file/Acrobat file], SF 2001-PAD.)
2. Prior experience with pressure systems.

   Note: Managers validate that qualified personnel are designated to the job task. Pressure Advisor Qualification Form (Word file/Acrobat file) is supplied for the convenience of the Manager for validation. A copy should be maintained by the organization.
3. Having completed the following classroom training courses:
   - PRS150, Pressure Safety Orientation
   - PRS160, Pressure Advisor Training
   - PRS250, Advanced Pressure Safety
   - PRS115, Cryogen Safety (if applicable)
   - Commercial Hardware Training, or equivalent

Pressure Installers

Note: Pressure installers (PIs) act as the lead point of contact for issues related to the pressure system.

Pressure installers (PIs) are responsible for:

- Installing and modifying pressure systems without supervision.
- Procuring pressure hardware.

  Supervising activities of non-PIs performing installation and modification tasks.
- Performing maintenance and other non-routine tasks to the pressure system.

Qualifications for PIs include:

1. Be designated by their manager based on job tasks.
2. Qualification to be determined by the line manager with concurrence of the Pressure Safety Program owner.
3. Complete the following classroom training courses:
   - PRS150, Pressure Safety Orientation
   - PRS250, Advanced Pressure Safety
   - PRS115, Cryogen Safety (if applicable)
   - Commercial Hardware Training, or equivalent
4. Complete local and on-the-job training as specified by the organization.

Note: Managers validate that qualified personnel are designated to the job task. Pressure Installer Qualification Form (SF 2001-PIQ [Word file/Acrobat file]) is supplied for the convenience of the Manager for validation. A copy should be maintained by the organization.

Pressure Operators

Pressure operators use or operate pressure systems in a repetitive, routine manner. Pressure operators do not modify or install pressure hardware, with the exception of changing out pressure cylinders and regulators.

Pressure operators are responsible for:

- Being aware of the hazards of pressure systems.
- Operating the system safely and within its designed operating parameters.
- Seeking advice from PA on questions of compliance and safety.
- Verifying that the pressure system has been assembled to the satisfaction of a PI.
- Verifying that the pressure safety requirements regarding operation and documentation for the system(s) have been met.

Qualifications for pressure operators include:

1. Be designated by their manager based on a job task.
2. Complete the following classroom training courses:
    - PRS150, Pressure Safety Orientation
    - PRS115, Cryogen Safety (if applicable)v
3. Complete local and on-the-job training as specified by the organization.

Note: Managers validate that qualified personnel are designated to the job task. Pressure System Operator Qualification Form (SF 2001-PQF [Word file/Acrobat file]) is supplied for the convenience of the Manager for validation. A copy should be maintained by the organization.

PRESSURE SAFETY PROGRAM SUPPORT ORGANIZATIONS

This section lists the consulting organizations that support the Pressure Safety Program. In addition to this list, specific names and phone numbers of consultants are listed in Appendix F, “Pressure Safety Assistance Index”.

Pressure Safety Committee

The Pressure Safety Committee (PSC) formulates pressure safety requirements and administers the pressure safety program.

Note: The PSC is governed by a charter approved by the ES&H & Emergency Management Center 10300 Director.

Committee membership includes:

- A Chairman who is appointed by the Director, Integrated Safety and Security Center.
- A Secretary who is appointed by the PSC Chairman.
- A representative from each division that is knowledgeable in applicable pressure safety disciplines.
- Additional members appointed by the Chairman to assure that the committee has at least one expert in each of the following disciplines:
  - Applied Mechanics
  - Materials
  - Safety Engineering
  - Facilities Engineering
  - Other disciplines as deemed appropriate by the Chairman.

The PSC is responsible for:

- Establishing and documenting pressure safety requirements in the *Pressure Safety Manual* (MN 471000) and *Safe Handling of Cryogenic Fluids* (GN 470100).

- Regularly reviewing and, when necessary, revising these documents.
- Assisting SNL organizations by interpreting the pressure safety requirements of DOE orders, criteria, guides, and other codes, standards, and practices.
- Reviewing the adequacy and availability of SNL pressure testing capabilities.
- Developing, reviewing, approving, and mandating pressure safety awareness training.
- Periodically monitoring the effectiveness of the Pressure Safety Program and establishing criteria to assess the effectiveness of the Pressure Safety Program and its implementation by SNL organizations.
- Communicating pressure-related safety issues and concerns to affected Members of the Workforce and management. v
- Staying aware of relevant industry standard codes, standards, hardware, and procedures related to pressure safety issues.
- Maintaining communication with the DOE Pressure Safety Committee and implementing its initiatives.
- Interfacing with the Purchasing Department on matters applicable to pressure safety, including, but not restricted to, JIT contracts.
- Advising management on resources needed to develop and maintain a viable Pressure Safety Program.
- Publishing pressure safety bulletins.
- Maintaining a Pressure Safety web page on the Sandia Internal Restricted Network.

Safety Engineering Department (10322)

Department 10322 pressure safety personnel are responsible for:

1. Interpreting laws, codes, standards, and regulations that apply to pressure safety

and provide updates to the PSM as necessary.

2. Providing consultation on pressure safety issues.

Support Organizations

Other support functions include, but are not limited to:

1. Materials Mechanics.
2. Materials Application Engineering.
3. Nondestructive Evaluation (NDE).
4. Solid Mechanics Engineering.
5. Design Definition (Pressure Drawing Review).
6. Welding.
7. Facilities Engineering.
8. Component Development.
9. Purchasing.
10. Training.
11. Quality.

Hardware Procurement Support Organizations

Hardware procurement support in the purchasing of pressure hardware can come from:

- Safety Engineering Department (10322) and Health & Safety Department (8517).
- Quality assurance functions.
- Buyers supporting Center purchasing operations.

- Feedback from users and PAs.

Responsibilities of the support organizations are to provide:

- Supplier qualification.
- Pressure hardware (including JIT) procurement.
- Investigation of pressure hardware quality and support issues as needed.

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*PRESSURE SAFETY TRAINING PROGRAM

*Training Requirements

Managers shall verify that individuals responsible for developing and conducting job-specific pressure systems training and pressure safety training have the appropriate education, training, and skills to discharge this responsibility. See CPR400.1.1/ MN471001, *ES&H Manual*, Chapter 11, “ES&H Training” for instructor qualification requirements.

Training requirements for pressure system personnel are listed in Table 2-1 and on the qualification forms SF 2001-PAQ [Word file/Acrobat file], SF 2001-PQF [Word file/ Acrobat file], and SF 2001-PIQ [Word file/Acrobat file]. All personnel involved with pressure systems are required to take the course PRS150, Pressure Safety Orientation. Those designated to perform the duties of PI shall also receive instruction on the particular type of hardware being used by the organization, either from a commercial vendor or as on-the-job training within the organization. New personnel shall demonstrate the skills and abilities necessary to perform the duties of a PI, while under direct supervision of an Installer, prior to meeting the qualification requirements.

Table 2-1. Training for Pressure System Personnel

Role or Work Activity	Required
Operator - System Operation	PRS150 PRS115

<table>
<tr><td>Installer - Assembly or modification of hardware</td><td>PRS150
PRS250
Commercial Hardware
PRS115</td></tr>
<tr><td>Advisor - Consultation & Audit</td><td>PRS150
PRS160
PRS250
Commercial Hardware, if necessary</td></tr>
<tr><td colspan="2">PRS150 and PRS115:

• If activities involve pressure only, no cryogenic fluids: PRS150.
• If activities involve cryogenic fluids only, no pressure: PRS115.
• If activities involve cryogenic fluids and pressure: PRS150 and PRS115.

Contact the Technical and Compliance Training Department (3521) in New Mexico and Department 8522 in California for information regarding classes.</td></tr>
</table>

Commercial Hardware Training

The Just-in-Time vendor provides a basic hardware-specific safety seminar for the types of fittings provided. Organizations using other types of hardware must provide for vendor-assisted training or on-the-job training.

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Forward to Next Section

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Sponsor: Dori Ellis, 4000, Acting

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Pressure Safety Manual

3. PRESSURE SAFETY PRACTICES

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
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* Indicates a substantive change

OVERVIEW

Objectives

The objectives of good pressure system design are to:

- Operate safely, which is Sandia's **primary** goal
- Attain the intended system objectives.

Policy

A pressurized operation is justified in manned areas at SNL **only** if the system is demonstrated to be safe.

Unmanned operation is mandatory if safety cannot be demonstrated. Even for unmanned operation, the responsible line manager must assess the consequences of damage to facilities and equipment.

The Pressure Safety Committee (PSC) will make determinations of interpretation or adequacy should any doubt exist that the intent of this Program has been met.

MINIMIZING RISKS AND EXPOSURE

Introduction

This section contains a partial list of techniques used to minimize risk and exposure to the hazards of pressure systems.

Minimizing Risks and Exposure to Pressure Hazards

Requirements

Members of the Workforce shall use one or more of the following measures to minimize risks and exposure to pressure system hazards:

- **Identify all hazards and consequences.** Methodically identify all hazards. (Perform a Preliminary Hazard Assessment.) Consider especially how failure may occur, and the possible consequences.

- **Go "remote."** The safest locations for pressure systems are remote from people. Consider these factors:

  - How often are people near pressure systems?

  - How long do people remain near pressure systems?

  - What is the potential for much greater system damage at high pressure?

- **Minimize pressure and total volume.** Stored energy available for release in case of sudden rupture of a pressure vessel is proportional to total volume, pressure and compressibility of the fluid. Examine carefully all alternatives to placing high-energy systems in densely populated, high-dollar-value areas.

  CAUTION **Caution:** Do **not** use volume or pressure greater than required.

- **Use recognized standards.** Standards are available for design of a system that derives from analytical procedures and experience. (See the Bibliography)

- **Design conservatively.** When in doubt, use conservative judgment.

  CAUTION **Caution:** Do **not** rely too heavily on what you think is an "inherent" safety factor. Sometimes the supposed factor is not present.

- **Use material with a predictably safe failure mode.** "Brittle" materials sometimes fail unpredictably. For such materials it may be pointless to increase the factor of safety.

  CAUTION **Caution:** In manned areas never use a brittle material for a pressure system unless the system is properly shielded.

- **Demonstrate structural integrity by overpressure test.** Place pressure vessels in service only after they pass appropriate overpressure tests. Conduct the overpressure tests at a level exceeding the Maximum Allowable Working Pressure (MAWP) as shown in Figure 3-1.

- **Operate within the original design intent.** Do **not** exceed MAWP. Do **not** change working fluids or service environments without taking into consideration possible harmful effects.

- **Provide backup protection.** When required, install suitable pressure relief devices at appropriate locations in pressure systems to assure that the pressure level will stay within predetermined safe limits in spite of possible equipment malfunctions or operational errors.

  Note: Redundancy in relief devices is recommended for the more hazardous systems.

- **Use proven hardware.** The lack of information about the manufacturer's design, test, fabrication, and quality control procedures often makes obtaining reliable hardware the most difficult requirement.

  The Just-in-Time (JIT) contract imposes quality program requirements on pressure hardware suppliers for Sandia. Appendix H lists manufacturers who, through experience and reputation, provide pressure hardware of proven quality. If the quality of any pressure hardware received is questionable, perform a thorough inspection and evaluation as necessary.

- **Use protective shields.** Secondary containment structures, barricades and/or shielding are required in these circumstances:
  - Material has an unpredictable failure mode
  - Quality of critical hardware is unknown
  - All conventional criteria have not been met.

    Example: Too low a factor of safety
- **Use tiedowns.** Tying down tubes, hoses, and piping at frequent intervals can prevent serious injury. Flexible lines that fail under pressure oftentimes will thrash about unless restrained.

The Hazard of Liquids Under Pressure

Requirements

Members of the Workforce shall be alert to the sudden development of leaks. Even a small leak of a liquid under pressure can spew jets of the liquid at high velocities with penetrating force.

KEY RELATIONSHIPS IN PROPERLY DESIGNING A PRESSURE SYSTEM

Guidance

Members of the Workforce should review Figure 3-1 for the key relationships in the proper design of a pressure system.

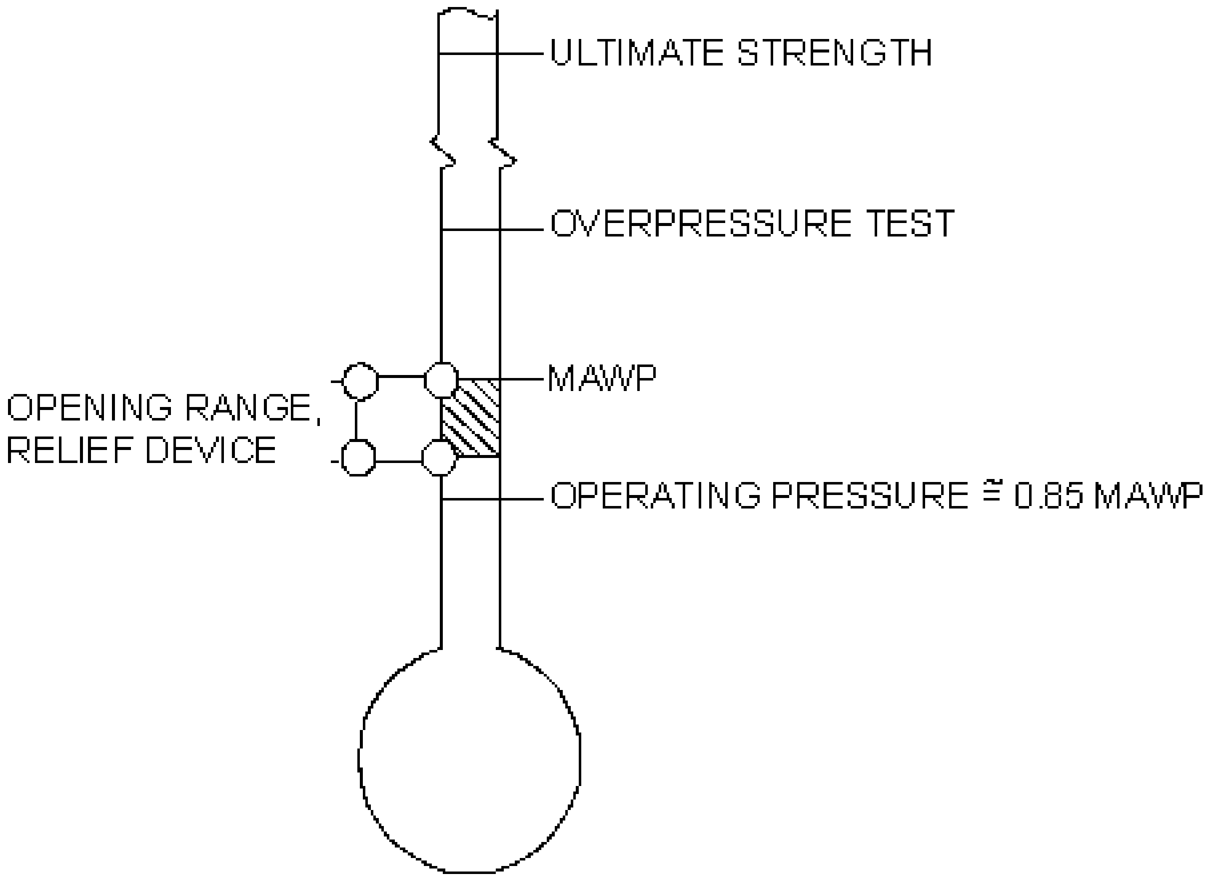

Figure 3-1. Key Relationships

List of Key Factors

Requirements

Members of the Workforce shall ensure that the following key factors are included in the design of a pressure system.

- **Relief Devices.** When a pressure relief device is required, it should **not** actuate at operating pressure. The setting of the relief device must **not** exceed the MAWP of the protected component. (See Chapter 8 for periodic inspection and test requirements.)
- **Operating Pressure.** The MAWP becomes the design pressure for the system. The highest operating pressure is usually equal to 0.85 MAWP.
- **Overpressure Test.** Overpressure-test the vessel before placing it into service. Overpressure-test should be 1.3 x MAWP (based on design factor of safety as indicated below)

SELECTING THE FACTOR OF SAFETY

Requirements

Managers shall ensure that pressure systems have the following:

- A minimum factor of safety of **3.5**, based on maximum principal stress and ultimate material strength, is required for ASME Section VIII, Division 1 type vessels. Vessels or components which **do not fall within the jurisdiction** of the ASME or other Codes (ANSI, API, etc.), **because of shape, size, operational characteristics, etc.,** must be analyzed to the extent necessary to show that, by design, the vessel or component meets or exceeds the minimum Code standards prior to use in a manned area.

- An adequate factor of safety must exist and be documented for pressure components to be used in a manned area. Examples of components which do not normally have a factor of safety of 3.5 **but which fall under the jurisdiction of other standards, and are therefore acceptable,** are:
  - Department of Transportation (DOT) cylinders (see Title DOT 49 CFR)
  - Weapon systems (see SAND90-8220, *Pinto Criteria*, or DG 10210 *Reservoir Design and Certification*).

Note: Some systems or components may not have a factor of safety of 3.5 because their designed operational parameters place them beyond the scope of the existing Codes:

- Optimum design sophistication and material/processes selection combined with quantitative nondestructive evaluation (NDE) requirements, **or** extensive service experience and testing, are necessary before justifying less than a factor of safety of **3.5**.

  Note: Shielding of components and/or operators may be appropriate in these instances, and is required when any doubt exists as to the adequacy of the design safety margin.

- A PSAR. (See Ch. 9.) is required for all systems and/or components that have a factor of safety of less than **3.5** and do not fall under the jurisdiction of accepted codes or standards.

SELECTING PROPER MATERIALS AND FABRICATION PROCESSES

Note: Pressure vessel design criteria, including the *ASME Code*, may not properly address toughness and defect considerations. Some pressure vessel failures are directly attributable to this oversight. It is, of course, very important to also satisfy material strength and chemical compatibility requirements.

Responsibility

Requirements

Managers who are responsible for designing pressure systems shall ensure that the Materials Application Engineering and Design Support contact is consulted early in the design process. Together, the line and Materials Organizations can make proper material/process selection to assure predictable system behavior.

Important Factors Most Often Overlooked

Guidance

Members of the Workforce should be aware that:

- The majority of pressure vessel failures can be traced directly to using materials and processes that are not tolerant enough of defects (i.e., they lack toughness). For low-temperature applications, consult the Materials Application Engineering and Design Support contact for the proper material selection.

- Several frequently used pressure vessel steels exhibit a significant decrease in toughness at low temperature. This fact makes the use of these materials questionable. With appropriate specifications, this problem can be eliminated. Many pressure vessel steel specifications have, as a **supplementary callout**, toughness-vs.-temperature requirements.

- Selecting proper materials and fabrication processes according to the *ASME Code* is satisfactory if, and only if, the appropriate toughness-vs.-temperature requirements are specified. (See ASME Code Section VIII, Division 1, Paragraph UCS-68-68.)

CAUTION **Caution: Do not procure a pressure vessel without dealing with the toughness issue.**

CONDUCTING ADEQUATE OVERPRESSURE TESTS

Note: The purpose of the overpressure test and nondestructive evaluation is to assure that the pressure vessel is free from critical defects or critical design flaws. The critical defect size depends on the applied stresses, flaw geometry, and material toughness.

See Chapter 6, “Testing And Evaluating Pressure Systems,” for a complete discussion of overpressure testing.

Requirements

Managers shall verify that an overpressure test has been performed before placing a pressure vessel in service.

DESIGNING AND SELECTING PRESSURE VESSELS

Guidance

Managers may choose one of two design alternatives when obtaining pressure vessels:

- An *ASME Code* design (see SF 2001-CPA, Pressure System Checklist for Pressure Advisors [Word file/Acrobat file])

- A non-Code design.

Once a design is chosen, the user must then choose whether the equipment is to be:

- Bought commercially, **or**

- Fabricated in-house.

CONSIDERATIONS FOR SECONDARY CONTAINMENT AND PROTECTIVE SHIELDS

Note: The text of this section was moved unchanged from the old Chapter 6.

Note: A protective shield is designed as a barrier between a pressurized component and personnel or facilities to protect against the effects of rupture or leakage. In general, pressure systems should be designed, built, and tested to allow use of the system without auxiliary shielding. However, some systems require special shields to ensure a safe working environment.

Requirements

Members of the Workforce shall use protective shields to guard against the hazards of pressure systems:

- Projectiles.

- Overpressure.

- Toxic effects.

- Fire.

- High-energy jets resulting from leakage.

Types of Protective Measures

Guidance

Members of the Workforce should be aware that the most effective protective measure against the hazards of pressure systems is keeping a safe distance between the pressurized component and themselves or facilities that require protection.

In addition to distance, there are three conventional types of protective shields:

1. A rated cell can be designed to:
   - Protect against both penetration and external overpressure.
   - Avoid damage from toxicity.
2. The secondary container, if properly designed and used, is capable of:
   - Containing the explosive force, preventing external damage and escape of toxic materials.
   - Preventing fire.
3. A barricade, which is designed to provide a barrier only against penetration. This is the least effective shield.

When To Use Shields

Requirements

Members of the Workforce shall use protective shields for any situation involving hazards to themselves or facilities where conformance with accepted design criteria is:

- Marginal.
- Impractical.
- Impossible.

Examples of When to Use Shields

Guidance

Examples of when to use shields are:

- The material used in the pressure system is known or suspected to be subject to brittle fracture.
- Factors of safety are less than recommended.
- No proof test has been conducted.
- An item of hardware is questionable.
- The experiment is an intentional burst test.
- The validity of supporting calculations is questionable.
- System complexity or unusual operating circumstances warrant added protection.

Design Consideration

Note: What constitutes a protective shield is a difficult question. For example, a 1/4-in. steel plate around a small glass vacuum bell jar is overdesign. On the other hand, nothing but distance or a specially designed bunker can protect against sudden release of energy levels up to 74 X 106 ft-lb (equivalent to 50 lb of TNT).

Requirements

The responsible manager shall anticipate potential hazards and shall be prepared to deal with them.

Guidance

Managers should consider the following design points:

- **Brittle materials** can pose extreme hazards, depending on factors such as a location near personnel and facilities, energy level, and mode of operation. Protective shields must be adequate to stop fragments and to control overpressure.

- **No brittle materials, but some question of design detail,** raises the concern of how to stop flying fragments or how to protect against hazards, such as whipping lines, component response, and ruptured gage faces. In this case the hazard itself suggests the type of shielding.

- **Hydraulic lines** contain liquids under pressure that can be forced through small orifices such as ruptures, holes, or leaking connections, at velocities great enough to penetrate the human body. Except in extreme cases, lightweight metal structures can provide the required protection.

- **Vacuum vessels.** The failure of a vacuum vessel reduces local pressure below atmospheric pressure and can generate debris.

AVAILABLE CONSULTING SERVICES

Guidance

Many consulting resources are available to aid the designer, including:

- **The organizational PA**, who should be the first point of contact for advice and assistance. Advise the PA early of your plans for new pressure systems.

- **Applied Mechanics groups**, which furnish analysis and design support for new pressure vessels ranging from simple to complex.

- **The Materials Organization**, which assists in selecting materials and fabricating processes for pressure vessels.

- **The NDE group**, which provides nondestructive techniques for evaluating pressure systems.

- **Experimental Mechanics**, conducts proof tests and monitors pressure vessel response.

- **The Tritium Research Laboratory Safety Advisory Committee at Livermore** for approval of experiments to be conducted in the TRL.

- **Safety Engineering**.
- **The Pressure Drawing Review Program Coordinator.**

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Pressure Safety Manual

4. PROCURING PRESSURE VESSELS AND SPECIAL SYSTEM COMPONENTS

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
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* Indicates a substantive change

OVERVIEW

This chapter describes the requirements for the design, fabrication, testing, and documentation of pressure vessels and special components. Special components are one-of-a-kind components for special applications that are not available as stock items from commercial suppliers. These components must meet the same requirements as vessels to assure an adequate margin of safety. The term "vessels" as used in this chapter shall include these special components.

PROCURING PRESSURE VESSELS AND SPECIAL SYSTEM COMPONENTS

Requirements

When procuring pressure vessels and special system components, Members of the Workforce shall ensure that they:

- **Meet or exceed the requirements of this manual.**
- **Have:**
  - An adequate factor of safety.
  - Proper materials and processes.
  - An adequate overpressure test.

Guidance

Members of the Workforce should:

- **Secure approvals at an early stage from representatives of the following functions:**
  - Materials Application Engineering and Design Support contact.
  - Materials Mechanics Department (9123) or the Materials Mechanics Department (8725).
  - PA.
- **Establish early liaison with an SNL buyer to expedite procurement of hardware or services**.
- **Use appropriate portions of the following checklist for procurement of pressure vessels, special system components, and services not available through the Just-in-Time (JIT) contract (see next topic).**

STANDARD CHECKLIST

Requirements

Members of the Workforce shall provide appropriate information from the following checklist to the contractor who needs a minimal package of technical information to provide acceptable pressure vessels, special system components, or services:

1. **Specify and define these operating conditions**:
    - Maximum Allowable Working Pressure (MAWP).
    - Normal operating temperatures, and temperature extremes.
    - Cyclic nature of pressure loading.
    - Presence of hostile environments.
2. **Select the design procedure**.
    - Select an appropriate design, preferably based on the use of Section VIII, Division 1, *ASME Code*, if applicable.
    - Specify an adequate factor of safety as part of the design. (See Ch. 3, Selecting the Factor of Safety, for the process necessary prior to justifying a factor of safety of less than **3.5.)**
3. **Select or specify the materials and processes**.
    - Consult the materials organizations as to the adequacy of the contractor's proposals, and specify the materials and processes to be used.
4. **Specify an overpressure test and include these items**:
    - Test level, which is usually **1.3** X MAWP (see Ch. 6).
    - Holding time at test pressure
    - Temperature during test
    - Instrumentation, measurements, and methodology desired
    - Whether a Sandia representative is needed to witness the test
    - Any special requirements.
5. **Specify all documentation**. This includes supplementary notes and any required certifications for fabrication and procurement that are specified in this chapter.

PROCUREMENT

Methods

Requirements

Members of the Workforce shall procure vessels and special components by one of the following methods:

- Designed and built by SNL.
- Designed by SNL and built by outside contractor or by another DOE agency
- Designed and built for SNL by outside contractor or by another DOE agency
- Bought from a supplier's commercial stock
- Obtained "used" from surplus or previous owner.

Material Toughness

Requirements

Members of the Workforce shall:

- Ensure that custom pressure vessels in the first three categories above are constructed of required materials that meet, as a minimum, the toughness criteria from the *ASME Code*, Section VIII, Division 1, Paragraphs UG-20.

  Note: The *ASME Code* addresses material toughness requirements for low-temperature properties of carbon and low-alloy steels for use in pressure vessels. Paragraph UG-20 of the *Code* may require impact testing on any of these materials if the design temperature/thickness of the material falls below the threshold values given in UCS-66. New welded-joint design requirements are addressed in UCS-68. Stress considerations are shown in Figure UCS-66.1.

- Ensure that pressure vessels bought from a supplier's commercial stock meet the ASME Code and are registered with the National Board

- Allow the use of the above materials for commercial pressure vessels with no further SNL requirement for impact testing per UG-84 if the pressure vessel is designed to the latest material toughness considerations addressed in the *Div. I Code*.

Design Considerations

Guidance

Members of the Workforce should consider the following items when their vessel is designed either in-house or by an outside agency:

- If designed in-house, an *ASME Code Stamp* cannot be obtained for the vessel

- The preferred design approach is to use the *ASME Code*. Pressure vessel designers can select appropriate dimensions for a pressure vessel from the empirical equations, figures, and charts in Section VIII, Division 1, of the *ASME Code*. The *ASME Code* is recommended because of its simplicity and because it covers both vacuum and internally pressurized vessels. By following the rules of Section VIII, Division 1, of the *ASME Code*, the designer can fabricate an acceptable pressure vessel either in-house or by outside contract.

- Provide a complete set of design parameters.

- Obtain the Materials Application Engineering's approval of the materials.

- Obtain the following from the contractor before fabrication:

    - Set of drawings

    - Copy of the design calculations and certifications of the design criteria

    - List of materials

- If an outside agency designs the vessel, indicate SNL's design approval by marking and documenting the set of drawings and returning them to the contractor.

CAUTION **Caution:** State **in writing** that SNL's approval of the drawings does not relieve the contractor of the obligation to supply a vessel conforming to specifications.

- Obtain an *ASME Code* vessel if the basic design parameters fall within the purview of the code.

Fabrication

Members of the Workforce shall, when building a vessel in-house or having an outside agency build a vessel, ensure that the following items are considered:

- Specify that an outside contractor must furnish these certifications to document the pressure vessel work:
    - Material properties (e.g., yield stress, ultimate stress, elongation, fracture toughness properties, etc.)
    - Process specifications followed (e.g., weld, heat treat, stress relief)
    - Inspection techniques and results (specify complete set of NDT evaluations required)
    - Details of overpressure test and results (specify overpressure test procedures). Overpressure test may also be done in-house and is required before any vessel is used at SNL (see Ch. 6).
- Vessels designed and fabricated to the *ASME Code* by a Certified Code Shop are code-stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors.

Buying from Commercial Stock

Requirements

Members of the Workforce shall:

- Determine the adequacy of pressure systems bought from a supplier's commercial stock for:

- Pressure vessels in manned areas
- Situations where potential equipment or facility damage or loss is unacceptable.

  Note: The preferred procedure is to **buy ASME** and obtain an *ASME Code* stamp.

Observe these principles when buying from a supplier's commercial stock, whether or not the vessel is *ASME Code*-stamped:

- **Manufacturer**. Deal only with a reputable manufacturer, preferably one whose products are known to perform as advertised (see Appendix H)
- **Materials.** Identify the material the vessel is made of, and obtain a material certification if possible
- **Calculations.** Secure a set of the design calculations if possible
- **Factor of Safety.** Quantify factor of safety consistent with definition given in Chapter 3
- **Overpressure Test.** Determine whether an overpressure test was performed and, if so, what the test parameters were.

"Used" from Surplus or Previous Owner

Requirements

Members of the Workforce shall ensure that "used" pressure vessels or special systems meet the requirements of this manual with regard to:

- Adequate factor of safety
- Proper material and fabrication process
- Adequate overpressure test

- Pressure Safety Analysis Report (PSAR). All used pressure systems which come into SNL, regardless of prior successful operating experience, are required to have a PSAR. (See Ch. 9.)

Members of the Workforce shall observe these principles when obtaining used vessels:

- If *ASME Code*-stamped, require documentation of history of use and validation of *Code* stamp. The *Code* stamp on components may be invalidated by:
    - Modifications made by a non-*Code* shop
    - Operations beyond the design limits of pressure or temperature
    - Corrosion beyond allowable amounts.
- If non-*Code*-stamped: Require documentation to show that the design standards were met originally and are still valid.

Note: The requirements for a PSAR with an adequate data package still must be met (see Ch. 9). Some used equipment that does not have sufficient, or any, documentation may require extensive testing to reestablish its adequacy. Lack of this effort or the costs associated with its accomplishment, may preclude the use of these items in a manned area. It may be less expensive, in some cases, to purchase a new item.

ASME CODE VESSELS

Introduction

Note: This section discusses the advantages and disadvantages of procuring pressure vessels designed and built according to *ASME Code* from outside contractors, and outlines the general procurement process. This discussion applies **only** to vessels carrying "U" or "UM" stamps.

ASME Code Stamp

Members of the Workforce should:

- Be aware that an *ASME Code* stamp is desirable and is recommended, but is **not** mandatory.

- Before selecting an *ASME Code* design procedure, determine if they want an ASME stamp. A "U" stamp is preferred over a "UM" stamp since the "U" stamp is applied when inspection is performed by a Code Inspector, not by an employee of the vessel manufacturer. The "UM" marking can be applied by an employee of the vessel manufacturer, when authorized by a Code Inspector.

  Note: All pressure vessels for which an *ASME Code* stamp is obtained should be registered by the vendor with the National Board of Boiler and Pressure Vessel Inspectors. Unstamped vessels cannot be registered.

Advantages

Guidance

Members of the Workforce should be aware of the following advantages of procuring pressure vessels designed and built according to *ASME Code* from outside contractors:

- **Legal**
  - Code shop assumes limited responsibility for vessel failure
  - Make use of industry-accepted standards.
- **Economic**
  - Design and drafting costs are less
  - Fabrication costs **may** be less
  - Preparing a PSAR is simplified, if one is required.
- **Design**
  - Design is conservative
  - Assures that the design meets the PSM requirements.

Disadvantages

Guidance

Members of the Workforce should be aware of the following disadvantages of procuring pressure vessels designed and built according to *ASME Code* from outside contractors:

- **Economic**
  - Fabrication costs **may** be more.
- **Design**
  - The design is conservative and may cause problems if size and weight are important
  - Does not normally cover size of less than 6 in. inside diameter, or an operating pressure of less than 15 psi, although in some instances a Code Stamp may be obtained
  - Provides for only these shapes:
    - Spherical
    - Cylindrical
    - Certain defined shells of revolution, **or** flat plates for the heads of cylindrical vessels.
  - Only the vessel is coded, not the bolted closures, piping, etc.
  - Modifications or repairs must be done by *ASME Code* shops.
- **Materials**
  - Limited to those listed in the *ASME Code*, Section VIII, Division 1
  - Information may not be state of the art
  - Not all the materials listed in Section VIII, Division 1, are acceptable to SNL in certain applications. The designer should therefore verify with the

Materials Application Engineering (6219) that his preliminary selection from the list is satisfactory for intended use.

General Procurement Process

Members of the Workforce shall follow this process for procuring pressure vessels designed and built according to *ASME Code* from outside contractors.

Step	Who	Action
1	SNL requester	Define design parameters in accordance with "Checklists: Requirements for Pressure Vessels Fabricated to the *ASME Code* by Certified Code Shops," this chapter.
2	SNL requester and Purchasing representative	Define contract requirements in accordance with "Checklists: Requirements for Pressure Vessels Fabricated to the *ASME Code* by Certified Code Shops," this chapter.
3	Purchasing representative	Send Request for Quotation to ***ASME Code*** shops **only.**
4	SNL requester	Review bid information from the contractor for the following: • Negotiate as necessary on design • Check the material with the Materials Organization • Ensure overpressure test of **1.3**x MAWP (see Ch. 3, "Conducting Adequate Overpressure Tests," and Ch. 6.) **Caution**: When using *ASME Code*-approved carbon and low-alloy steels, ensure that overpressure test is done at the lowest operating temperature.
5	Purchasing representative	Place contract.

6	SNL requester	• Review fabrication drawings for acceptance • Receive the pressure vessel only after confirmation of testing and documentation.

PRESSURE VESSELS FABRICATED TO THE ASME CODE BY CERTIFIED CODE SHOPS

Note: Certain requirements must be met to obtain a pressure vessel fabricated to *ASME Code*, Section VIII, Division 1, from an outside contractor.

Checklist of Design Parameters

Requirements

Members of the Workforce shall use this checklist of **design parameters** when preparing contracts for pressure vessels fabricated to the *ASME Code* by certified code shops:

- Geometry.
- Maximum allowable working pressure.
- Operating temperature range.
- Working fluid
- Use cycle (e.g., 2 per hour, 6 per year).
- Material.
- Corrosion allowance.
- Overpressure-test requirement. **Reminder:** Test level=1.3 x MAWP.

- Special requirements (e.g., special closures, pressure relief devices, access doors, supports, inspections, environmental considerations for temperature and corrosion, additive finish).

Checklist of Contract Requirements

Requirements

Members of the Workforce shall use this checklist of **contract requirements** for pressure vessels fabricated to the *ASME Code* by certified code shops:

- Design and fabricate in accordance with Section VIII, Division 1, of *ASME Code*

  Materials Note: SNL may request minimum charpy V-notch impact energies for parent material and weld material (fusion zone and heat-affected zone) at specific temperatures. (See *ASME Code*, Section VIII, Division 1, Table UG-84.)

- Vessel shall be Code-stamped and registered with the National Board
- Requester shall obtain fabrication drawings for approval before fabrication
- Requester shall obtain two copies each of the material certification, manufacturer's data sheets, and the inspection report before acceptance
- Address shipping and handling
- Vendor furnishes all hardware (e.g., bolts, nuts, gaskets, seals)
- Date(s) required.

CRYOGENIC SYSTEMS

Procuring Cryogenic Systems

Guidance

Members of the Workforce should follow this procedure to procure cryogenic systems:

Step	Who	Action
1	Line Organization	Contact the Facilities Customer Representative to discuss requirements for cryogenic systems.
2		Initiate a Request for Facilities Support (RFS)
3	Facilities Engineering	• Assemble specifications for the cryogenic system and delivery systems • Give the specification to the requesting line organization along with required signoffs.
4		Proceed with site work and the delivery system.

The purchasing organization is responsible for procuring cryogenic storage vessels and liquid cryogens.

LABELING PRESSURE SYSTEMS AND VESSELS

Labeling

Requirements

Members of the Workforce shall ensure that:

- Pressure vessels and other system components are labeled to identify them with the associated data package.
- Labels shall be affixed so that they do not detract from the vessel's strength or function.

Label Data

Requirements

Members of the Workforce shall ensure that labels are appropriate for the type of component and the method of procurement.

- **All Systems/Vessels**
    - An identification name to reference it to the "Data Package".
- **For ASME Code Vessels**
    - Manufacturer's name and the year built
    - Manufacturer's serial number
    - MAWP and maximum operating temperature
    - Date and pressure level of overpressure test
    - Supplementary data as appropriate
- **For Relief Valves**
    - Serial number
    - Set pressure (verified by pressure test)
    - Date tested
    - Identification of the tester (PRV Test Station ID).

RECORDS

Requirements

Members of the Workforce shall complete the documentation required to make up the Data Package that is created for all pressure systems regardless of procurement means.

Note: A Pressure Safety Analysis Report (PSAR), may be required in addition to the "Data Package" for some systems. (See Ch. 9.)

Managers shall:

- Retain the Data Package and/or PSAR as a permanent file for the life of the pressure system.
- Ensure that the required records are maintained, retrievable, and identified with the referenced hardware, including any reference to documented subsystems.
- Receive and retain Data Package information from the Space & Real Estate Management Department (10854) for systems that are acquired as part of a major facilities contract or under contract to a commercial contractor following inspection and acceptance by Department 10854.

  Note: Data Package information will be turned over to the user organization at the time of occupancy or acceptance of the facility or system.

Guidance

Members of the Workforce should document the pressure ratings of the types of components in systems consisting of commercially available components.

Note: For those components that do not have this information stamped on the items themselves, a copy of the appropriate page/section from the supplier's catalog with the item description and rating highlighted adequately documents this category of components.

Members of the Workforce should document system that contain components that have been custom designed and fabricated. These components are not listed in commercial suppliers' catalogs and the information to document the integrity of the vessel and component is generally more extensive. Optional information includes:

- Specifications and ratings.
- Design and as-built drawings.
- Calculations to support design factor of safety.
- Materials callout and any supplementary notes.
- Certification information, generally for Code vessels.

- Processing information such as welding, manufacturing techniques, or special materials treatments.
- Overpressure test accomplishment and results.

Note: See Chapter 9 for documentation information.

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Sponsor: Dori Ellis, 4000, Acting

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Pressure Safety Manual

5. SELECTING AND ASSEMBLING PRESSURE HARDWARE

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* Indicates a substantive change

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*MANIFOLDS

A pressure manifold is defined as a system of components used to connect a pressure source to downstream equipment. Common examples of pressure sources include gas cylinders, “house” nitrogen supplied by the Facilities Department, air compressors, etc. Common examples of downstream equipment include laboratory instruments such as reaction chambers or pressure vessels, lasers, chromatography applications, vibration-isolation tables, inert gas storage boxes, etc.

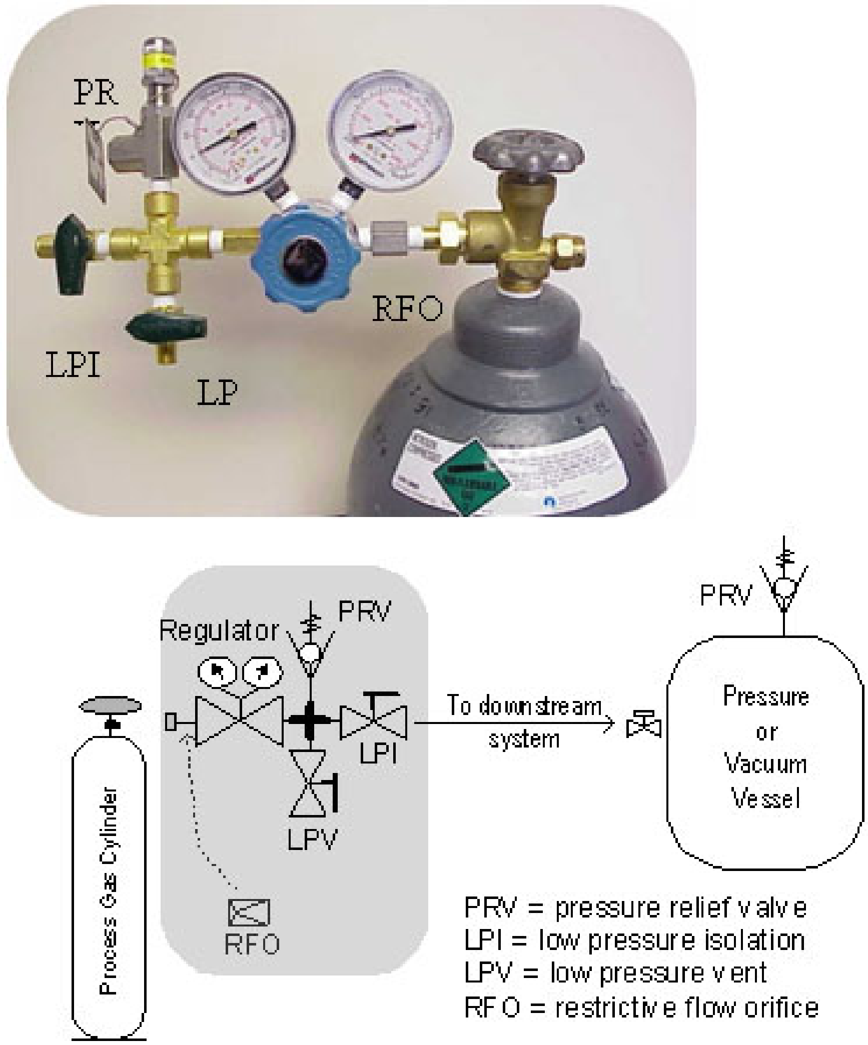

Figure 5-1. Typical pressure manifold setup.

Requirements

Members of the Workforce shall ensure that pressure manifolds:

- Are designed to maintain all components within their maximum allowable working pressure limits. Where high-pressure sources are connected to lower-rated downstream equipment, the pressure must be reduced to the required level.

  Note: Pressure regulators (see Figure 5-1) are commonly used to reduce the source pressure to a lower operational downstream pressure.

- That use regulators have overpressure protection based on the potential failure of the regulator (unless the system is rated for the maximum source pressure). Regulators can fail in a variety of ways. One common failure is where a rise in outlet pressure occurs due to internal leakage through the regulator (sometimes referred to as outlet pressure creep). The outlet pressure of the regulator could rise to the full pressure of the cylinder or pressure source.

Note: Pressure-relief valves (see Figure 5-1) or rupture disks are commonly used to protect the system from accidental overpressure from regulator failure or procedural error. Alternate methods, such as automated gas panels with overpressure sensors and automatic shutdown of the pressure source, can also be acceptable.

- Incorporate a means of shutting down or isolating the pressure source.

  Note: The gas cylinder valve could be used for system isolation; however, a separate shut-off valve, as shown in Figure 5-1, is recommended.

- Address the safe venting of pressure from any and all parts of the system.

  Note: System pressure could be vented through the downstream equipment; however, a separate vent valve is recommended, as shown in Figure 5-1.

Members of the Workforce shall not connect incompatible gases to a common manifold.

Guidance

Figure 5-1 shows a configuration that complies with the above considerations and can be used for many laboratory applications. Pressure systems that incorporate a downstream pressure or vacuum vessel may require an additional pressure-relief device.

The Restrictive Flow Orifice (RFO) is an option used for Pressure-Relief Valve (PRV) sizing. Consult Safety Engineering SMEs for assistance in manifold design and component selection.

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*REGULATORS

Note: The distribution systems of pressure sources (gas cylinders, air compressors, “house” nitrogen supplied by the Facilities Department, etc.) consist of pressure regulators and manifolds. For a pressure source to be effective and safe, the regulator must take in gas from the supply system and reduce the pressure to a lower working pressure. It is important to obtain the correct regulator, consistent with the gas involved and the operation intended. Manifolds distribute and control gas flow from regulators.

Note: Consult pressure safety SMEs or suppliers for regulator selection criteria.

Requirements

Members of the Workforce shall:

- Use a proper regulator, rated for the application, for the control of the delivery pressure.

- Store unused regulators in a clean place to avoid particulate contamination that can induce regulator failure.
- Make sure that all hazardous gas has been safely vented (and purged, if required) from the entire regulator before removing it from a flammable, toxic, or radioactive system.
- Make sure that the threads on the regulator's Compressed Gas Association (CGA) connection correspond to those on the cylinder-valve outlet according to the CGA Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.
- Never use adapters or force connections that do not fit perfectly.
- Use only oxygen regulators for oxygen service.

  CAUTION **Caution:** Never use a regulator for oxygen service unless it is clearly specified and marked for oxygen use, and has not been used for other purposes.

- Inspect regulators at regular intervals, as appropriate to the application.
- Consider establishing replacement intervals based on system design factors, such as degree of hazard, type of failure mode, compatibilities of soft-seat components, and experience with like components.
- Replace damaged, defective, or unreliable regulators immediately.
- **Not** make repairs or modifications to regulators.
- **Not** calibrate regulators and regulator gauges obtained from commercial sources.

CAUTION **Caution:** Regulators are not safety devices and shall not be relied on as such. Manufacturer's pressure-relief valves on regulators are only there to protect the outlet stage of the regulator (regulator body and diaphragm) and do not serve to protect downstream equipment or the regulator's low-pressure outlet gauge.

PROTECTIVE PRESSURE-RELIEVING DEVICES

Requirements

Members of the Workforce shall ensure that all pressure vessels and systems are protected from pressures above maximum allowable working pressure (MAWP) by doing one or more of the following:

- Ensuring that the pressure source is limited to the MAWP. This makes it impossible to overpressurize the system, even in the event of various component failures, fire, or procedural errors.

- Installing a pressure-relief device that is set to begin relieving pressure at a pressure level at or below the system MAWP.

  Note: Any and all portions of the system that may be isolated and can be pressurized above the MAWP must be protected with a relief device.

  CAUTION **Caution:** Never set a relief device higher than the MAWP of the lowest-rated component it is intended to protect. Regulators are not to be used as protection against overpressurization.

Factors in Sizing Protective Devices

Guidance

Members of the Workforce should consider the following factors when selecting a protective device for a pressure system or a vessel:

- Determine the rate of flow that can be produced by the pressure source(s) in a system.

- Select a device (or multiple devices) of proper capacity.

Determining Rate of Flow

Guidance

Note: Anything that can provide pressure is considered a pressure source (e.g., pressure cylinders, compressors, pumps, intensifiers, gas generators, explosives or other chemical reactions, and temperature increases in closed systems). See Caution below.

Members of the Workforce should consider the following factors when determining the necessary flow rate:

- Ordinary operation of pressure sources.

- Operational mistakes.

- Equipment failures.
- Unusual circumstances such as fire.

Note: The *ASME Boiler and Vessel Code* requires a relieving capacity sufficient to prevent the pressure from rising more than 21% above the MAWP in case of exposure to fire.

Note: The rate of flow is the manufacturer's rated capacity if the pressure source is mechanically limited, such as in the following examples:

- Motor-driven compressors.
- Intensifiers.
- Regulator combinations.

CAUTION **Caution:** Protection against explosive pressure usually cannot be obtained from safety valves, relief valves, and rupture discs. This is because of the very short time (less than or equal to 10 ms) in which high-level pressure can produce damage and failure. These types of systems should not be treated as pressure systems under the precepts of this manual. They are containment vessels, and demonstration of containment is required as specified by CPR400.1.1, *ES&H Manual*, Chapter 9, "Explosives Safety."

Selecting a Device of Proper Capacity

Requirements

Members of the Workforce shall ensure the capacity of a protective device at 110% of the set pressure shall be **equal to or greater than** the flow that can be produced by all sources.

Guidance

Members of the Workforce should review the following information for assistance when selecting protective devices:

- **ASME Code-Stamped Safety and Relief Valves and Rupture Discs That Meet the ASME Code**. These will already be marked with the capacity for that device.
- **Non-Code Devices**. Record the capacities found in the manufacturer's catalogs in the system data package.

  Note: Measure the capacity if it cannot be found in the literature.

  Note: When appropriate, convert the safety device capacity from air to another gas.

Special Sizing Problems

Requirements

Members of the Workforce shall ensure that, for systems in which the pressure source is a gas cylinder with a regulator, the flow capacity of the relief device(s) shall be equal to or greater than the maximum rate at which the regulator will supply gas if it undergoes a failure.

Note: If this flow rate under failure condition is **not** known, it must either be determined or a component with a known flow-limiting effect must be installed in the system.

Guidance

Members of the Workforce should be aware that a system that operates at low pressures, but has a high-pressure source, presents special sizing problems, including:

- A vacuum system or laser using a backfill or purge from a standard DOT cylinder. If a failure occurs when the full cylinder pressure is suddenly applied to the system, the normal small relieving device on the system cannot handle the purge and the system will be damaged.
- A brittle vessel pressurized with a standard DOT cylinder. The sudden release of pressure could fracture the brittle vessel before the relief valve has time to function.

Members of the Workforce, to address the problems presented in the examples above, should:

- Use a flow-restricting device on the pressurizing side of a brittle vessel or other system to reduce the rate of pressure increase and to allow time for the relief valve to react to the higher pressure. Types of systems that should use flow-limiting devices include:
  - Brittle vessels, because they may not withstand the shock of full pressure applied suddenly
  - Small-volume vessels being pressurized from a large-volume source.

  Note: Flow-restricting devices and excess-flow valves are available commercially. Metering valves and other components, including regulators, have a physical-design flow coefficient (C_v), which can be considered when determining the flow characteristics of the system. A combination of these and/or multiple relief devices may be required to adequately protect a system. The types of devices used should be selected based on design requirements.
- Other solutions are to:
  - Design safety valves in conjunction with other types of restrictions such as tubing or reducer fittings

- Use two or more stages of flow reduction.

  Note: Systems using this flow-limiting restriction concept must be carefully engineered for adequate flow reduction.

Note: Engineering reference works such as *Mark's Standard Handbook for Mechanical Engineers* and commercial fittings catalogs contain orifice and pipe flow equations.

Preferred Pressure-Relieving Devices

Note: Pressure-relieving devices that meet *ASME Code* requirements are preferred over non-Code devices. However, pressure relief valves 1/2" and smaller in size are generally not subject to *ASME Code* requirements.

Requirements

Members of the Workforce shall ensure that ASME Code devices meet the following requirements:

- Pressure tolerances on valves and discs are Code-specified.
- For safety valves marked with a Code stamp, a sample of these safety valves is tested by the manufacturer for capacity.
- Each protective pressure-relief device is marked with
- The manufacturer's identification.
- The design or type number.
- The pipe size of the inlet of the device.
- The flow capacity.

- All safety and relief valves shall be marked with the set test pressure.
- All ASME safety valves shall be marked with a Code stamp.
- Rupture discs shall be marked with a maximum and minimum bursting pressure and associated temperature.

Note: Rupture discs:

- Burst pressure is dependent on temperature.
- Are **not** marked with the *ASME Code* stamp.

Correct Placement

Note: Correct placement of protective pressure-relief devices in a system is as important to safety as are set pressure and capacity.

Requirements

Members of the Workforce shall comply with the following rules:

1. Do **not** isolate the relief device from the pressure hardware it is intended to protect.

2. All hardware between the system relief device and the component(s) it is intended to protect shall be large enough not to unduly restrict the flow to the relief device.

3. All hardware not protected by a relief device shall have an MAWP of at least the maximum pressure possible from the source.

4. If a pressure system can be divided into subsystems that may become overpressurized, each portion shall be protected by a relief device set at **no greater than** the MAWP for that particular pressure section.

5. Orient relief devices so that their discharge is not hazardous to people.

   Note: A relief device must often be placed on a riser to keep the devices from hot or cold system fluid when:

   - The temperature is outside the operating range of the relief device.
   - Freezing is a problem.

6. Construct, locate, and install pressure-relief devices so that they are accessible for inspection and cannot readily be rendered inoperative.

CAUTION **Caution:** Do **not** use externally adjustable safety valves without the proper safety wiring. They can be adjusted to above system MAWP **without the system user's knowledge.**

7. For all pressure systems containing explosive, toxic, or otherwise hazardous fluids, piping must be used on the outlet of the relief devices to carry the hazardous fluid to a safe discharge area or recovery system. The discharge line shall be large enough not to reduce the capacity of the safety valve below the capacity required to protect the system pressure. When used in liquid service, it shall be designed to facilitate drainage to prevent liquid from lodging in the discharge side of the relief device.

8. Test safety and relief valves as follows:

  - Perform supplier tests before delivery
  - Perform line organization inspections and test periodically thereafter (see Table 8-1).

9. Use rupture discs instead of safety or relief valves where normal system leakage must be minimized, and in dirty, gummy systems. Rupture discs may be used in very high (20,000 psi and above) pressure systems where it is difficult to find reclosable-type safety or relief valves.

   CAUTION **Caution:** Do **not** use rupture discs where it is important to minimize the loss of working fluid. They do not reseal, and unrestricted flow results when pressure is relieved. (Can be used in conjunction with a recovery system, as in rule 7 above.)

10. If possible, mark the relief pressure for rupture discs on permanently attached tabs. Otherwise, closely control and identify the discs and tag them appropriately.
11. Since rupture disc burst pressure varies with temperature, the disc must be located so that the expected temperatures will not cause the disc either to burst above the system MAWP or to burst prematurely.
12. Make certain that the system working fluid does not alter the burst characteristics of the disc.
13. Destroy unidentified rupture discs.

PRESSURE GAUGES

Safety Gauges

Guidance

Members of the Workforce should be cognizant that a safety-type gauge has a blowout plug or panel in the back of the gauge, the sides and front of the gauge are one integral part, and the cover is made of plastic.

Rules for Using Gauges

Requirements

Members of the Workforce shall try to use a gauge that meets at least one of the following criteria for commercial pressure gauges that are acceptable for use:

- UL-approved compressed-gas regulator and/or filter gauges with a maximum outside diameter of 3 in.

- Gauges for **gas** pressure not over 30 psi
- Gauges for **liquid** pressure not over 200 psi.

Members of the Workforce, when using a gauge that does not meet the above criteria, shall follow the steps below to ensure that the pressure gauge provides equivalent protection:

1. Use only safety-type gauges made of materials compatible with the working fluid.
2. Protect the gauges against pressure surges by installing one or more of the following:
   - A properly set pulsation damper.
   - A restricting orifice.
   - A relief valve.
3. Locate pressure gauges to minimize exposure to personnel.
4. Replace glass gauge covers with plastic, replace nonsafe gauges, or install a gauge guard.

   Note: The guard should have appropriate standoffs. It should be made of at least 3/8-in.-thick polycarbonate or 5/8-in. acrylic plastic, undamaged and free of gripper marks, tool chatter marks, and other stress risers.
5. Pressure gauges should have a full-scale range of about double the operating pressure. The range should **never** be less than 1.2 times the pressure at which the relief device is to function. When these constraints cannot be met, protective shielding is required.
6. Do **not** use gauges whose indicator needles turn twice or more unless:
   - A clearly visible total pressure indicator is present.
   - A clearly visible warning to read this indicator is posted.
7. Place a substantial guard between the back of the gauge and personnel for all gauges with blowout backs, blowout plugs, or open backs.

   CAUTION **Caution:** This guard should **not** interfere with venting the gauge in case of gauge failure. Require at least 1/2 in. of clear space between the back of the gauge and the guard or panel.

Guidance

Because there are no ES&H standards requiring the calibration of commercially available pressure gauges that are used in pressure systems, including regulator gauges, Members of the Workforce should be cognizant that:

- The ASME Standard for Pressure Gauges, B40.100, defines gauge accuracy and gives guidance on calibration standards for gauge testing.
- Regulator gauges do **not** have the accuracy required for use as an indicator for critical pressure functions.
- Instruments in systems that are used for establishing design specifications or health protection are calibrated using CPR100.3.1, *Standards and Calibration.*
- Instruments used in design-specification or health-protection activities have the necessary accuracy, are appropriately labeled, and are placed in a continuing recall system for periodic calibration, maintenance, and repair.
- For other systems, line operators must make the determination as to whether the indicating devices in use should be calibrated, and so labeled if necessary, for the proper functioning of equipment or accuracy of experimental data.
- These indicators should not be relied upon as safety devices.
- Fail-safe components such as relief valves/burst discs should be designed into pressure systems.

GAS CYLINDERS

Note: The Department of Transportation (DOT) regulates the design, testing, filling, and transportation of commercially available gas cylinders.

Inspections

Requirements

Members of the Workforce shall ensure that:

- DOT-required hydrostatic testing of the cylinder is completed before refilling, if more than a specified time interval has elapsed.

  Note: The intervals are specified in 49CFR 49, *Transportation*.

- The last inspection date is stamped on the valve end of the cylinder.

- For specification DOT-3A or 3AA cylinders, a five-pointed star stamped after the most recent test date indicates that the cylinder may be retested every ten years instead of every five years.
- The cylinder retest interval has not been exceeded.

Markings

Requirements

Members of the Workforce shall verify that all gas cylinders have the following identifying markings:

- **Cylinder Certification.** The DOT requires that the following information be stamped on the cylinder:

DATA	EXAMPLE
Type of Cylinder	DOT 3AA
Pressure Rating	2065 psig
Serial Number, Mfgr	9734 XYZ
Inspection Date	11--**98**

- **Gas Identification.** Each cylinder must be labeled with the name of its contents. Chalk marking or color coding are **not** acceptable for gas content identification. Since color codes may vary from one supplier to another, always read the label on the cylinder to ensure that you are using the appropriate gas. In addition to the gas identification label, the JIT supplier will apply a barcode to each cylinder in order to meet the requirements of the SNL Chemical Inventory System (CIS). Upon return of the cylinder, the JIT supplier will remove the CIS barcode. It is important to maintain the identity and tracking of all gas cylinders. If either the gas identification label or the CIS barcode begins to peel off or otherwise is deteriorated, please ask the JIT supplier to replace it immediately.
- **Cylinder Filling Data.** Nonliquefied gases may be filled to the service pressure marked on a cylinder. These markings will appear on the shoulder of the cylinder, e.g., DOT 3AA-2065, which indicates that the cylinder has been manufactured in accordance with DOT specification 3AA and the cylinder filling pressure is 2,065 psig at 70°F. Consult 49CFR 49, *Transportation,* for filling procedures and restrictions. On the other hand, liquefied gases must be filled by weight.

Hazards

Requirements

Members of the Workforce shall plan a course of action in the event of leaks of toxic or flammable gases such as:

- Having a self-contained breathing apparatus available in the event of a toxic gas leak.
- Consulting the industrial hygiene representative on the appropriate Division ES&H Team to assess the hazards when cylinders of toxic or flammable gases are leaking.
- Consulting the environmental protection representative on the appropriate Division ES&H Team to remove and dispose of the defective cylinders.
- **Not** returning leaking cylinders to the supplier until they have been properly emptied and labeled (e.g., as a “leaker”, or “has a defective valve”, etc.).

Safe Handling

Guidance

Members of the Workforce should observe the following safe practices when handling gas cylinders:

- Never force a cylinder cap or cylinder valve. If the cap cannot be opened by hand or the valve cannot be opened by the wheel or small wrench provided, the cylinder should be returned.
- Open the cylinder valve slowly.
- Before opening the cylinder valve, fully close the hand control knob (turn counterclockwise) on the regulator.
- Never drop cylinders or permit them to strike each other.
- Chain, strap, or affix cylinders in use and in storage in a manner that prevents them from falling (see Figure 5-2).
- Leave the valve protection cap on each cylinder until it has been secured against a wall or bench, or placed in a cylinder stand, ready to be used.
- Do **not** drag, roll, or slide cylinders.
- Use a suitable hand truck when moving cylinders.
- Do **not** lift cylinders using gas cylinder caps.
- Never tamper with safety devices in valves or cylinders.
- Do **not** handle oxygen cylinders with oily hands, oily gloves, or greasy materials. The reaction between oxygen and oil or grease can cause a violent explosion when even minute quantities of oil or grease are involved. Use extreme care to eliminate any chance of oxygen contact with oil or grease.

Note: Containers are "in use" when: >

- Gas is flowing from the containers.
- The container gas is maintaining pressure in a supply line.
- The container is standing-by during and between operations utilizing the gas.

- Do **not** place cylinders where they might become part of an electrical circuit.
- Do **not** use white lead, oil, grease, or any other oxygen non-approved pipe-sealing compound to make a joint in an oxygen system. An explosion may occur if oxygen comes in contact with these materials. Threaded connections in oxygen piping should be tinned or made up with litharge and glycerin (litharge and water for service pressures over 300 psi) or other joint compounds approved for oxygen service. Gaskets should be made entirely of noncombustible materials.
- Never interchange regulators and hose lines among different types of gases. Explosions can occur if oil in confined spaces comes in contact with oxygen under pressure.
- Never use oxygen to purge lines in pneumatic tools or in any way as a substitute for compressed air. Doing so could cause an explosion or fire.
- Utilize four-wheeled carts for moving large cylinders.
- Secure cylinders that are being transported in vehicles.
- For empty or partially filled cylinders that are no longer needed for current activities:
  - Call the JIT supplier to pick them up.
  - Do **not** allow these cylinders to accumulate in work or storage areas.
  - Use yellow tape to mark the cylinder "for pickup."
  - Do **not** tape over the gas identification label or CIS barcodes.
  - Handle them with the same safety precautions as used for full cylinders.
  - Maintain a positive pressure on gas cylinders.

Sample Cylinders

Guidance

Members of the Workforce should be cognizant that small sample cylinders and calibrated leak cylinders:

- Are commercially available.
- Conform to DOT specifications and comply with DOT regulations.
- Are (mostly) hydrostatically pressure-tested and lot-burst-tested per 49CFR 49, *Transportation.*
- Like gas cylinders, should **not** be permanently plumbed into a pressure system. If done so, DOT specification and retest intervals are no longer applicable.

Storage

Requirements

Members of the Workforce shall comply with the following storage requirements:

- Cylinders shall be stored in accordance with appropriate standards. Storage areas must be approved by Facilities ES&H (FESH) Support. Cylinders "not in use" shall not be allowed to accumulate in rooms, hallways, or basements.
    - Cylinders may be stored in the open, but shall be protected against extremes of weather and from the dampness of the ground to prevent rusting. During the summer, cylinders stored in the open should be shaded against the continuous direct rays of the sun.
    - Gas cylinders shall **not** be stored in mechanical or electrical equipment rooms.
- Container storage areas in users' facilities shall be prominently posted with the name of the gases to be stored and with "NO SMOKING" signs, where appropriate.
- Where gases of different types are stored at the same location, containers should be grouped by types of gas, and the groups arranged to take into account the gases contained. Full and empty containers should be stored separately and the storage layout so planned that containers comprising old stock can be removed first with a minimum handling of other containers.
- Storage rooms shall be well ventilated and dry. Where practicable, storage rooms should be of fire-resistive construction. Storage room temperatures shall not exceed 125°F (51.7°C). Storage in subsurface locations should be avoided.
- Containers shall **not** be stored near readily ignitable substances such as gasoline or waste, or near combustibles in bulk, including oil.
- Containers shall **not** be exposed to continuous dampness and should not be stored near salt or other corrosive chemicals or fumes. Corrosion may damage the containers and may cause the valve-protection caps to stick.
- All compressed gas containers in service or in storage shall be stored standing upright where they are not likely to be knocked over, or the containers shall be secured (Figure 5-2). At

container delivery locations and warehouses, the nesting of tightly stacked containers is considered an equivalently safe manner of storage. Gas containers with a water volume up to 305 in^3 (5.0 L) may be stored in a horizontal position.

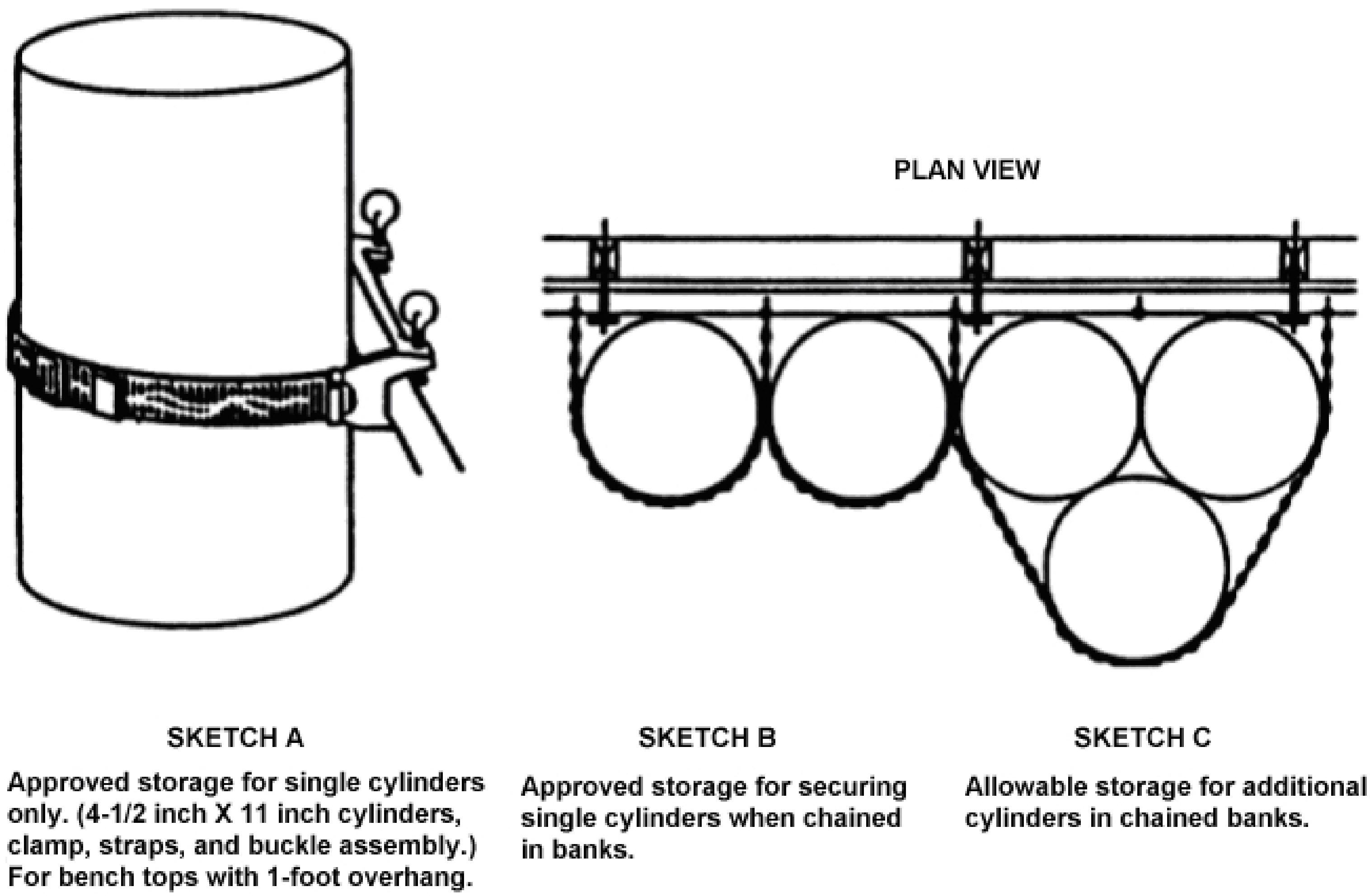

Figure 5-2. Approved Gas Cylinder Storage Configuration

- Containers shall be protected from any object that will produce a harmful cut or other abrasion in the surface of the metal. Containers shall not be stored near elevators, gangways, or unprotected platform edges, or in any location where heavy moving objects may strike or fall on them.

- Liquefied gas containers, except those designed for use in a horizontal position on tow motors, etc., shall be stored and used valve-end up. Acetylene containers shall be stored and used valve-end up. Storage of acetylene containers valve-end up will minimize the possibility of solvents being discharged. ("Valve-end up" includes conditions where the container axis may be inclined as much as 45° from the vertical.)

COMMON COMPRESSED GASES

Before Using Compressed Gases

Requirements

Members of the Workforce shall:

- Have permanent gas system installations and storage areas designed and installed through the Facilities Management & Operations Center (10800) or Facilities Planning and Engineering (8512). This ensures that the appropriate codes and standards will be reviewed for applicability and compliance.
- Review other available information as applicable to ensure that their systems are in compliance. Under 29 CFR 1910.1200, *Hazard Communication*, manufacturers, importers, and distributors of compressed gases are required to label their containers and to provide Material Safety Data Sheets.

Managers shall:

- Provide employees with information and training on the hazards in their work areas.
- Ensure that the applicable information is reviewed and made available to all users of the system. A list of relevant codes and organization source references that are applicable to the use of **compressed gases** is provided at the end of this chapter.

Acetylene

Note: Acetylene, which sometimes carries the trade name Prestolite, is a colorless gas with the odor of garlic and is highly flammable and explosive under certain conditions.

CAUTION Acetylene is an anesthetic and, when breathed in large quantities, may cause death.

Requirements

Members of the Workforce shall:

- **Never** use copper fittings or pipe on acetylene cylinders.

  CAUTION The combination of acetylene with copper produces an explosive compound.

- Not pipe acetylene at pressures greater than 15 psig without special precautions.

- See the Compressed Gas Association (CGA), *Handbook of Compressed Gases* Pamphlet G-1, *Acetylene*, for a more thorough discussion on the properties of acetylene and the safe use of acetylene cylinders, and review NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, for design and installation requirements.

Ammonia

Note: Ammonia gas is less toxic than chlorine but deserves similar respect in handling.

Requirements

Members of the Workforce shall:

- Have appropriate respirators or shields readily available in places where ammonia is used.
- Discuss protective clothing and respiratory equipment needs with the appropriate Division ES&H Team.
- Store and use ammonia cylinders in an upright position to keep the liquid away from valves.
- **Not** allow ammonia to come into contact with copper, zinc, or alloys containing copper as a major element.
- Consult the Facilities Management & Operations Center (10800) safe standard piping requirements for anhydrous ammonia. Never remove check valves because suckback into the ammonia tanks may cause an explosion.

Carbon Dioxide

Note: Carbon dioxide is a heavy, inert gas that is colorless and odorless. Although it is neither an anesthetic nor an irritant, an atmosphere of the gas will **not** support life. It is in liquid form in a cylinder.

Chlorine

Note: Chlorine is a greenish-yellow nonflammable gas, about 2 ½ times heavier than air. It is a corrosive, suffocating, and irritating gas. It is shipped as compressed liquefied gas.

Requirements

Members of the Workforce shall:

- Have appropriate respirators or shields readily available where chlorine is used.

- Discuss protective clothing and respiratory equipment needs with the appropriate Division ES&H Team.

- Store and use chlorine cylinders in an upright position to keep liquid away from valves.

Hydrogen

Note: Hydrogen is the lightest gas known. Hydrogen is colorless, odorless, nontoxic, and tasteless. It is flammable and will burn in concentrations between 4.1% and 74.2% in air.

Requirements

Members of the Workforce shall:

- Obtain Fire Protection approval for small system installations (<400 cu. ft. of hydrogen).

- Obtain approval from Facilities ES&H (FESH) Support for hydrogen installations of more than 400 cu. ft. (more than two cylinders). Cylinders shall be located outdoors.

- Notify FESH of planned new hydrogen installations.

- **For small systems (<400 cu. ft.), comply with all previously stated requirements and the following:**

    - Install small systems in a room having high-point exhaust ventilation and no pockets where hydrogen can accumulate under the ceiling, under an upper floor, or under a roof.

        Note: Hydrogen systems should be shut off during nonoperational hours in buildings where full-time ventilation is not provided.

    - Protect cylinders from the sun's rays and from **all** heat sources.

    - Protect cylinders from physical damage.

    - Carefully remove leaking cylinders from the building and tag them as leaking.

    - Do **not** permit cylinders containing oxygen or chlorine within 10 feet of a hydrogen cylinder unless an intervening noncombustible wall separates them.

    - Keep combustible material 12 inches or further from any high-pressure pipe or upstream of the regulator valve. Under the right conditions, hydrogen passing through a piping leak to the atmosphere can self-ignite.

    - Mark each hydrogen installation with a sign stating:

HYDROGEN, FLAMMABLE GAS

NO SMOKING

- Place shut-off valves where they are readily accessible.

- Because a regulator valve could fail, a relief valve shall be positioned to protect the low-pressure system from excessive pressure. The relief valve shall discharge or be piped to a safe location.

- For small-volume laboratory systems, installing an exhaust hood over the equipment will usually suffice to remove leaking gas.

- Consider possible hydrogen embrittlement when choosing containers, piping, and fittings.

- Leak-check piping, using an inert gas, after installation and after any modification to the piping.

Liquefied Petroleum Gas (LPG)

Note: Liquefied petroleum gases are known under various trade names, the most common being Insto-gas, Pyrofax, and Phil-gas, and are either propane, isobutane, propylene (propenes), butylenes (butenes), butane, and any mixtures of these hydrocarbons. These gases are flammable, colorless, and odorless and are required to have an odorant added to indicate the presence of gas in case of leakage.

Liquid Air, Liquid Oxygen, and Liquid Nitrogen

Requirements

Members of the Workforce who handle cryogenic fluids shall:

- Wear protective clothing when handling cryogenic fluids as specified by the appropriate Division ES&H Team.

- Transport and store cryogenic fluids, until used, in the supplier's insulated containers, which provide means for the venting of gas as the liquid vaporizes. The outlet of such containers should never be obstructed. Empty containers shall be kept clean and returned promptly to the supplier.

- **Never** store cryogenic fluids in small, closed compartments without adequate ventilation. A well-ventilated storage space shall always be provided.

- To prevent spontaneous combustion, never store or use containers of liquid oxygen or mixtures of liquid oxygen where they may come in contact with combustible gases or other combustible materials.

- Entrust handling of cryogenic fluids only to competent persons trained to use them. Because of their extremely low temperature (about 320°F below zero), these liquids will seriously burn the skin much as hot liquids would. Never permit them to come in contact with the skin or be allowed to soak clothing.

- Never pour liquid oxygen on clothing, fabrics, rags, waste, or other combustible materials.
- Do **not** allow the gaseous oxygen arising from liquid oxygen to penetrate clothing. Combustible substances in the presence of oxygen are extremely flammable.
- Never store or use liquid oxygen in proximity to an open flame. Any flame may expand enormously in an oxygen-enriched atmosphere, which may result in an explosion. Liquid air or liquid oxygen shall **never** be put in containers contaminated with oil, grease, or carbonaceous materials of any kind. They shall **never** be used in combination with other substances without knowing what the result may be.
- Because the composition of liquid air changes as the liquid evaporates, if liquid air is allowed to remain in the container, the proportion of oxygen will increase. If it is allowed to remain in a container until a large portion of the liquid is evaporated, an analysis shall be made before it is used for any purpose where high oxygen content would be dangerous. The proportion of oxygen in mixtures of liquid oxygen and nitrogen will also increase if allowed to remain in the container. The liquid mixture shall be analyzed before it is used for any purpose where a high oxygen content would be dangerous.
- Do not allow air to become entrapped in insulation around nitrogen pipes as it may be liquefied at points where the nitrogen vaporizes within the pipe system. Oxygen-enrichment of the liquefied air can result in an explosive hazard in combustible insulation.

Note: See CPR400.1.1.36/GN470100, *Safe Handling of Cryogenic Fluids*, for cryogenic fluids handling precautions.

Oxygen

Note: Oxygen is a colorless, odorless, and tasteless gas. Although it is nonflammable, it readily supports combustion and greatly enhances the rate of burning.

Requirements

Members of the Workforce shall not permit oil and grease to come in contact with oxygen cylinders, valves, regulators, gauges, or fittings. Explosive mixtures can result when oxygen and hydrocarbons are combined.

PIPING

Design Criterion

Requirements

Members of the Workforce shall ensure the same level of safety is observed for the piping in pressure systems as for the vessel and other components.

CAUTION High-pressure systems may not have a safety factor of **3.5**. When in doubt, additional information and analysis are necessary to document the safety of these systems.

Design Considerations

Guidance

Members of the Workforce may use commercial piping obtained from a reputable supplier provided that it meets the requirements of ASME B31.1, *Power Piping,* at its specified rating. The suppliers' catalogs or technical bulletins specify the minimum bending radius or other restrictions that should be observed when installing this equipment. Special tools, such as bending tools, may be available.

Note: When there is doubt concerning the rating or use of any commercial component, additional investigation and/or consultation may be justified.

Flexible hose should not be bent beyond its rated minimum bend radius. Over-bending will introduce hazardous stress risers.

Recommendations for Selecting Wall Thickness

Guidance

The following recommendations are provided for Members of the Workforce when selecting wall thickness of piping:

1. Commercially supplied piping should have the appropriate wall thickness for the intended use and pressure rating. Consult the supplier or the appropriate catalog/product guide.

2. Where commercial piping is **not** available for a specific application, design piping and tubing in accordance with ASME specifications where applicable.

3. Appendix C, "Piping and Tubing Notes," provides comparable equations for tubing calculations.

   Note: Pressure Installers should be cognizant of the vendors' restrictions on bending radius of piping and tubing. Special tools should be used when called for. Supplier's catalogs or technical representatives should be consulted.

Anchoring Rigid Piping

Requirements

Members of the Workforce shall ensure that rigid piping is properly installed following these rules:

1. Configure piping to allow for thermal expansion and contraction.
2. Support the piping to avoid vibration, using adjustable wrought-iron or malleable-iron hangers at 8-foot intervals.
3. Anchor piping to withstand thrust, torsion, and other operating conditions. This extends the service life of the piping and provides protection in the event of line failure.
4. Tubing will have hangers spaced not over 5 feet apart.
5. Minimize runs of pipe.

Flexible Hoses

Requirements

When working with flexible hoses, Members of the Workforce shall:

- Verify the MAWP from the supplier.
- Ensure that the terminations are properly installed.
- Avoid sharp bends. Follow hose manufacturer's recommendations.

  Note: Rigid tubing is preferred whenever the system design and operational considerations allow.
- Relieve all pressure from a hose when it is not being used.
- Anchor the flexible hose at both ends when it is pressurized above 150 psi **and** is greater than 3 feet in length by:
  - Attaching tiedowns securely to the hose **(not** the termination) because hose failures usually occur when the hose releases from the termination.
  - Ensuring that anchoring devices, such as whip-checks, must be capable of withstanding a force greater than 50% of the MAWP times the cross-sectional of the hose's OD.

COMPRESSED AIR SYSTEMS

House Air Systems

Note: House or shop air systems provide compressed air to drops or hose reels at 150 psi or less. Generally the air source is from a compressor.

Potential Injuries

Guidance

Members of the Workforce should be cognizant of potential injuries that can occur when working with pressurized air or gas. Examples of potential injuries from the misuse of pressurized air or gas include the following:

- A strong blast of air or gas from a hose can dislodge an eye from its socket, rupture an eardrum, or induce hemorrhaging.
- An air jet from a 100-psi line released through a 1/8-inch diameter or smaller opening at skin surface can enter through a cut or sore and inflate the flesh, and even cause air embolism (bubbles) in the bloodstream.
- A highly compressed gas stream needling through a very small opening that contacts the skin can pierce the skin, permeate the flesh in depth, and cause tissues to inflate, causing excruciating pain from expansion of the gas.
- A stream of air from a hose at a pressure of 30 psi or more can drive metal chips at speeds that make them missile threats to eyes or face.

Blowing or Dusting

Requirements

Members of the Workforce shall not use compressed air for cleaning purposes (blowing or dusting) except where pressure is reduced to less than 30 psi, and then only with effective chip-guarding and personal-protective equipment. The pressure source must be regulated to less than 30 psi or a safety-type nozzle, which restricts the output to less than 30 psi, must be installed on the line.

Members of the Workforce shall observe the following precautions:

- Do not exceed the maximum air pressure of 30 psi.
- Wear safety glasses or safety glasses with a face shield.

- Do **not** blow dust or chips if other people are in the immediate area or without wearing adequate chip guards.
- Do **not** dust off clothing with air or any other compressed gas.
- Sweep up metal chips that are too large or heavy for blowing at this pressure.
- Install the safety nozzles on the air supply hose when they are being used for blowing or dusting.

Note: Placing signs reading "Caution - 30 psi Max for Dusting" in the vicinity of the air supply outlet is recommended to remind people of the requirement.

Note: Several brands of safety air nozzles are available, such as "SAFE-T-BLOW" and "Guardair", and may be ordered through the Just-in-Time system. These nozzles restrict the pressure at the output of house air (100 psi maximum) systems to less than 30 psi without having to regulate the pressure.

SUPPLIERS AND THEIR PRODUCTS

Just-in-Time (JIT) Procurement

Guidance

The JIT contract for pressure hardware imposes quality program requirements on suppliers that are consistent with CPR500.2.1, *Quality-Significant Procurement Handbook,* and the SNL Suspect/Counterfeit Items Program, to ensure that various types of pressure or vacuum components supplied to Sandia are free of suspect or counterfeit parts and are adequately tested and certified. The Sandia Pressure Safety Committee (PSC) has determined that material furnished to Sandia can be used without further testing or certification.

For the purpose of evaluating JIT contract proposals pertaining to pressure and vacuum equipment, the PSC should appoint one or more members to provide technical assistance in evaluating the proposals and suppliers.

Non-JIT Purchases

Requirements

Pressure Installers shall:

- Ensure that non-JIT purchases of vacuum and pressure hardware meet the requirements of

Chapter 4, "Procuring Pressure Vessels and Special System Components."

- Be aware of the information in CPR500.2.1, *Quality-Significant Procurement Handbook,* and the SNL Suspect/Counterfeit Items Program.

Guidance

Hardware procured from sources other than through the JIT contract may require additional investigation, analysis, inspection, or testing. Members of the Workforce should consult their organizational Pressure Advisor regarding this hardware. (Appendix H, "Suppliers of Quality Pressure Hardware," lists suppliers of quality pressure hardware.)

Pressure Installers who purchase pressure components should obtain vessels and components consistent with the requirements of CPR500.2.1, *Quality-Significant Procurement Handbook,* and the SNL Suspect/Counterfeit Items Program, when deemed applicable.

REFERENCES

Requirements Source Documents

National Codes and Standards

ASME B31.3, *Chemical Plant and Petroleum Refinery Piping*, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

AWS Z49.1, *Safety in Welding and Cutting*, American Welding Society, 550 N.W. LeJeune Road, P. O. Box 351040, Miami, FL 33135.

API 620, *Recommended Rules for Design and Construction of Large, Welded Low Pressure Storage Tanks*, American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005.

ASME Boiler and Pressure Vessel Code (Section VIII, Unfired Pressure Vessels), American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017-2392.

ASTM G88, *Guide for Designing Systems for Oxygen Service*, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

Code of Federal Regulations, Title 49 CFR (Transportation), Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Compressed Gas Association, *Handbook of Compressed Gases*, Compressed Gas Association, 1235 Jefferson Davis Highway, Arlington, VA 22202. (Appendix 4 of the handbook lists the CGA Pamphlets and Bulletins that address the safe transportation, handling, and use of compressed gases.) These publications are available on microfilm in the Design Information Center.

DOE Pressure Safety Guidelines, M-089.

Material Safety Data Sheets (provided by supplier).

Matheson Gas Data Book, 6th ed., Matheson Gas Products, Inc., Secaucus, NJ 07094 (1980).

National Board Inspection Code - A Manual for Boiler and Pressure Vessel Inspectors, National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229.

NFPA 70, *National Electrical Code*, National Fire Protection Association, 1 Battery March Park, Quincy, MA 02269.

National Fire Protection Association Codes Pertaining to Compressed Gases

Designation Number	Title
NFPA 43C	Storage of Gaseous Oxidizing Materials
NFPA 45	Standard on Fire Protection for Laboratories Using Chemicals
NFPA 49	Hazardous Chemicals Data
NFPA 50	Standard for Bulk Oxygen at Consumer Sites
NFPA 50A	Standard for Gaseous Hydrogen Systems at Consumer Sites
NFPA 50B	Standard for Liquefied Hydrogen Systems at Consumer Sites
NFPA 51	Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes
NFPA 51A	Standard for Acetylene Cylinder Charging Plants
NFPA 51B	Standard for Fire Prevention During Welding, Cutting and Other Hot Work
NFPA 52	Standard for Compressed Natural Gas (CNG) Vehicular Fuel Gas Systems
NFPA 53	Recommended Practice on Materials, Equipment, and Systems in Oxygen-Enriched Atmospheres
NFPA 54	National Fuel Gas Code
NFPA 58	Liquefied Petroleum Gas Code
NFPA 59	Utility LP-Gas Plant Code
NFPA 59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)
NFPA 99	Standard for Health Care Facilities (supersedes NFPA 3M, 56A, 56B, 56C, 56D, 56E, 56G, 56HM, 56K, 76A, 76B, and 76C

The contact for these codes is NFPA, 1 Battery March Park, Quincy, MA 02269 (Telephone: 1-800-344-3555).

Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) under the United States Department of Labor promulgates regulations "to assure safe and healthful working conditions for working men and women." These OSHA regulations are published in Title 29 of the Code of Federal Regulations under Part 1910 relating to General Industry Standards, Part 1915 relating to Shipyard Employment, and Part 1926 relating to Construction Industry Standards.

Under the General Industry Standards of 29 CFR Part 1910, the following sections will be of particular interest to users of compressed gases:

- 29 CFR 1910.94, *Ventilation*
- 29 CFR 1910.95, *Occupational Noise Exposure*
- 29 CFR 1910.101, *Compressed Gases (general requirements)*
- 29 CFR 1910.102, *Acetylene*
- 29 CFR 1910.103, *Hydrogen*
- 29 CFR 1910.104, *Oxygen*
- 29 CFR 1910.105, *Nitrous Oxide*
- 29 CFR 1910.110, *Storage and Handling of Liquefied Petroleum Gases*
- 29 CFR 1910.111, *Storage and Handling of Anhydrous Ammonia*
- 29 CFR 1910.251, Subpart Q, *Welding, Cutting, and Brazing*
- 29 CFR 1910.307, *Hazardous (classified) Locations*
- 29 CFR 1910.1000, *Air Contaminants*
- 29 CFR 1910.1047, *Ethylene Oxide*
- 29 CFR 1910.1200, *Hazardous Communication*

Fire Code

International Fire Code, 2000, International Code Council, 5203 Leesburg Pike, Suite 600, Falls

Church, VA 22041

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Corporate Process Requirement No: CPR400.1.1.27
Sponsor: Dori Ellis, 4000, Acting

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Pressure Safety Manual

6. TESTING AND EVALUATING PRESSURE SYSTEMS

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
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* Indicates a substantive change

TYPES OF PRESSURE TESTS

Requirements

Members of the Workforce shall ensure that non-rated pressure components and systems that they work on have had one or more of the following SNL-required tests performed on them:

- The overpressure test.
- The burst test.

- The operational leak test.
- Nondestructive Evaluation (NDE).

Note: Pressure vessels and components purchased from qualified vendors that have a stated maximum allowable working pressure (MAWP) do not require additional testing.

PRESSURE TESTING LABORATORIES

Guidance

Managers of using organizations should decide whether testing is done either:

- By the manufacturer under SNL-specified conditions.
- In-house.
- By a qualified outside source other than the manufacturer.

At SNL/NM, managers should consult the Materials Application Engineering and Design Support contact about pressure testing support to line organizations.

OVERPRESSURE TEST

Note: Of the various types of pressure tests that can be done at SNL, or at SNL discretion, by a qualified outside source, the overpressure test is the most important because it:

- Shows the most about structural integrity.
- Completes the initial design cycle.
- Is a primary tool for later reevaluation.

The objective of a properly administered overpressure test is to demonstrate that failure should **not** occur with a vessel at operating pressure and temperature.

Test Considerations

Requirements

Managers shall:

- Ensure that as much of the entire pressure system is tested as practical.
- Be prepared for a failure. Failures anywhere in the system are potentially serious.
- Use protective shielding and test remotely.

Note: Sudden release of pressure in the vessel usually constitutes a greater hazard than release of pressure elsewhere in the system, because the vessel itself stores more of the energy.

Note: More comprehensive testing should be considered for systems containing toxic or radioactive materials.

Use of Overpressure Tests

Requirements

Managers shall use the overpressure test:

- To reveal any major faults in the design or fabrication of a new pressure vessel
- To discover any flaws of critical size
- To establish a minimum potential for the growth of flaws if the material in the vessel is well characterized.
- As an effective reinspection tool because the test can re-establish the former potential for flaw growth and enable another period of successful operation.

Guidance

In fatigue applications, Members of the Workforce should use the system parameters as an aid in determining when to schedule the next overpressure test. Overpressure tests answer the following questions of structural integrity in old vessels:

- Has alteration weakened the vessel?
- Has subcritical flaw growth advanced so that flaw size becomes critical at or lower than overpressure-test level?

Note: Nondestructive Testing (NDT) is necessary to establish the existence of flaws or the potential for future flaw growth. NDT includes radiography, ultrasonics, magnetic particle inspection, and acoustic emissions monitoring (see Nondestructive Evaluation (NDE) in this chapter). Supplementary monitoring (acoustic emissions, strain, displacement, etc.) during an overpressure test creates a much stronger safety argument, is useful in future evaluations, and is recommended whenever possible.

Limitations of Overpressure Test

An overpressure test in itself is **not** enough to establish a pressure rating for a vessel to be used in manned areas, or elsewhere, if vessel failure is unacceptable (see Ch. 3.) Other key factors in determining pressure ratings are:

- An adequate safety factor
- Selection of proper materials and processes.

Adequate Overpressure Testing

Note: Sensible overpressure tests cannot be done, at least the first time, without prior analysis.

Requirements

Managers shall ensure that an overpressure test of **1.3** x MAWP (maximum allowable working pressure) is performed for vessels that are designed in accordance with Section VIII, Division 1 of the *ASME Code*.

CAUTION **Caution:** If an *ASME Code* pneumatic test was used, the overpressure test may have been carried out only to **1.1** X MAWP. This is not adequate for manned areas.

Who Performs Tests and When

Note: The determination of who performs overpressure tests depends on whether the vessel is new or used.

Requirements

Managers shall ensure that:

- Vessels are appropriately tested depending on the type:
  - **New vessels** shall always have been tested before use, preferably by the fabricator or other qualified outside source.
  - **Used vessels acquired from outside of SNL** shall be tested in-house or by a qualified outside source before installation.
  - **Vessels in use** shall be tested in-house or by a qualified outside source at intervals discussed later in this chapter in "Periodic Reevaluations of Pressure Systems."

  Note: **All** pressure vessels have been overpressure-tested, including those bearing the *ASME Code* stamp.

Adequate Holding Time

Note: Even experts disagree as to adequate holding time at maximum pressure during overpressure test. The reason is that the number of variables may differ widely. If the vessel has not reached general yield, the pressure usually stabilizes quickly at proof level. If general yield is occurring, the pressure may never stabilize, and even long holding times will not matter.

Members of the Workforce may consider the test successful if there is no abnormal drop in pressure after a 3-minute holding time.

CAUTION **Caution:** If you observe a drop in pressure, general yielding is the probable cause if there are no system leaks. This condition results in failure to pass the overpressure test.

Test Pressures

For a factor of safety equal to **3.5**, managers shall require an overpressure-test pressure of **1.3** X MAWP, based on the ASME Section VIII, Division 1 Code design.

What to Do If a Leak Develops

Requirements

If leakage is detected during the overpressure test, Members of the Workforce shall:

- Lower the pressure to one-half the value reached before they enter the test area to locate the leak.
- Obtain approval from the PA or safety engineering representative on the appropriate Division ES&H Team if pressure greater than one-half the attained value must be used to find the leak.

Excessive Test Pressures

Guidance

Members of the Workforce should be aware that excessive overpressure-test pressures may cause:

- General yield, determined by measuring the diameter of a vessel before and after testing or by other diagnostic method of determining dimensional change. General yield results in permanent dimensional change of the structure, which is usually undesirable.

  Note: General yield differs from local yield, which is part of the "shakedown" process in a well-balanced design and is usually harmless.

- Reduction of service life for the vessel. Reduction of service life for the vessel can occur because some flaws in the vessel undergo further subcritical growth, reaching a larger size than with more reasonable overpressure-test levels. Therefore, not as many fatigue cycles to failure remain at the operating level.

Selecting Temperatures

Guidance

Members of the Workforce should:

- Obtain guidance from the Materials Application Engineering and Design Support contact for materials that will be subjected to temperature extremes during an overpressure test. This is especially important for vessels whose material toughness decreases with change from ordinary room temperature to operating temperature (e.g., carbon steels used at low temperature).

- Test vessels constructed of materials that exhibit adequate toughness throughout the operating temperature range at normal operating temperature.

In Situ Testing

Requirements

Because rupture can occur unexpectedly during overpressure testing, managers shall:

- Fully evaluate the consequences for Members of the Workforce and facilities **before** in situ overpressure testing.

- Advise both line management and the appropriate Division ES&H Team of the risks.

WARNING Do **not** proceed with testing until these persons have decided the risks are acceptable.

LEAK TEST

Pretest Rules

Note: Leak tests may require physical exposure of the operator to a pressure system.

Requirements

Members of the Workforce shall comply with the following rules before conducting a leak test:

- Follow all rules for manned-area operation
- Do **not** exceed MAWP during leak testing

Guidance

Members of the Workforce may perform an operational leak test at MAWP on a vessel or system in service when reevaluation has determined that a full overpressure test is not necessary.

NONDESTRUCTIVE EVALUATION (NDE)

Introduction

Many NDE tools are available to assist in evaluating a pressure vessel:

- During and after fabrication
- When it is installed and operating
- When it is being reevaluated.

Section V of the *ASME Code* relates to the requirements and methods for nondestructive examination. These nondestructive examination methods are intended to detect surface and internal discontinuities in materials, welds, and fabricated parts and components. Examples include radiographic examination, ultrasonic examination, liquid penetrant examination, magnetic particle examination, eddy current examination, visual examination and leak testing. In the foregoing methods, the skill, experience and integrity of the personnel performing these examinations are essential to obtain meaningful results. Nondestructive examination personnel shall be certified in accordance with ASNT-TC-1A to at least Level II. The following sections discuss NDE procedures that are useful in pressure system evaluations and describe the type of data the user will obtain from these inspections.

See Appendix F for assistance in conducting NDE.

List of NDE Evaluation Tools

Guidance

Members of the Workforce should reference the following list of the more common NDE procedures:

- Visual inspection
- Overpressure test with acoustic emissions monitoring
- Radiography
- Ultrasonics
- Liquid penetrant and magnetic particle tests
- Acoustic emissions
- Strain and displacement gages.

The Overpressure Test

Requirements

Managers shall ensure that pressure vessels have passed an overpressure test **before** it is placed into service.

CAUTION **Caution:** Tests such as the radiography, ultrasonics, liquid-penetrant, magnetic-particle, and acoustic-emission tests do not jeopardize the vessel, but they may identify the need for repair of detected defects. Any repairs would invalidate an overpressure test.

Radiography

Guidance

Members of the Workforce should be aware that radiography is:

- The NDE method most relied on to inspect welded joints.
- Commonly used to examine for surface and subsurface discontinuities. The use of this method may be restricted due to the configuration of the welded joint or the limitations of the radiographic equipment. Radiography will not give an indication of the depth of discontinuity unless special procedures are used.

Persons who interpret radiographic films of welds should have not only a knowledge of welding and welding discontinuities, but also be able to exercise good judgment as to whether the discontinuities are actually defects.

Ultrasonics

Guidance

Members of the Workforce should use ultrasonics to locate internal voids, inclusions, laminations, and cracks in the material under examination. During an ultrasonic inspection, pulses of high frequency sound waves are introduced into the material by an ultrasonic transducer. Flaw interfaces reflect portions of the energy of the pulse back to the transducer, and the examiner sees the reflections on a CRT screen of an oscilloscope. The degree of reflection depends on the physical state of matter on the opposite side of the interface. For instance, sound waves are almost completely reflected (i.e., no attenuation) at metal-gas interfaces. Thus cracks, laminations and other discontinuities that act as metal-gas interfaces can easily be detected.

The principal advantages of ultrasonic inspection are that it can determine, to a degree, the position, size, nature and orientation of flaws (e.g., internal cracks) located deep within the component. In addition, it provides instantaneous indications of flaws and its high sensitivity permits the detection of extremely small flaws. All examinations performed shall be done according to a written procedure.

Liquid Penetrant and Magnetic Particle Test

Guidance

Members of the Workforce should use liquid penetrant and magnetic particle tests to inspect only the **surface** of a material or assembly. The liquid penetrant method is used to detect discontinuities which are open to the surface of the material being examined. This method may be used on both ferrous and nonferrous materials. Liquid penetrant examination may be used for the detection of surface discontinuities such as cracks, seams, laps, cold shuts, laminations and porosity.

Members of the Workforce should use the magnetic particle method only on ferromagnetic materials to reveal surface discontinuities and, to a limited degree, those located below the surface. The sensitivity of this method decreases rapidly with depth below the surface being examined, and therefore it is used primarily to examine for surface discontinuities.

Acoustic Emissions

Guidance

Members of the Workforce should use the acoustic emissions NDE method to show the existence, general location and growth of flaws. Acoustic Emission (AE) describes a phenomenon whereby transient acoustic waves are generated by a material undergoing localized inelastic strain (e.g., delamination, crack growth or fracture). AE is used to detect and locate flaws during proof testing of pressure vessels. It is capable of detecting severe flaws in time to allow depressurization before catastrophic failure occurs.

Note: The acoustic waves propagate throughout the vessel from the site of the generating flaw. A single sensor can detect flaw growth in a vessel while an array of sensors can locate the site of the growing flaw. AE performs a 100% volumetric inspection of a vessel without scanning. The only flaws that it detects are flaws that are activated by the pressurization; flaws that are not affected by the pressurization, and are therefore benign, are not detected by AE. The sensitivity is such that the fracture of a single crystallite in a metal can be detected.

Note: AE monitoring is done in real time so that a measure of the flaw growth as a function of time or pressure is always available to the operator. AE is capable of determining the severity of the flaw with increase in pressure but it cannot determine the actual size of the flaw. Once AE has located a flaw, sizing should be done by ultrasonics or radiography.

PERIODIC REEVALUATIONS OF PRESSURE SYSTEMS

Manager Activities

Requirements

Managers shall:

- Ensure that periodic reevaluations of all pressure systems are performed for safety and for proper maintenance (see Ch. 9).
- Establish initial criteria upon which reevaluations are based in the original "Data Package" or Pressure Safety Analysis Report (PSAR).

Guidance

Managers should consider the following information when establishing intervals for reevaluation, testing, inspection, and maintenance of pressure systems:

- **Reevaluation:** This is a formal analysis of the safety and integrity of the pressure system performed at specific intervals to assure that the particular system components have not degraded beyond any of the criteria specified for that system.
- **Testing:** Testing, to include any form of NDE (usually performed on a vessel), may be part of the overall **reevaluation** of a system, or part of the specified

requirement for a particular component (such as the testing and tagging of relief valves).

- **Inspection:** Inspections should be made at frequent enough intervals to assure that no component of the system is in an inoperable condition prior to use. This could be as often as daily, prior to use, or as part of the Periodic Evaluation, depending on the type of component or system and the hazards involved.

  Examples:

  - Inspect and test relief valves (see Ch. 9)
  - Check the condition of hoses, fittings, and tubing
  - Verify proper pressure manifold installation

- **Maintenance:** Any component replacement, cleaning, or inspection is considered part of the maintenance requirements for that system.

Note: This information is specified in the controlling document for the system. The intervals and procedures should be monitored by the user organization to assure that the appropriate functions are performed at the specified intervals. This could be controlled by an operator's service log, start-up/shut-down procedures, operating procedure or division recall system (e.g., computer or index tickler file).

Reasons for Reevaluating Pressure Systems

Guidance

Managers should be aware that pressure systems deteriorate over time, just as does any piece of equipment. The amount of attention placed on a system is based on an evaluation of the degree of hazard associated with the failure of any component. System design, maintenance, component replacement, inspection, de-rating, re-test, or removal from service, should **not** be accomplished after the fact (e.g., after a component failure, unless the failure mode is acceptable, e.g., regulator no longer regulates). The system user is in the best position to make these determinations, using the guidance provided and with consultation as necessary. Some intervals are specified as requirements; others are recommendations (see Ch. 9).

Reevaluation Criteria

Guidance

Managers should be aware that environmental effects are among the primary causes of time-dependent degradation and are important considerations for pressure system evaluations. Stress corrosion cracking, for example, is one of the most common causes of pressure vessel failure. When discussing fatigue, it is the environmentally assisted failures which are the most common. When incompatible materials are used together with cyclic loading, corrosion fatigue becomes a primary failure mode. Thermal cycles should be factored into fatigue considerations. In these situations, crack initiation and/or growth can be assessed by nondestructive evaluation techniques.

Managers should reevaluate pressure systems for the following reasons:

- **Corrosion allowance/hostile environments.** Some working fluids are corrosive and inspection intervals are established to assure that the system does not deteriorate beyond allowable limits. External environments can also contribute to the deterioration of system components, such as relief valves.

- **Materials properties, mechanical fatigue.** Flaws can be expected to grow as a function of the fluctuation of stress intensity of the flaw and the environment. Material property characteristics and criteria are to be analyzed as part of the initial system evaluation, and reevaluated at established intervals to determine how serious the effect is.

- **Component limitations.** Certain components may have limited life or critical replacement intervals. The reevaluation process confirms these requirements and intervals.

- **Conversion of the system to a different use.** The reevaluation establishes the adequacy and integrity of the system under its intended new application.

- **Structural modifications.** The potential of invalidating the *ASME Code* of a pressure vessel, or affecting designed safety or operational aspects of a system, are reevaluated.

When to Reevaluate Pressure Systems

Requirements

Managers shall ensure that pressure systems that are the high energy/high hazard or unique systems have a formal reevaluation as required by their PSAR, but not less frequently than:

- Every 5 years.
- After 1000 pressure cycles, based on service log entries.

  Note: The PSAR establishes the reevaluation criteria and interval. Generally, system degradation will be based on a certain number of cycles where a reevaluation, such as some form of NDE, is required. When the reevaluation criteria is not dependent upon the number of pressure cycles, an adequate time interval is specified.

Guidance

Members of the Workforce should develop a reevaluation program for all pressure systems when they are installed. Since life evaluation considerations are very system dependent, the users should consult their PA and seek assistance from appropriate personnel in Appendix F. This will help the user establish reevaluation intervals, as well as the type of inspections and tests which should be performed at that time. The reevaluation program should take into account factors such as cracking, corrosion, effects of other adverse environments, the type and likelihood of failure (are there welds which require periodic inspection?) and the consequences of failure. Finally, the reevaluation program should be documented and placed in the permanent records for the pressure system (PSAR, Data Package, etc.) so that the proper inspection intervals can be maintained. Managers may establish more stringent reevaluation intervals. Intervals for systems with a corrosive working medium should be more frequent. Because all pressure systems are unique, it is not possible to give a specific interval that would apply to all systems. Inspection and reevaluation intervals are determined by each owning organization, using the guidance provided in this manual along with assistance from your PA and other experts listed in Appendix F.

All Other Systems: Managers and the pressure system owner are responsible for establishing reevaluation intervals, and should make use of all available assistance, including their Pressure Advisor, when determining these intervals (see Appendix F).

Overpressure testing: Managers should have overpressure testing done as part of the reevaluation process if either of the following conditions is met:

- The original overpressure test has been invalidated
- The age of the system dictates another overpressure test.

Some form of NDE, such as acoustic emission, should also be employed during the overpressure test. The process consists of more than simply observing that failure did not occur.

Note: Do not automatically perform an overpressure test when reevaluation is due. Unless the reevaluation criteria for the vessel established a requirement for an overpressure test at a specified interval, or it is determined one is necessary, an overpressure test may not be beneficial to the vessel, especially without other NDE techniques included to provide amplifying information. See "Limitations of Overpressure Test" in this chapter.

Note: Overpressure testing cannot by itself qualify a vessel, but is only one of the three criteria discussed in Chapter 4. The Data Package should contain confirmation that these criteria have been met.

Alternatives to Overpressure Testing

Guidance

Managers should consider the following alternatives when reevaluation shows the need to perform an overpressure test, but the test is difficult or impractical to conduct:

- Lower the MAWP (de-rate the system). The reduced amount should be established as part of an analysis where consultation from the appropriate support organizations is involved.
- Provide protective shielding around the component in question, or between that component and the operator.

Use of Available Assistance

Guidance

Managers should make use of a wide array of assistance within SNL. The Pressure Advisor is always the first point of contact. The PA has the training to help the user establish a proper reevaluation program. Experts are also available to help the user in more specific areas such as stress analysis or nondestructive evaluation. Appendix F lists these SNL Personnel.

Note: This assistance is especially important in instances where non-code (e.g., in-house) designs have been carried out with minimal analysis, certification and documentation. In these cases, a more in-depth reevaluation process is needed to prove a continued safe operation.

Documentation

Guidance

Members of the Workforce should document the reevaluation program and retain the documents with the pressure system permanent records. SF 2001-CPA, "Pressure System Checklist for Pressure Advisors" (Word file/Acrobat file) is reviewed by the reevaluation program for any necessary action items. This procedure will help the user adhere to the proper inspection intervals and evaluation tests. Similarly, all reevaluation results should be retained with the pressure system documentation. For example, the results may include, a memo from the acoustic emissions test engineer which states, "Use of the pressure system may continue. However, another retest should be performed in two years." Additional inspections or maintenance procedures provide useful information during the reevaluation phase. These items should also be recorded in the pressure system records.

PRESSURE SYSTEM REEVALUATION CHECKLIST

Guidance

Members of the Workforce should use the Pressure System Reevaluation Checklist, which was prepared to assist in performing a consistent periodic evaluation of pressure systems. It was written to be general but addresses most of the important pressure safety considerations. It is intended as an aid in evaluating the safety of your pressure systems and is not a mandatory part of the pressure system data package.

Note: Attachment 6-1, Pressure System Reevaluation Checklist (Word file/Acrobat file) is only an example. Members of the Workforce can develop their own checklist, tailored to meet their specific needs. This checklist guides Members of the Workforce through all aspects of a pressure system. If further evaluation is required, this form will help identify what additional analysis will be required.

Members of the Workforce should perform the following tasks as a comprehensive pressure system reevaluation:

- **Data Package Review.** Any reevaluation begins by studying the pressure system being inspected. Look over the data package. Does it address the failure modes, MAWP, and system contents? The data package should address reevaluation and should state what evaluation tools you will be employing and at what intervals.

  Has the failure mode been determined?

  Look in the data package to find the mechanism of degradation for the system. Is it identified? What special features have been incorporated into the system to protect against this type of degradation? This will help you determine what items you will want to pay special attention to during the inspection.

- **Visual Inspection.** In most cases an annual visual inspection will give a good indication of system conditions. This should be supported by a complete history of the pressure system and by documented testing. A baseline should be established to compare inspection results.

- **Visual Internal Inspection.** Many times a visual internal inspection will show if further investigation is needed. Examine the inside of the system for signs of excessive corrosion or erosion. Measurements (see NDE methods) may be required to determine if the corrosion has exceeded allowable limits.

- **Post Inspection Report.** A record of the type of inspection, the findings, and the corrective actions is necessary to develop a long term plan for pressure system operations. This information will also be used to plan the next pressure system evaluation.

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Pressure Safety Manual

7. VERIFYING THE SAFE OPERATION OF PRESSURE SYSTEMS

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MN471000, Issue N
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* Indicates a substantive change

OVERVIEW

Pressure systems (pressure vessels and components) are inherently hazardous. Under certain circumstances stored energy released suddenly can injure personnel and damage facilities. Therefore, before operating a new pressure system it is imperative to perform a preliminary hazards analysis to prevent or minimize hazards.

IDENTIFYING POTENTIAL HAZARDS

Note: Identifying potential hazards is of paramount importance in planning, designing, and setting up workable procedures to assure consistently safe operation of pressure systems. Once a hazard is identified, protective measures can be devised.

Common Sources of Hazards

Guidance

Members of the Workforce should be cognizant that hazards arise from many sources, and that human shortcomings are a principal problem in assuring the safe operation of pressure systems. Some common hazards are:

- Human error - failure to follow established procedures; untrained operators.
- Unexpected high pressure.
- Unexpected temperature changes.
- Built-in defects.
- Lack of established procedures that are clear, concise, and easy to understand.
- Lack of fail-safe mechanisms (e.g., interlocks and pressure safety devices).
- Modifications.
- Detrimental combination of unusual events.

- Loss of electrical power resulting in trapped pressure volumes.

Typical Questions

Guidance

Members of the Workforce should address the problem of providing a safe pressure environment by asking, and satisfactorily answering, pertinent questions **in advance of operations.** Typical questions to identify important hazards include:

- How much energy would be released if the system suddenly failed?
- Is a Pressure Safety Analysis Report (PSAR) required? **If yes**, has it been prepared and properly signed off (See Ch. 9.)
- Is the system in a manned or high-dollar-value area? **If yes**, have we satisfied all basic criteria, including overpressure-testing of the pressure vessel, as may be required by rules elsewhere in this document?
- Have potential hazards to adjacent work areas been considered?
- Should the system be relocated to further minimize risk?
- Have hazards posed by the presence of toxic or flammable substances been protected against?
- What further design features (e.g., mechanical interlock or entry control) can be incorporated to enhance safety?
- Have emergency shutdown features been provided? Can features be easily activated, and when they are needed, are they effective promptly?
- Have the relief devices been properly set, and are they properly labeled?
- Have pressure vessels been properly identified?
    - Labels on all vessels, as specified in Ch. 4.
- Have personnel been adequately trained to operate the system?
- Is it clear in posted instructions that only personnel designated by the responsible

manager are authorized to operate the system?

- Are instructions available on how to operate the system safely? **If yes**, is the system controlled so that the operator must follow these instructions before startup?
- Are technical work documents (TWDs) current? Have they been signed off by management at the appropriate level?

TECHNICAL WORK DOCUMENT (TWD)

Developing a TWD

Requirements

Managers shall ensure that:

- Pressure system safety and compliance with this manual are documented in a Data Package (see Chapter 9 for full documentation requirements.)
- A TWD is created when identified as necessary in the Preliminary Hazard Assessment (PHA) or if the system has certain additional hazards. A list of hazards that mandate the use of a TWD is included in CPR400.1.1/MN471001, *ES&H Manual*, Chapter 21, "Technical Work Documents (TWDs)."

  Note: A pressure system that meets the *Pressure Safety Manual* requirements does **not** require a technical work document (TWD), although one may be developed anytime Members of the Workforce determine a need to further document system safety.

Review and Approval

Requirements

In addition to the review and approval specified in Chapter 21, the responsible Pressure Advisor shall:

- Review TWDs for pressure systems.
- Sign the ES&H Contact Sheet.

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Pressure Safety Manual

8. SERVICING PRESSURE VESSELS AND COMPONENTS

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* Indicates a substantive change

OVERVIEW

This chapter describes who is responsible for servicing pressure vessels and components, what items need inspection, and how to maintain the equipment in a safe operating condition.

PRESSURE VESSELS AND COMPONENTS

Note: Pressure installations are divided into the following two categories according to use:

- Research and development systems.
- Building pressure systems.

Note: The following organizations share responsibility for servicing pressure systems:

- The line organization
- Mechanical & Structural Engineering Department (10862).

Primary Responsibility

Requirements

The manager shall be responsible for:

- Determining who should maintain the equipment in his or her organization, including building facilities
- Ensuring that either the responsible using organization or the Mechanical & Structural Engineering Department (10862) services the equipment at specified

intervals.

Research and Development Systems

Requirements

Managers of pressure and vacuum systems used in research and development shall be responsible for maintaining these systems.

Building Pressure Systems

Requirements

The Mechanical & Structural Engineering Department (10862) shall be responsible for maintaining building pressure systems. Systems maintained and inspected by the Mechanical & Structural Engineering Department (10862) are identified with a maintenance number. Information about any Maintenance Numbered item may be obtained by contacting any maintenance planner.

Note: Building pressure systems may include, but are not limited to:

- Compressors
- Boilers
- Air receivers
- Air tanks
- Compressed air systems such as air regulators, valves, and hose reels
- Cryogenic liquid or gaseous systems such as nitrogen and hydrogen.

CRYOGENIC SYSTEMS

Conformance

Requirements

Managers of cryogenic systems shall:

- Ensure that systems conform to applicable standards and specifications (e.g., *Handbook of Compressed Gases*, published by the Compressed Gas Association, Inc.).
- Be responsible for system safety and operation.

Designing and Maintaining

Requirements

The Mechanical & Structural Engineering Department (10862) shall:

- Be responsible for designing, modifying, inspecting, and maintaining cryogenic systems.
- Ensure that all safety devices associated with cryogenic systems are certified.
- Ensure that cryogenic system safety devices are periodically inspected.

MAINTENANCE OF COMPONENTS

Requirements

Members of the Workforce shall refer to Table 8-1 for requirements and guidance for the maintenance of pressure system components.

Table 8-1. Requirements and guidance for the Maintenance of Pressure System Components

Components	Requirements	Guidance

Pressure Relief Valves	Owners of pressure systems shall be responsible for pressure relief valve (PRV): • Identification (tagging) and tracking. • Visual inspections. • Operational checks Testing/certification. • Determination of replacement intervals.	
	Continuous Use. Owners of pressure systems shall maintain certification for continued use. Table 8-2 provides guidelines for determining the frequency of evaluation as a function of application.	To help supply information for the certification process, the Materials Engineering Department (9123), or another approved PRV test station, tests and adjusts PRVs in accordance with Appendix J and provides test results to the line organization. **Note:** PRV testing consists of applying pressure to a valve to determine the cracking, popping, and re-seat pressures. See Appendix J for complete details of PRV test procedures and policies.

	Inspections. PRVs shall be periodically inspected for evidence of leakage, corrosion, or other type of damage and for evidence of usage conditions that may cause the valve to malfunction. Inspections are visual external inspections only, and can be done in situ. Always replace, or repair in accordance with factory specifications, any damaged or defective valve.	The valve should be operated manually as part of the inspection, provided this would not present a hazard to personnel or degrade the valve or system performance. The discharge path should be inspected to be sure it is free and will not accumulate unforeseen backpressure.
	New Valves. New valves shall be inspected in accordance with the instructions above for damage or contamination that may have occurred during packaging and shipment. (See Appendix H for information on qualified suppliers.)	New PRVs purchased from qualified suppliers may be accepted for use at SNL for an initial interval without further testing.
Bolts and Other Closure Hardware	Establish a replacement schedule by consulting the stress analysis and materials organizations. Have a qualified vessel design specialist specify the correct torquing procedure, bolt lubrication, and torque limits for the specific sealing application.	Repeated high torquing, fatigue, and corrosive environments can cause premature failure.

Flexible Hoses, Fittings, and Tiedowns	• Hoses, fittings, and tiedowns need frequent inspections. • Replace these items if they appear damaged or excessively worn, or if leakage is detected in the hose or fittings.	
Valves and Fittings	• Replace valves and fittings periodically, depending on their condition and the corrosive effects of the pressurizing fluid. • Establish a replacement or retest schedule by consulting the stress analysis and materials organizations.	
Seals	• Periodically check O-rings, gaskets, and packings for leaks. • Replace as needed.	
Filters	Establish a regular schedule to clean and change filter elements.	

Regulators	• Managers shall establish more stringent replacement intervals based on the operating conditions of regulators. • Dates of installation shall be recorded in the system documentation. • Replacement intervals shall be established.	Regulators may be procured through the JIT supplier. Damaged or improperly operating regulators should be replaced. **Note:** Make sure that regulators are designed for the proper medium. Regulators should not be depended upon as a safety device to prevent overpressurization. Regulators should be reworked or replaced by the supplier at regular intervals based on the following: • Degree of hazard (pressure, working fluid). • Consequences of a failure (exposure of personnel to a hazard vs. failure to regulate). Recommended intervals: • Inert gas, <2500 psig: 5 years. • Corrosive or toxic gas or >2500 psig: 3 years.

Temperature Effects

- In many buildings, automatic shutdown systems for heat and air conditioning have been installed as energy-saving devices.
- A drop in temperature in building heating systems could cause failure of vessels fabricated from certain materials, such as coarse-grained A515 steel.
- Managers who have pressure systems in buildings with automatic shutdown for heat and air conditioning should take the following precautions:
    - Consult with the materials specialist
    - Arrange with Facilities Operations and Maintenance Department to maintain the work area at a safe temperature level.

Note: See Chapter 3 for a discussion of materials considerations.

Guidance

Members of the Workforce should consider the following table for the testing of pressure relief valves. If variations of intervals from the schedule are necessary, appropriate documentation should be developed to document the justification of the intervals changes. For further guidance, consult the pressure safety SMEs.

Table 8-2. Summary of Relief Valves by System Use, Inspection and Recommended Testing Intervals, and Responsible Organizations

Operating Conditions	Inspection and Testing Intervals
Inert Applications (under 3000 psig) dry air, gases or liquids not reactive to valve materials, and non-glutinous fluids	• Inspect annually • Test & tag every 3 years
High Pressure Applications (over 3000 psig)	• Inspect annually • Test & tag every 2 years

Harsh Internal or External Environments, corrosives, glutinous or reactive fluids, otherwise damaging environments	• Inspect every 6 months • Test & tag annually
Notes: Satisfactory test results do not alone validate the proper application of a PRV. Also consider such things as MAWP, flow capacity, correct placement, and ramifications of valve leakage in PRV applications. PRVs on pressure vessels manufactured under ASME Sections I and IV should be maintained in accordance with the recommendations of ASME and the National Board of Boiler and Pressure Vessel Inspectors in order to keep their ASME Code status current. Sandia will not attempt to provide flow capacity measurements or ASME approved repair functions, and can only perform an operational check to determine the cracking and re-seat pressures of ASME Code valves. The Facilities organization meets the need for "test and tag" by periodically exercising and inspecting pressure relief valves according to Maintenance Job Plans. This type of valve does not need to be tagged.	

MAINTAINING PRESSURE VESSELS

Internal Corrosive Conditions

Guidance

Members of the Workforce should periodically:

- Check vessels with internal corrosive environments for reduced wall thickness by visual inspection and NDE techniques (see Appendix F, Pressure Safety Assistance Index).
- Inspect vessels and systems to ensure that no unauthorized modifications have been made.

- Ensure that all safety relief devices for the vessel are in place and functioning properly.

SPECIAL SERVICING RISKS

CAUTION **Caution:** Special care is needed in some situations to safeguard against certain risks when servicing pressure vessels and components.

Requirements

Note: Obtain prior approval for special cases from the appropriate ES&H organization.

Members of the Workforce shall consider the following special cautions when servicing pressure vessels and components:

- Location of relief devices. Do **not** isolate the relieving device from the pressure system it is protecting.
- Repair of pressurized systems. Do **not** repair a system when it is pressurized.
- Oxygen systems. Assure that oil and grease do **not** get into valves, fittings, and pipes of oxygen gas systems.
- Compressors. Obtain guidance from the Mechanical & Structural Engineering Department (10862) in preventing fires and explosions in compressors.

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Sponsor: Dori Ellis, 4000, Acting

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Pressure Safety Manual

9. DOCUMENTING THE OPERATIONAL SAFETY OF PRESSURE SYSTEMS

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
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*Indicates a substantive change

DOCUMENTATION CRITERIA

Requirements

Managers shall ensure that:

- All pressure systems are documented in a formal "Data Package" in accordance with the criteria described in this chapter.
- The integrity of pressure components is documented.

Note: Some pressure systems may require additional documentation depending on the hazards associated with them. When doubt exists concerning the degree of hazard, obtain guidance from the appropriate consultants listed in Appendix F.

Guidance

Managers should use a graded approach to documentation depending on the:

- Complexity of the system.
- Applicable codes or standards
- Method of procurement, design, and fabrication.

DATA PACKAGE

Note: The Pressure Data Package serves as a tool for design review of the pressure system. The amount of information contained in the Data Package varies with the complexity of the system. The Data Package contains all the facts and evaluations that have been made and are needed for:

- Documenting compliance with this manual (this implies compliance with applicable codes, standards, and practices).
- Formally evaluating the system after persons familiar with it are gone (to include reevaluation criteria for vessels or components).
- Answering the question, "Is this system safe to operate in a manned area?"
- Use as a training tool for pressure operators.

Requirements

Managers shall ensure that the Data Package that they approve:

- Is maintained for the life of the pressure system.
- Is revised to reflect modification of, or additions to, the system, vessel(s), or other components.
- Contains special precautions implemented to ensure that non-rated components or hazardous configurations are not inadvertently used.
- Is on file and is retrievable.
- Is traceable to the system it documents.
- Is reviewed and signed by the personnel responsible for the system, including:
    - Data package author.
    - Pressure Installer.
    - Pressure Advisor.
    - All system users.
- Contains, as a minimum, the following information:
    - Materials used and suitability.
    - Pressure ratings of vessels and components.
    - The factor of safety for specially designed, non-Code-stamped vessels, usually determined by structural analysis.
    - The performance of proper overpressure tests.
    - Consideration of hazards.
    - Design and fabrication data for custom components.

Note: The rating associated with commercial components obtained from recognized pressure hardware suppliers, usually the MAWP, is based on the recognized Code or standard applicable to those components. Unique components are those which are not available from commercial suppliers as off-the-shelf components. They must meet the applicable code or standard. These components are similar to vessels in their documentation requirements. When there is doubt concerning the adequacy of any pressure component, seek additional information. Your Pressure Advisor can help you with this effort.

Members of the Workforce who prepare Data Packages shall include the following content:

- Cover sheet with the following: Data Package, System's name, location, required signatures.
- Abstract - summarizes the pertinent information about the system, why it is adequate and safe to operate, and highlights any special requirements or analyses.
- Design criteria and specifications (for vessels or unique components).
- Drawings (system configuration, and vessel or unique component drawings when applicable).
- Materials and process callouts (vessels and unique components).
- The rated MAWP for each component (e.g., tubing, fitting, valves, vessels).
- Any structural analysis or materials approval (generally for vessels or unique components).
- Operating parameters (temperature ranges, cycles, restrictions).
- Factors of safety (for vessels or unique components).
- If system doesn't have a PSAR, provide justification.
- Date placed into service, and periods of required replacement, cleaning, servicing, inspecting, and testing of components. (See Ch. 8 for recommended intervals.)

  Note: The Data Package documents these requirements for the type of vessels and components unique to the system. In order to track these intervals, other mechanisms must be in place such as a tickler file or recall system.

- Overpressure tests, accomplishment date, temperature or special conditions, and pressure (for vessels and unique components).
- The Manufacturer's Data Report (Form U-1) for *ASME Code* pressure vessels.

  Note: Form U-1 is available for vessels carrying the *ASME Code* stamp and registered with the National Board of Boiler and Pressure Vessel Inspectors (called the National Board) of Columbus, Ohio. However, the forms lack supplementary procurement notes essential for material and process definition. Include this information in the Data Package when it is necessary because of requirements unique to that vessel.

- Reference should be made to other technical work documents (TWDs) pertinent to the system such as ES&H SOPs, Service Logs, Operating Procedures, or maintenance and servicing guides.
- Date of last reevaluation.
- Description and date of permanent modifications.
- Pressurization mediums allowed.
- Memos and reports supporting original evaluation and all subsequent evaluations.
- Calculations showing that the relief device has the proper flow capacity to protect all pressure components in the event of a pressure rise.
- Signature page for all users.

Managers shall **not** require that a Data Package be created for the following:

- Components that are standard, commercially available shop tools, or heating, ventilating, and air conditioning (HVAC) systems. These systems are inspected and maintained by Facilities Engineering. Where industry practices require documentation, such as U-1 Forms on ASME Code registered and stamped air receiver tanks, Facilities Operations will maintain these documents for all like systems.

- DOT gas or liquid supply cylinders and tanks. These items are stamped and tested at the required intervals by the vendor. They should be documented in the system "Data Package" to indicate the pressure source and maximum pressure available.

Note: For Facilities applications, the informational intent of the Data Package is satisfied through the Facilities design specifications that are maintained in the Facilities Technical Library and Procurement Project files, and Operating and Maintenance instructions, specifications, and records that are are maintained in the appropriate Building Mechanic's office and are tracked through the MAXIMO database.

PRESSURE SAFETY ANALYSIS REPORT (PSAR)

Note: The PSAR is a special report generated and approved, by signature, by the line organization intending to use the pressure system. It is used by management for the engineering analysis of certain pressure systems with high hazard potential. It addresses pressure hazards, describes how concerns are approached, and documents compliance with SNL's safety policy. The PSAR engineering analysis of a pressure system has two major goals:

- To evaluate the structural integrity and overall safety of a pressure system
- To provide supervisors additional oversight and control, beyond the basic Data Package, for more hazardous pressure systems.

Requirements

Managers shall task Pressure Installers to develop PSARs when any of the following conditions is present in the system:

- Use of brittle material.
- Any system that has a factor of safety of less than **3.5** and does not fall under the jurisdiction of accepted codes or standards.
- Vacuum systems greater than 70 ft^3.

- For any secondary containment.
- Any system that requires a service log.
- If adequate overpressure testing cannot be conducted (see Ch. 6).
- When a preliminary hazard assessment indicates the need for a PSAR.
- When used pressure systems come into Sandia, **regardless** of previous successful operating experience elsewhere.

Managers shall **not** require a PSAR if the system meets any of the following criteria:

- The only pressure vessel in the system is a DOT-approved cylinder.
- The components are standard, commercially available shop tools, machine tools, or heating, ventilating, and air conditioning (HVAC) systems. The pressure system is operated as an unmanned operation or behind a barricade.

Managers shall ensure that a PSAR they are approving:

- Is reviewed and signed by the personnel responsible for the system, including:
    - PSAR author.
    - Pressure Installer.
    - Pressure Advisor.
    - All system users.
- Is maintained with the Data Package.

Guidance

Managers should consider using a PSAR for the following:

- To evaluate the safety of a new pressure system.
- When an existing system is modified.

- When using oxidizing, toxic or flammable fluids.
- When using new materials that need evaluation.

SERVICE LOGS

Requirements

Managers shall:

- Determine which pressure systems require the use of service logs (i.e., that are operating outside of normal conditions).
- Ensure that service logs contain, at least, the following information:
    - Identification of pressure system.
    - What fluid is contained.
    - For systems known to have limited operational life, record cyclic pressure levels (maximum, minimum, and nominal) and number of cycles.
    - Test dates.
    - Operating temperatures.
    - Description of modifications and switchout of parts and date performed.
    - Operators.
    - A record of any maintenance that may relate to continued safe operation.

Members of the Workforce shall maintain a service log for any pressure system that the manager determines is operating in an adverse environment or that is subject to multiple modifications or deviations in the mode of operation as a way of ensuring the continuing safety of the system.

> **Note:** Examples of some adverse operating conditions are:

- Alternating pressures.
- Low operating temperatures.
- Corrosion.
- Any combination of these factors.

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Pressure Safety Manual

APPENDIX A – PRESSURE SYSTEM CHECKLIST FOR PRESSURE ADVISORS

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
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OVERVIEW

SF 2001-CPA, Pressure System Checklist (Word file/Acrobat file) is not intended to be all-inclusive, but is a convenient tool for listing some of the more important pressure safety considerations. Attention to the detailed practices in this document will help users gain more confidence in the safety of the pressure system.

PRESSURE SYSTEM INVENTORY

Guidance

Note: Pressure Advisors (PAs) form the core of Sandia National Laboratories' Pressure Safety Program. Every applicable research, development, and service organization should have its own PA. The number of PAs may vary according to the size of the various organizations. The number of PAs should be such that each PA can be familiar with the location of pressure systems within his or her responsibility.

PAs should be familiar with the location and types of pressure systems in their jurisdiction. If there are too many systems for one PA to manage easily, managers should appoint enough additional PAs to balance the oversight burden (see Ch. 2, "The Pressure Safety Program.").

PAs should be aware of the pressure system inventory information presented in the following PSM chapters:

- Minimizing Risks and Exposures (see Ch. 3, "Pressure Safety Practices").
- Periodic Re-evaluations of Pressure Systems (see Ch. 6, "Testing and Evaluating Pressure Systems").
- Identifying Potential Hazards (see Ch. 7, "Assuring the Safe Operation of Pressure Systems").

PRESSURE SYSTEM DOCUMENTATION

Guidance

Members of the Workforce who are responsible for pressure system documentation should be aware:

- Of the following key elements of pressure system safety:
  - Adequate factor of safety, usually a factor of safety of **3.5,** based on ultimate strength.
  - The demonstration of proper materials and processes.
  - Adequate and documented overpressure testing prior to placing pressure system into service.

- That pressure system safety documentation includes:
    - Labeling Pressure Systems/Vessels (see Ch. 4, "Procuring Pressure Vessels and Special System Components").
    - Maintaining Records (see Ch. 4, "Procuring Pressure Vessels and Special System Components").
    - Technical Work Documents (TWDs) (see Ch. 7, "Assuring the Safe Operation of Pressure Systems").
    - Pressure Safety Analysis Reports (PSARs) (see Ch. 9, "Documenting the Operational Safety of Pressure Systems").
    - Data Packages (see Ch. 9, "Documenting the Operational Safety of Pressure Systems").
    - Service Logs (see Ch. 9, "Documenting the Operational Safety of Pressure Systems").

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APPENDIX C – PIPING AND TUBING NOTES

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
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Note: This appendix provides a location for miscellaneous information regarding piping and tubing.

Alternative for Calculating the MAWP of Piping and Tubing

The *ASME Code*, Section VIII, is based on the Tresca or Maximum Shear Stress criterion. To apply this criterion to piping or tubing:

First, calculate the maximum principal stress (maximum hoop stress)

$$\sigma_\theta = \frac{P(ID^2 + OD^2)}{OD^2 - ID^2}$$

Second, calculate the minimum principal stress (minimum radial stress)

$$\sigma_r = -P$$

Subtract the minimum princial stress from the maximum principal stress to get twice the maximum shear stress.

$$2\tau_{max} = \sigma_\theta - \sigma_r = P\left(1 + \left(\frac{ID^2 + OD^2}{OD^2 - ID^2}\right)\right)$$

Twice the maximum shear stress must be a factor of 4 less than the tensile strength of the material

$$2\tau_{max} \le \frac{\sigma_{ALT}}{4}$$

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APPENDIX D – VACUUM SAFETY

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OVERVIEW

This appendix contains the pressure safety requirements for vacuum systems and includes information on the following:

- Approved and reputable suppliers
- Guidelines for acceptable design and system specifications
- Design and system requirements for systems not fabricated by approved manufacturers
- Vacuum system pressure sources and overpressure protection techniques
- Vacuum application pressure relief devices
- Gravity/vacuum closure devices and procedural controls for overpressure protection
- Precautions for gauges and other devices
- Requirements when using brittle materials
- Precautions for vacuum viewports and nonrated components
- Precautions for vacuum pumping systems

- Requirements for data packages and pressure safety analysis reports
- Guidelines for documenting vacuum systems

INTRODUCTION

What Are Vacuum Systems?

Guidance

The term "vacuum" refers to a space that has gas pressure below ambient atmospheric pressure. These systems may present some hazards and employ components that are unique and separate from pressure systems where the gas-pressure is greater than ambient atmospheric pressure. A vacuum system includes all of the components, e.g., the main vacuum vessel, plumbing, and pumps.

Negative Internal Pressure

Guidance

Vacuum systems contain less than ambient atmospheric pressure, also referred to as "negative internal pressure." Measurements of the remaining gases in vacuum systems are referred to as pressure measurements (operating pressure or system ultimate pressure), and are typically in absolute units, such as microns, torr, millibar, or pascals.

Note: The *ASME Boiler and Pressure Vessel Code*, Sec. VIII, Div. 1, Part UG-28 refers to these systems as being under "external pressure."

Positive Internal Pressure

Guidance

Systems containing pressures greater than ambient atmospheric are differentiated from negative internal pressure systems by referring to them as "positive internal pressure" systems. Pressure measurements for positive internal pressure systems are often not in absolute units but are commonly in gauge pressure units (typically, pounds per square inch gauge [psig]).

Vacuum-Only Systems

Guidance

"Vacuum-only" systems are systems in which all intended processes or experiments are conducted at pressures less than ambient atmospheric pressure. These systems are brought up to atmospheric pressure for backfill and venting operations. Minimal positive (greater than ambient atmospheric) internal pressures may be allowed for purge purposes when opening a system to the atmosphere.

In general, vacuum-only systems are designed for negative internal pressure and contain components and design concepts that make a positive internal overpressure test inappropriate. Therefore, other means may be used to determine the safety of these systems.

Vacuum-only systems must be protected from accidental overpressurization by applicable protective devices or techniques discussed in this appendix.

Pressure Sources Associated with Vacuum Systems

Requirements

System owners shall address the possible effects of any positive-pressure sources, such as process or backfill gases, connected to the system when considering the vacuum system's safety and approach to overpressure protection.

Vacuum Systems Used at Positive Internal Pressures

Requirements

System owners shall be aware that vacuum systems that are also used at positive internal pressures are subject to the requirements of the *Pressure Safety Manual*.

Pressure Safety Related to Vacuum Systems

Guidance

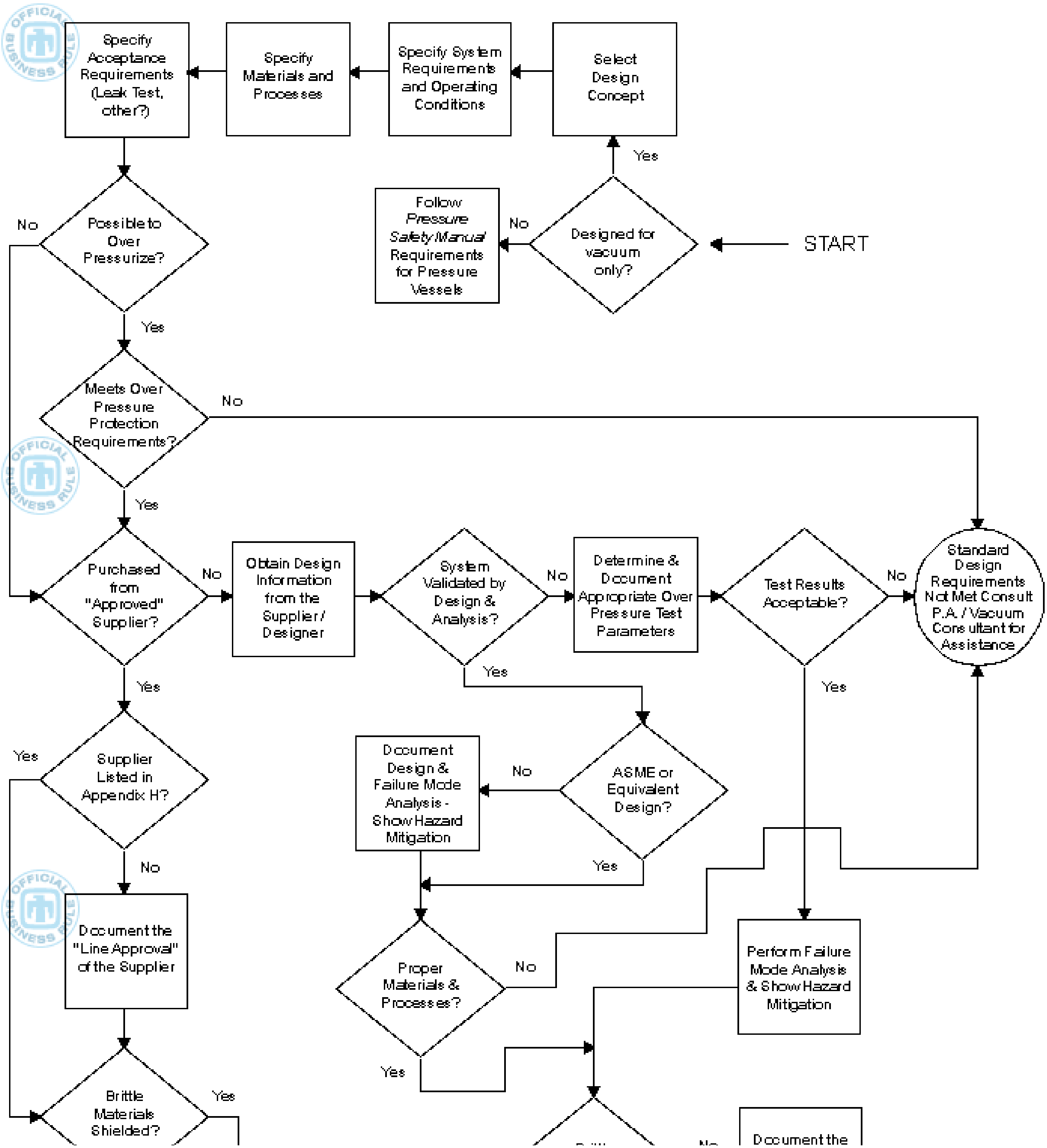
Vacuum systems, like all pressure systems, are required to be safe when used in occupied areas. A thorough approach to the pressure safety aspects of vacuum systems involves evaluating systems to ensure that they meet the following requirements:

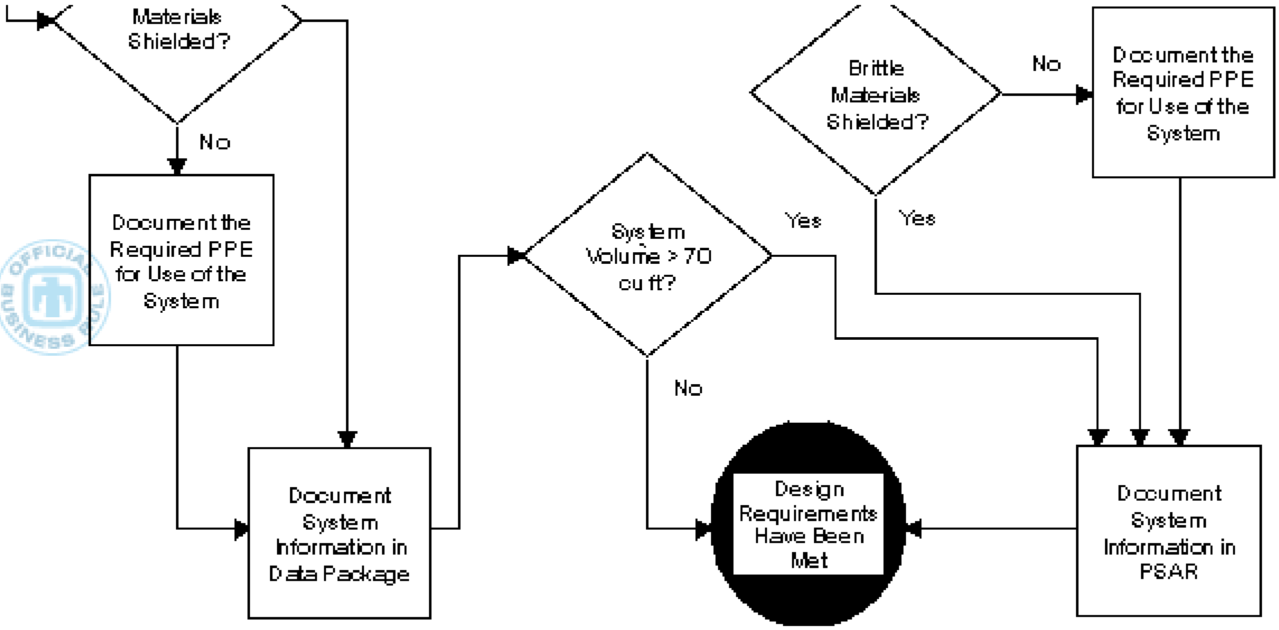
- Design and fabrication employing industry standard practices that provide an adequate safety factor with respect to the mode of intended use and the predicted failure mode.
- Proper materials and processes of construction.
- Appropriately rated components for the given application.
- Identification of all pressure sources associated with the vacuum system.
- Adequate overpressure protection from pressure sources associated with the system.
- Shielding or isolation of certain nonrated or brittle material components or the use of personal protective equipment in the vicinity of these components.
- Documentation of the system safety.

Flowchart for Evaluating Vacuum Systems

Guidance

The following is a vacuum system design guidance flowchart that presents the suggested steps for evaluation of a vacuum system.





APPROVED AND REPUTABLE SUPPLIERS

Who Are Approved and Reputable Suppliers?

Guidance

The terms "approved" and "reputable" indicate suppliers who have a proven history of acceptable quality products and who adhere to industry standard design parameters with respect to the following:

- Materials of construction
- Wall thicknesses
- Adequate safety factors
- Fabrication techniques

Experience shows that vacuum systems (or components) fabricated by reputable manufacturers adhere to acceptable safety standards. The acceptance and documentation of these systems is therefore simpler than that of systems or components not fabricated by reputable manufacturers.

Criteria for an Approved Supplier

Guidance

A vacuum system meets the safety requirements of this manual if that system is purchased from an "approved" supplier, which includes systems assembled from commercially available components from approved suppliers. The following are factors for approving a supplier:

- Industry experience in the acceptable design and fabrication of similar systems
- The time as a "reputable" supplier (preference is given for five or more years). Suppliers with less than five years experience may be approved if they can show experience in the acceptable design and fabrication of similar systems.

Who Approves Suppliers?

Requirements

The system owner shall approve the supplier, with the agreement of the SNL organization manager, pressure advisor or vacuum consultant, and any applicable SNL purchasing agent.

Note: An SNL pressure advisor shall sign all purchase requisitions for vacuum systems and components in the special approval block of the Purchase Requisition Form as required by CPR500.2.1, *Procurement Manual*, Section 3.1.2.5, "Special Handling and Notification Copies."

Listing of Approved and Reputable Suppliers

Guidance

Vacuum system personnel should see Appendix H for a listing of reputable vacuum equipment manufacturers who may be approved for fabrication of a vacuum system. This list is not intended to be all inclusive; other suppliers may be approved by the SNL organization involved with the acceptance of the system.

ACCEPTABLE DESIGN AND SYSTEM SPECIFICATIONS

Steps for Designing, Fabricating, or Purchasing a Vacuum System

Guidance

Vacuum system personnel should use a step-by-step approach when specifying, designing, fabricating, or purchasing a vacuum system such as the following:

1. Select a design concept.
2. Specify and define the system requirements and operating conditions.
3. Select or specify the materials and processes.
4. Specify any leak rate testing or other certifications that may be required for acceptance of the system.

Selecting a Design Concept

Guidance

Vacuum system personnel should consider the following when selecting a design concept:

- Use vacuum **industry standard** design parameters for systems fabricated by reputable suppliers.
- Show an adequate safety factor with consideration to a safe failure mode for systems not fabricated by reputable manufacturers. Use *ASME Boiler and Pressure Vessel Code*, Sec. VIII, Div. 1, Part UG-28 as a minimum standard for vacuum systems. This does not imply that vacuum systems require an ASME Code stamp; the ASME Code stamp is not available from many of the industry leading vacuum system manufacturers.

  Note: Vacuum industry standard designs are generally based on structural stiffness and minimization of deflection as incorporated in *ASME Boiler and Pressure Vessel Code*, Sec. VIII, Div. 1, Part UG-28 for shells and tubes under external pressure. Conversely, ASME requirements for positive internal pressure design are based on yield parameters.

  Note: Welding techniques for vacuum systems may differ from those of positive-pressure systems. Skip welding (for example, on the outside of flanges) allows for leak testing and minimizes virtual leaks.

Specifying System Requirements and Operating Conditions

Guidance

Vacuum system personnel should consider the following when specifying and defining the system requirements and operating conditions:

- Include a complete description of the size and geometry of the system.
- List specific requirements (e.g., on pumping ports, access ports, instrumentation requirements, and types of flanges to be used).
- Specify ultimate system pressure and the expected operating pressure regime of the system.
- Identify the system gas load (e.g., list the gas species and estimate the process gas load, leakage, and outgassing) and specify the pumping speed(s) and types of pump(s) expected to be used to evacuate the system.
- Specify the time allowed to achieve the ultimate system pressure and any applicable bakeout times and temperatures required to achieve this ultimate pressure.

Selecting or Specifying Materials and Processes

Guidance

Vacuum system personnel should consider the following when selecting or specifying materials and processes:

- Consult with materials experts about the proper selection of the vacuum system's materials of construction. Generally, the materials should exhibit a ductile failure mode throughout the range of operating temperatures.
- If applicable, specify the system's requirements for ultimate pressure, temperature ranges, permeation and desorption characteristics, and compatibility with system process gases that may adversely affect the material's properties.
- If applicable, specify production processes for the materials of construction. For example, vacuum melted stainless steel may be an appropriate specification for systems expected to be operated in the ultra high-vacuum (UHV) range.
- Specify vacuum industry standard weld designs that minimize leakage (actual or virtual).
- If applicable, specify other parameters, such as surface finish or cleaning/bakeout procedures, for certain vacuum applications.
- Compile applicable documentation of the above design parameters, including any applicable engineering drawings or calculations, for the system data package.

DESIGN AND SYSTEM REQUIREMENTS FOR SYSTEMS NOT FABRICATED BY AN APPROVED MANUFACTURER

Using Suppliers Who Are Not Listed as Approved and Reputable

Requirements

Vacuum system personnel shall:

- Request additional information from suppliers **not** listed as approved and reputable or compile the additional information to ensure that the vendor can meet the safety requirements of this appendix.
- Perform a thorough design review before suppliers begin fabrication when dealing with suppliers without a proven history.

Design and Processing Criteria

Requirements

Vacuum system personnel shall accept that a vacuum system **not** fabricated by an approved supplier meets the appropriate design and processing criteria if information from the supplier that describes materials of construction, welding, and system design parameters has been obtained and the system meets one of the following:

- The system has been qualified with an overpressure test, typically at 1.5 atm (18 to 22 psig, depending on altitude) to confirm the structural integrity of the vessel or component. Determine the specifics of the overpressure test as appropriate for each case.

  Note: ASME code calls for internal overpressure tests. However, most vacuum systems contain components designed for external pressure only, which makes an internal overpressure test inappropriate. External overpressure tests also may not be appropriate for some vacuum vessels.

- The system has been qualified by a safety analysis.

What the Safety Analysis Must Satisfy

Requirements

Vacuum system personnel shall ensure that a safety analysis for a vacuum system from a supplier who is not listed as approved and reputable satisfies both of the following:

- An adequate factor of safety based on the appropriate failure mechanism, which shows the design safety margins for the vessel or component to indicate why the system is safe. The vessel or component should satisfy the requirements of the *ASME Boiler and Pressure Vessel Code*, Sec. VIII, Div. 1, Part UG-28 for shells and tubes under external pressure, or show that the design is equivalent to those requirements.

- Proper materials and processes, including joining processes (for example, welding and brazing) were used in construction of the system.

Note: An external overpressure test is **not** required.

Additional Analysis for Systems Not Meeting the Code

Requirements

Vacuum system personnel shall:

- Ensure that additional analysis is performed for systems that do **not** satisfy the requirements of the *ASME Boiler and Pressure Vessel Code*, Sec. VIII, Div. 1, Part UG-28 or the equivalent. The additional analysis must assess the design safety factor based on the applicable failure mode and show consideration for the consequences of failure and any applicable mitigation techniques to show that the system is safe.

- Ensure that the metal used for vacuum systems must exhibit a ductile failure mode throughout the temperature range of operation; in general, annealed 300 series stainless steels, 6000 series aluminum, and copper/brass alloys meet this requirement.

Systems Used in Harsh Environments

Requirements

Vacuum system personnel shall:

- Consult materials and metallurgy experts to ensure that those materials have sufficient ductility for the application If system operation calls for harsh environments (e.g., containment of corrosives).
- Ensure that Pressure Safety Analysis Reports (PSARs) are completed for systems that are qualified by safety analysis.

Note: The PSAR must consist of the safety analysis along with the standard data package information for the system.

Specifying and Verifying Welds and Brazes

Guidance

When specifying and verifying welds and brazes, vacuum system personnel should consider the following guidelines:

- Specify and verify proper welds and brazes for the joint design and material of construction.
- Determine and perform appropriate tests for each case and detail them in the system documentation.
- Determine and document the consequences of failure.

Note: ASME code calls for internal overpressure tests. However, most vacuum systems contain components designed for external pressure only, which makes an internal overpressure test inappropriate. External overpressure tests also may not be appropriate for some vacuum vessels.

VACUUM SYSTEM PRESSURE SOURCES AND OVERPRESSURE PROTECTION TECHNIQUES

Vacuum System Safety

Requirements

Vacuum system personnel shall provide overpressurization protection for vacuum systems which have identified pressure sources with a safety manifold as shown in Chapter 5 of this manual or shall otherwise adequately protect them by an alternate technique from overpressurization.

Vacuum Systems Versus Positive-Pressure Systems

Guidance

Vacuum systems meet the SNL definition of pressure systems; however, there are basic differences between vacuum systems and positive (greater than ambient atmospheric) internal pressure systems that should be recognized and appreciated to adequately address safety concerns and maintain vacuum system integrity.

Briefly stated, all plausible pressure sources of vacuum systems should be identified and adequate overpressure protection should be provided to protect the vacuum system and components from these pressure sources. Overpressure protection can be implemented using a variety of techniques.

Evaluation of all plausible pressure sources in any given system is necessary to adequately address overpressure protection.

Vacuum system personnel should be cognizant of the following vacuum system pressure sources and overpressure protection techniques.

Process and Backfill Gases

Guidance

Some common pressure sources associated with vacuum systems include process and backfill gases.

Process gases are typically gases supplied from high-pressure gas cylinders. Backfill gases are also supplied from gas cylinders or may be supplied from "house" sources, such as nitrogen gas from a liquid nitrogen tank.

Less Common Pressure Sources

Guidance

Additional types of pressure sources that are not as commonly recognized include the following:

- Liquid nitrogen traps or other cryogenic devices or pumps could leak or regenerate gases into the vacuum system.
- Water-cooling lines fed into the vacuum system could, under failure conditions, also pressurize the system, especially if water leaks contact heated components and produce steam inside the system.
- Vacuum pumps that are connected incorrectly (inadvertent connection of the exhaust side of a mechanical vacuum pump to the vacuum system) could cause accidents.

  Note: Additional labeling of pump inlet and exhaust ports is suggested where this is a possibility.
- A vacuum pump with a three-phase motor could, with improper wiring, turn in the wrong direction

and thereby pressurize rather than evacuate the system.

Effects of Increasing Temperature

Guidance

Increasing temperature may affect system pressure in vacuum systems capable of operation above room temperature. Typically, systems are heated while under vacuum for degassing or process purposes. However, if a closed system is inadvertently backfilled and then heated, pressure could rise significantly. A vacuum system, closed and vented to 1 atm at room temperature, will see a pressure rise of nearly 20 psig when heated to 400°C. This obviously could present a significant hazard that should be mitigated through the use of a pressure relief device or other controls or interlocks.

Positive-Pressure Gas Sources in Vacuum-Only Systems

Guidance

It is common for vacuum-only systems to be connected to positive pressure gas sources in order to admit process or backfill or purge gases into the system. These gas sources typically include the following:

- DOT cylinders
- Regulators
- Control hardware (for example, metering valves and mass flow controllers)
- Piping

The vacuum system's safety and approach to overpressure protection should identify these positive pressure gas sources and their possible effects on the vacuum system.

Other System Pressure Sources

Guidance

Other system-specific pressure sources may exist (e.g., the mixing of reactive gases or other chemical reactions and the subsequent generation of high pressures).

Techniques for Overpressure Protection

Guidance

The following are means for providing overpressure protection for vacuum systems:

- Pressure relief devices
- Gravity/vacuum closure devices

- Procedural controls

VACUUM APPLICATION PRESSURE RELIEF DEVICES

Requirements

Vacuum system personnel shall ensure that relief devices located directly on the vacuum chamber do not limit the vacuum integrity of the system. When relief devices are located on the associated gas supply lines, use relief devices on all pressure lines into the chamber and ensure that no unforeseen pressure sources exist in the chamber (such as the warming of cryogenic components).

Guidance

Vacuum system personnel should be cognizant of the following guidelines concerning vacuum application pressure relief devices.

Availability of Hardware

Guidance

Pressure relief devices specially intended for vacuum system applications that have the necessary low set pressure and high flow capacity and that provide reliable service (low leakage rates) are made by vacuum or cryogenic equipment manufacturers. They are available through the JIT or other vacuum component suppliers in the form of pressure relief valves and burst disks. The selection of a particular pressure relief device and its location on the system is dependent upon the specific system construction, system hazards, and vacuum requirements.

Hardware suitable for even the most stringent demands of ultra high-vacuum systems is commercially available, with typical ranges from 2 to 5 psig for pressure relief valves and 3 to 5 psig for burst disks.

Characteristics of Relief Devices

Guidance

There are three main characteristics of relief devices for vacuum applications:

- Low set pressure
- High flow capacity
- High quality(minimal leakage)

Placement of the Relief Device

Guidance

Determine the correct placement of the pressure relief device according to the guidance in Chapter 5 of this manual. Generally, the relief device should be located on the vacuum system itself or on the pressure source line as it leads to the vacuum system. When located on the pressure source line, the device should relieve at a pressure low enough to protect the vacuum system.

Determining the Set Pressure

Guidance

Because a maximum allowable working pressure (MAWP) is generally not specified for a vacuum only system or component, use the "as low as reasonably achievable" (ALARA) principle to determine the set pressure of the pressure relief device.

Evaluate the following to determine the set pressure:

- The type of pressure relief device chosen
- Location of the pressure relief device, either on the vacuum system itself or on the associated pressure source piping
- Reliable system operation
- Operational characteristics of the associated pressure source
- Any other system-specific hazards or concerns

Flow Capacity Concerns

Guidance

Vacuum systems present special sizing problems (relief device flow capacity), and devices may be necessary to reduce the pressure source flow rate to a level compatible with the relief device capacity. Refer to Chapter 5 of the *Pressure Safety Manual* under "Protective Pressure Relieving Devices" for a discussion of special sizing problems.

Calculations should show a minimal and acceptable amount of accumulated pressure across the relief device during the worst-case overpressure scenario.

Devices for Limiting Flow Capacity

Guidance

Flow-restrictive components in the pressure supply line can be used to limit the flow capacity requirements for the pressure relief valve.

Excess flow valves should also be used to address the issue of flow capacity. In these cases, the relief device must have sufficient capacity to actuate the excess flow valve and thereby isolate the pressure source.

Excess flow valves used for this purpose should **not** be left in the locked or manually open position.

Leak Integrity

Guidance

The leak integrity of the relief device should be commensurate with the vacuum system requirements.

When selecting a pressure relief device, the leak integrity of both the mounting connection and valve closure seal should be evaluated.

For More Information on Pressure Relief Devices

Guidance

Seek advice from your pressure advisor, local vacuum consultant, or the Safety Engineering Department (3122) (Safety Department [8517] at SNL/CA) on the selection and location of pressure relief devices for vacuum systems.

Vacuum component sales representatives can also supply information on pressure relief device characteristics.

GRAVITY/VACUUM CLOSURE DEVICES AND PROCEDURAL CONTROLS FOR OVERPRESSURE PROTECTION

Guidance

Vacuum system personnel should be cognizant of the following guidance.

Using Gravity/Vacuum Closure Devices

Guidance

Using a gravity closure device or a flange held in place merely by the vacuum pressure itself may be an acceptable overpressure protection technique. A gravity closure bell jar will lift and vent upon slight overpressures (typically around 2 psig).

In a similar approach, the closure hardware (for example, bolts or clamps) can be intentionally left off of a component, allowing the vacuum pressure alone to supply the sealing force to hold the flange in place and vent upon slight overpressure.

Precautions for Leaving Off Closure Hardware

Guidance

The following precautions should be taken when intentionally leaving closure hardware off of a component:

- Flanges should be identified as pressure relief ports so that well-intentioned personnel will not inadvertently replace the closure hardware or otherwise inhibit or restrict the functioning of these devices.
- Components should be located where personnel will not accidentally bump them and vent the system.
- Components should be positioned so that they will not fall or pop off and present a hazard to surrounding equipment or personnel.

Volume Limitation

Guidance

Overpressure protection devices are not necessary for vacuum systems for which analysis shows that it is impossible to overpressurize the system by any credible accident scenario (e.g., a 2 ft^3 [expanded gas volume] lecture bottle connected to a 6 ft^3 volume vacuum chamber cannot overpressurize the chamber).

Procedural Controls

A small-volume chamber (e.g., a section of tubing) can be charged to a particular pressure by the pressure source. This chamber can then be isolated from the pressure source and used to supply gas into the vacuum system. In this approach, the volume limitation is supplied through procedural controls (proper valve sequencing).

The use of a checklist to assure proper sequencing is recommended.

Note: Hardware controls are preferred over procedural controls.

PRECAUTIONS FOR GAUGES AND OTHER DEVICES

Requirements

Vacuum system personnel shall:

- Not depend upon gauge readings for system safety. Systems shall be protected from overpressurization by a pressure relief device or other acceptable technique.

  Note: Merely watching a gauge and manually shutting off a pressure source when the gauge reads a preset pressure (1 atm, for example) is **not** an acceptable procedure for overpressure protection of vacuum systems.

- Calibrate gauges for the specific gas or gases in use to ensure reliable indications.

- Choose electronic hardware and software components that "fail safe" or that, depending on the system design, will either close or open upon loss of power or pneumatic pressure.

- Address the potential for miscue or failure of electronic hardware, software, and hardware components(e.g., regulators and solenoid valves) during system design.

Guidance

Vacuum system personnel should be cognizant that:

- Thermal conductivity vacuum gauges are usually calibrated for air or nitrogen. If a different backfill gas is used, large errors in the pressure readout can exist.

- If helium is used (helium is more thermally conductive than nitrogen or air), the system pressure is actually less than what is indicated. If the backfill gas is argon (a less thermally conductive gas), the system pressure will be significantly higher than what the gauge indicates, and a system overpressurization could easily occur if the operator depends upon the gauge readout to prevent overpressurization.

- If a Pirani gauge, commonly calibrated for nitrogen, is used on a system backfilled with argon gas, the gauge readout will never reach atmospheric pressure, even with large positive internal pressures.

- Transducers that actually sense pressure (force per unit area, e.g.,such as capacitance manometers or Bourdon tube gauges) may be preferable in some applications because they are not dependent on the gas species and are, therefore, less susceptible to readout errors.

USING BRITTLE MATERIALS

Note: Brittle components (e.g., vacuum viewports, glass ion gauges, ceramic feedthroughs, and quartz reactor tubes) are commonly applied to vacuum systems. In some cases, the entire vacuum system may be constructed of brittle material (e.g., a laboratory glassware system commonly used in a chemistry lab). Adequate overpressure protection for systems employing these components is especially important, as is, the protection of personnel.

Precautions for Brittle Components

Requirements

Vacuum system personnel shall locate, shield, or position brittle systems or components away from personnel and equipment that could be damaged should the system or component fail.

Shielding Brittle Components

Requirements

Vacuum system personnel shall shield brittle components to protect personnel from the fragments of a system failure, and to protect brittle or otherwise fragile components from accidental damage by personnel.

Obtaining Shields

Guidance

Lexan shields are available through the JIT contract for standard vacuum viewport sizes. Metal shields are available for glass ion gauges.

Using Personal Protective Equipment

Requirements

Vacuum system personnel shall wear safety glasses or a face shield with safety glasses when working around unshielded glass vacuum systems or looking through an unshielded vacuum viewport.

Special Components Constructed of Brittle Materials

Requirements

Vacuum system personnel shall use the same shielding, isolation, and personal protection equipment when dealing with special components constructed of brittle materials as are required for routinely used components.

PRECAUTIONS FOR VACUUM VIEWPORTS AND NONRATED COMPONENTS

Operational Hazards for Vacuum Viewports

Note: Vacuum viewports have certain operational high-hazard conditions:

- Backfill or initial roughout operations present abrupt pressure transitions-the likelihood of viewport failure during these transitions is increased. Personnel should avoid exposure to vacuum viewports (or other brittle components) during these transitions.
- Rapidly changing temperatures or temperature gradients can also increase the risk of viewport failure. Avoid vacuum viewports during thermal processes such as system bakeout or exposure to heat sources from laser or ion beams.

Minimizing Thermal Gradients

Guidance

Vacuum system personnel should use layers of aluminum foil across a vacuum viewport to minimize thermal gradients during the bakeout process.

Scratched or Damaged Viewports

Requirements

Vacuum system personnel shall:

- Avoid scratching viewport surfaces as this can weaken the material and increase the risk of failure.
- Replace scratched or otherwise damaged viewports.

Mounting Viewport Flanges

Guidance

Vacuum system personnel should:

- When mounting viewport flanges, tighten the bolts using small angular turns and follow a regular pattern in order to mate the flange with minimum distortion.
- Be aware that special (nonrated) vacuum system components that may not meet the general requirements for structural integrity or ductility may be used in certain unique applications.

Examples of Nonrated Components

Guidance

An example of a special (nonrated) component is the ultra-thin "window" used on X-ray tubes/detectors or on other detectors for activities such as optical experiments and particle beam analysis.

Determining Level of Rigor for Precautionary Measures

Requirements

Vacuum system personnel shall:

- Determine the level of rigor for precautionary measures to be applied as a function of the degree of hazards presented by system or component failure.
- Consider the personnel hazards associated with component failure as well as the ramifications on the vacuum system operation and components, such as pumps and ensure that adequate overpressure protection is provided in these cases.

PRECAUTIONS FOR VACUUM PUMPING SYSTEMS

Evaluate Vacuum Pump Applications

Requirements

Vacuum system personnel shall closely scrutinize vacuum pump applications to ensure safe and reliable operations.

Special Precautions

Guidance

Vacuum system personnel should:

- Consider that special ventilation and exhaust scrubbing precautions may be required when pumping high-hazard gases, such as flammables, pyrophorics, toxics, or corrosives.
- Remember that vacuum pumps that pump hazardous gases may retain hazardous residues.

Informing Repair or Maintenance Personnel of Hazards

Requirements

Vacuum system personnel shall inform repair or maintenance personnel who may be exposed to hazardous residues of these hazards.

Form for Providing Information

Requirements

Vacuum system personnel shall use the SNL Vacuum Pump Repair Information Form (SF 2001-VPR [Word file/Acrobat file]) to identify hazards and solicit feedback from the repair facility for failure analysis.

Note: The form should accompany vacuum pumps sent out for repair.

Materials Compatibility

Requirements

Vaccum system personnel shall ensure the compatibility of the gases pumped with pump fluids and the pump's materials of construction.

Note: For example, special pump oils are needed to safely pump oxygen.

Pump Failure Modes

Requirements

Vacuum system personnel shall determine the vacuum pump failure modes and their ramifications on the vacuum system pressure if pump failure or improper pump connection could pressurize the vacuum system.

Take Additional Overpressure Protection Measures

Requirements

Vacuum system personnel shall:

- Take appropriate overpressure protection measures if pump failure may induce overpressurization.
- Consider the loss of utilities, such as loss of power or cooling water, on the operation of vacuum pumps and the possible effects on the vacuum system.

Guidance

Vacuum system personnel should use appropriate overpressure protection measures that may include the following:

- Additional labeling of the pump's inlet and exhaust ports if operators could confuse ports
- Confirm the proper pump operation before initial startup, following motor repairs, and following work on the facility electrical system
- Apply suitable overpressure protection devices to the system

---

DATA PACKAGES AND PRESSURE SAFETY ANALYSIS REPORTS

Note: A data package:

- Is required for vacuum systems, as for all pressure systems, to document safe design and construction.
- Must contain the facts needed to evaluate the vacuum system.
- Is a permanent record that vacuum personnel keep current with the system modifications.

Developing Data Packages

Requirements

Vacuum system personnel shall:

- Develop data packages applicable to vacuum systems according to Chapter 9 of the *Pressure Safety Manual*.
- Develop a pressure safety analysis report (PSAR) for:
  - Vacuum vessels with an internal volume greater than 70 ft^3 because they represent a large stored energy, and require additional engineering analysis of the system's structural integrity that is documented in the form of a PSAR.
  - Systems that are qualified by safety analyses (see the safety analysis information under "Design and System Requirements for Systems Not Fabricated by an Approved Manufacturer," for more information).

    Note: Chapter 9 of the *Pressure Safety Manual* contains additional details on PSARs.

The responsible SNL manager, the pressure advisor or other vacuum consultant, and the data package author shall determine the adequacy of and level of approval for data packages.

Maintaining and Referencing Operational Documents in Data Package

Guidance

Vacuum system personnel should consider that the data package is a good place to maintain or reference operational technical work documents (TWDs) such as the following:

- System diagrams
- Procedures

- Checklists that reference procedures, such as valve sequencing operations and gas cylinder changes

Note: See CPR400.1.1/MN471001, *ES&H Manual*, Chapter 21, "Technical Work Document (TWD)," for information on developing TWDs.

Review and Approval of Data Packages

Requirements

The responsible SNL manager, the pressure advisor, or other vacuum consultant, and the data package author shall determine the adequacy and approval of data packages.

Pressure Safety Analysis Report

Requirements

Vacuum system personnel shall require a Pressure Safety Analysis Report (PSAR) for:

- Recording additional engineering analysis of the system's structural integrity for vacuum vessels with an internal volume greater than 70 ft^3 because these represent a large stored energy.
- Systems that are qualified by safety analyses. Refer to safety analysis information under "Design and System Requirements for Systems Not Fabricated by an Approved Manufacturer," for more information.

Note: Chapter 9 of the *Pressure Safety Manual* contains additional details on PSARs.

DOCUMENTING VACUUM SYSTEMS

Identify and Characterize the System

Requirements

Vacuum system personnel shall identify and characterize the vacuum system in a Data Package including:

- Identify the system and supply a brief system abstract.
- Characterize the system, including information such as the following:
  - Manufacturer(s)

- Types of components
- Materials of construction

Guidance

Vacuum system personnel should use the manufacturer's catalog information or operators' manuals as sources of this information including:

- Estimate the system volume, including that of components such as the vessel, plumbing, and pumps.
- If applicable, document the overpressure test that qualifies the system.

Identify Component Automation and "Fail-Safe" Components

Requirements

Vacuum system personnel shall identify the consequences of failure in the data package for the following:

- System or component automation such as the following:
    - Microprocessor-controlled systems
    - Emergency shutoff valves
    - Interfaces to gas monitoring systems
- Pneumatic or solenoid valves designed to be "fail safe."
- The system status upon loss of utilities (for example, power, cooling water, pneumatic pressure for valves, and exhaust or ventilation) as they apply to the pressure safety aspects of the vacuum system.

List Pressure Sources

Requirements

Vacuum system personnel shall list all plausible pressure sources in the data package. Include a listing of the pressure line components and their ratings (for example, DOT cylinders, regulators, valves, and piping or tubing).

Document Overpressure Protection

Requirements

Vacuum system personnel shall document the following in the data package:

- Overpressure protection device or technique
- Applicable hardware
- Set pressure of relief devices and their flow capacity as applicable to the system's pressure sources
- Consequences of failure
- Personal protective equipment requirements

Identify Nonrated Components

Requirements

Vacuum system personnel shall identify and give special attention to nonrated components in the data package. Indicate a safe failure mode or shielding provided.

Identify Brittle Materials

Requirements

Vacuum system personnel shall list components that contain brittle materials and document shielding or procedures that provide for personnel protection.

If the system is predominantly of brittle materials, document the design material specifications and mechanical containment or administrative controls, including physical barriers, to preclude access to the potential hazard.

Document Pump Information

Requirements

Vacuum system personnel shall describe the vacuum pump system and document the following information in the Data Package:

- Date of installation
- Pressure range
- Maintenance practices
- Maintenance intervals
- Repair information
- Possible hazardous contaminants

- Plausible pump failure modes

Include Warnings and Special Instructions

Requirements

Vacuum system personnel shall include warnings or special instructions for maintenance or reapplication personnel and identify any hazardous substances that may remain in the vacuum system pumps or components and associated piping.

Document Procedural Controls

Requirements

Vacuum system personnel shall, for procedural controls that provide overpressure protection, document the pressure/volume calculations (along with the proper valve sequencing information) in the data package.

Document Positive-Pressure Gas Supply Lines

Requirements

Vacuum system personnel shall document gas supply lines in the data package covering the overall system, and document the MAWP based on the ratings of the gas line components.

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Pressure Safety Manual

APPENDIX E – CONVERSION FACTORS

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
Revision Date: September 29, 2006; Replaces Document Dated: June 6, 2006
Administrative Changes: October 16, 2006, November 20, 2006, April 2, 2007, April 19, 2007, and May 17, 2007

* Indicates a substantive change

Guidance

To convert from . . .	And obtain . . .	Multiply by . . .
atm	torr (mm of Hg @ 0° C)	760
atm	psi	1.4500E + 01
atm	in. of Hg (@ 0° C)	2.9920E + 01
atm	cm of Hg (@ 0° C)	7.6000E + 01
atm	ft of water (@ 4° C)	3.3900E + 01
in. of water (@ 4° C)	atm	2.4580E - 03
in. of water (@ 4° C)	in. of Hg	7.3550E - 02
in. of water (@ 4° C)	psi	3.6130E - 02
in. of water (@ 4° C)	kg/cm^2	2.5400E - 03
in. of Hg	torr (mm of Hg @ 0° C)	2.5400E + 01
in. of Hg	atm	3.3420E - 02
in. of Hg	ft of water	1.133
in. of Hg	kg/cm^2	3.4530E - 02
in. of Hg	psi	4.9120E - 01
bars	atm	9.8690E - 01

bars	psi	1.4500E + 01
bars	dynes/cm^2	1.0000E + 06
bars	kg/m^2	1.0200E + 04
bars	kpascals	1.0000E + 02
pascals	psi	1.4500E - 04
pascals	kg/m^2	2.0620E + 07
joules	Btu	9.4860E - 04
joules	ft-lb	7.3760E - 01
watts	joules/s	1
watts	Btu/hr	3.4129
Btu	ft-lb	7.7816E + 02
Btu	joules	1.0550E + 03
lb TNT	joules	1.9300E + 06
lb TNT	ft-lb	1.4200E + 06

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Pressure Safety Manual

APPENDIX F – PRESSURE SAFETY ASSISTANCE INDEX

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
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* Indicates a substantive change

This appendix is presented as a convenient listing of persons who can provide pressure safety advice Revisions should be submitted to Roger Shrouf.

Sandia National Laboratories Pressure Safety Committee Roster

Name	Committee Function
G.W. Wellman	Engineering Mechanics/ Stress Analysis
J.B. Kelley	Materials & Metallurgy Representative
N. D. Roberts	Pressure Testing Representative
C. E. Yagow	Design Drawing Representative
D. Vortolomei	Design Drawing Representative
R. D. Shrouf	Safety Engineering
S. R. Page	Safety Engineering
A. J. Lopez	Facilities Operations, Division 10000 Representative
D. L. Buller	Division 1000 Representative

M.D. Olbin	Division 2000 Representative
M. A. Cooper	Division 2000 Representative Alternate
W. R. Olson	Division 2000 Representative Alternate
L.R. Shapnek	Division 5000 Representative
W. L. Teague	Division 5000 Representative Alternate
D. P. Roach	Division 6000 Representative
W. L. King	Division 6000 Representative Alternate
P.G. Fugazzi	Division 8000 Representative
J. A. Orsbun	Division 8000 Representative Alternate

Pressure Safety Assistance Index - New Mexico Personnel

These personnel at Sandia National Laboratories, New Mexico, are available to answer your questions about pressure safety, design, testing, etc. (Alphabetical listing by subject)

Subject	Name
Barriers (Shielding Applications)	G. W. Wellman
Cryogenics:	
Facilities / Systems Maintenance	A. J. Lopez
Laboratory Systems / Safety	R. D. Shrouf, M. P. Lilly
Drawing Review Program	C. E. Yagow, D. Vortolomei
Engineering Mechanics	G. W. Wellman
Facilities Engineering	A. J. Lopez
Fire Marshall	G. Earhart
Gas Supplier (JIT Contract)	Matheson Tri-Gas Inc. 222-0261
Gas Cylinder Returns	Matheson Tri-Gas Inc. 222-0261
Hazardous Waste Management Facility:	
Disposal of Non-Returnable Gas Cylinders	L Spangler
High Pressure	D. P. Roach

Instrument Calibration	M. S. Benner
Leak Testing Standards	M. S. Benner
Leak Detection	D. R. Bronowski
Leak Detection Services	C. A. Walker
Materials	
Brittle Materials/Mechanical Properties/ Failure Analysis	S. J. Glass
Materials Properties	J. B. Kelley, G. W. Wellman
Plastic Materials / Mechanical Properties	F. R. Gruner
National Codes: ASME, ANSI, ASTM, etc.	G. W. Wellman
	J. B. Kelley
	R. D. Shrouf
Non-Destructive Evaluation:	
Acoustic Emissions	A. G. Beattie {Contractor} 890-5668
Liquid Penetrant	Z. Jacob
Pressure Testing	N. D. Roberts
Pressure Relief Valve Testing	P. W. Hatch, K. L. Robbins
Radiography	J. A. Casias
Ultrasonics	S. J. Younghouse
Pressure Advisor Roster	R. D. Shrouf
Pressure Fittings (JIT Contract)	Albuquerque Valve & Fitting 842-0213
Pressure Safety Committee Bulletins	R. D. Shrouf
Pressure Safety Library	R. D. Shrouf
Pressure Safety Manual:	
Revisions / Corrections	S. R. Page

Pressure Related Training Courses:	
SNL ES&H Courses (PRS115, PRS150, PRS160 & PRS250)	B. C. Lucero
American Vacuum Society (AVS) Courses	J. W. Weed
AVS Course Registrar	American Vacuum Society 271-9216 {NM Chapter: C. Blair}
Hardware Training(Fittings & Valve Safety Seminars)	Albuquerque Valve & Fitting 842-0213
Welding Safety Seminar	Matheson Tri-Gas Inc. 222-0261
Purchasing (JIT Contracts)	J. J. Coots, J. A. Jojola
Purchasing / Safety Liason for Pressure Related Hardware and Services	R. D. Shrouf
Safety Engineering	S. R. Page
	R. D. Shrouf, S. A. Walcott
Stress Analysis	G. W. Wellman
Vacuum Technology:	J. W. Weed
Vacuum Hardware (JIT Contract)	
Vacuum Safety	R. D. Shrouf
Welding Safety	S. R. Page
Welding Shop	J. O. Barela
Weld Technology	L. A. Malizia, Jr., C.V. Robino

Pressure Safety Assistance Index - California Personnel

(Draft Listing Roger Shrouf, 10322)

These personnel at Sandia National Laboratories, California, are available to answer your questions about pressure safety, design, testing, etc. (Alphabetical listing by subject)

Subject	Name

Barriers (Shielding Applications)	H. O. Armijo
Gas Dynamics	Vacant
Instrument Calibration	R. D. Pilkey
Materials Properties	S. L. Robinson
Non-Destructive Evaluation:	
Liquid Penetrant and Radiography	L. A. Johnston
Pressure Testing	M. F. Hardwick
Ultrasonics	J. C. F. Wang
Pressure Safety Training Courses	K. M. Mello
Safety Engineering	J. A. Orsbun
Site Specific Pressure Safety Committee:	
SNL, CA: Chairman	Vacant
Stress Analysis	Vacant
Welding Technology	G. R. Gibbs

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Pressure Safety Manual

APPENDIX G – THE PRESSURE SAFETY DRAWING REVIEW PROGRAM

Subject Matter Expert: Roger Shrouf and Pressure Safety Committee
MN471000, Issue N
Revision Date: September 29, 2006; Replaces Document Dated: June 6, 2006
Administrative Changes: October 16, 2006, November 20, 2006, April 2, 2007, April 19, 2007, and May 17, 2007

* Indicates a substantive change

INTRODUCTION

The Design Group (2990) has established a Pressure Safety Drawing Review Program in support of SNL's *Pressure Safety Manual* (PSM).

DRAWINGS REVIEWS

Requirements

Members of the Workforce shall ensure that all pressure system drawings generated by the Design Group (2990) are reviewed by the PAs in the Design Group (2990) for compliance with this manual.

Note: This program is intended to assist the line PA. It does **not** change the responsibility or authority of either the line PA or, ultimately, the line supervisor.

PAs in the Design Group (2990) shall certify compliance with the review requirement for pressure systems and component drawings generated by the Design Group (2990) by affixing a signed Pressure Data Stamp on the original drawing. This stamp constitutes a design specification. Signature authority is limited to SNL line PA's or Safety Engineering.

Note: The Purchasing Center (10200) cannot process pressure system drawings without the proper signatures.

Guidance

If a Member of the Workforce determines that the Pressure Safety Drawing Review Program should not be applied, this requirement will be waived on written concurrence for either the:

- Line PA.
- Manager.
- Safety engineering representative.

PAs in the Design Group (2990) typically should include the following actions in their reviews of pressure systems drawings:

- Examine for compliance with this document.
- Use the PSM checklist (SF 2001-CPA [Word file/Acrobat file]) in accordance with the PSM, **except** for the operating portion that is the responsibility of the line PA
- Identify the current line organization PA to the customer
- Inform the line PA of the program in the line PA's area
- Determine whether a PSAR is required

  Note: The Design Group (2990) has written a tutorial computer program defining total energy levels for the four gases listed in the PSM. This program is available to all PAs and engineering consultants. **Members of the Workforce are**

encouraged to use this program in the design of pressure systems.

- Recommend using *ASME Code*-stamped vessels when possible and ASME design procedures when Code-stamped vessels are not available or are inappropriate.
- Furnish *ASME Code* information, specifications for ANSI standards, welding specifications, and drawing note references as needed.
- Advise about Sandia expertise for materials, stress, pressure testing capabilities, welding, Safety Organization, etc.
- Urge application of and compliance with the PSM.

PAs in the Design Group (2990) will generally **not** review the following pressure systems drawings:

- WR components
- Commercial components

  Note: Procure from approved JIT source.

- Drawings not prepared by the Design Group
- An engineering review of the design.

  Note: The review by PAs in the Design Group (2990) is for safety compliance only.

Note: The Design Group supports an in-house training program and ASME-sponsored classes for their reviewers so the reviewer can help with design review if asked. However, responsibility for safe design and operation always remains with the line PA and, ultimately, the line supervisor. The Design Group will make design recommendations within their limits of expertise upon request.

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Pressure Safety Manual

APPENDIX H – SUPPLIERS OF QUALITY PRESSURE HARDWARE

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QUALIFIED SUPPLIERS AND THEIR PRODUCTS

Requirements

Users of pressure relief valves (PRVs) shall:

- For PRVs that are purchased from suppliers other than those listed under “Guidance,” document the suppliers' in-house test procedures and have them reviewed by the safety engineer on the appropriate Division ES&H Team or have the valve tested by an approved PRV test station at SNL before installation.
- Inspect new valves for damage or contamination and operate them manually, if possible, before use.
- Be aware that the PRV suppliers listed under “Guidance” perform acceptable in-house testing on all PRVs manufactured. New valves purchased from these suppliers are accepted for use at SNL for an initial interval without further testing. Refer to Appendix J for details on PRV applications.

Note: Special PRV applications may need more stringent testing of certain valve parameters before installation.

General List of Hardware and Suppliers

Guidance

The following is an informational list of hardware and suppliers who have proven reputations for supplying quality hardware:

Supplier	Types of Hardware
ASCO (Automatic Switch Co.)	Manual and solenoid valves
Ashcroft (Dresser Industries)	Safety-type pressure gages
Autoclave Engineers	• High-pressure tubing • Fittings • Valves • Relief devices
Crawford Fitting Company (Swagelok, Cajon, Whitey, Nupro, Sno-Trik)	• Tubing • Fittings • Valves • Vacuum fittings
Circle Seal Controls	• Safety relief valves • Regulators
Fike Metal Products	Rupture disk assemblies
Parker Hannifin Corp. (Aeroquip, Enerpac)	• Pressure fittings • Flex hose • Valves

Pressure Products Industries	• High-pressure valves • Vessels • Compressors
Victor Equipment Co.	• Pressure regulators • Adapters • CGA fittings

List of Pressure Relief Valve Suppliers

Guidance

The following list of pressure relief valve (PRV) suppliers is provided for information:

- Anderson, Greenwood & Co. (subsidiary of Keystone International)
- Autoclave Engineers
- Circle Seal Controls
- Crosby Valve & Gage Company (a Moorco Company)
- Dresser Industrial Valves, Industrial Valve Division
- Kunkle Industries Inc.
- Lonergan, Valve Division
- Nupro, a Swagelok Company
- Parker Hannifin Corp., Instrumentation Valve Division
- REGO Products (Engineered Controls International, Inc.)
- Rockwood Swendeman Corporation
- Semi-Gas Systems, Inc. (assembled systems using PRVs)
- Teledyne Farris Engineering

Note: This list is not intended to be all-inclusive. Other suppliers may be evaluated and added to the list in the future.

Vacuum Equipment Suppliers

Guidance

The following is an informational list of vacuum equipment suppliers who have a proven reputation for manufacturing quality vacuum chambers and systems that meet or exceed SNL safety requirements. These suppliers meet the criteria for "reputable" suppliers as defined in Appendix D, Vacuum Safety, and may be acceptable as an "approved" supplier in that context:

- Balzers Vacuum Components
- Edwards High Vacuum International
- HPS Division, MKS Instruments
- Huntington Mechanical Laboratories, Inc.
- Key High Vacuum Products, Inc.
- Kurt J. Lesker Company
- Meyer Tool & Mfg., Inc.
- MDC Vacuum Products Corporation
- NOR-CAL Products
- Perkin Elmer Vacuum Products
- Scientific Sales Associates
- Varian Vacuum Products
- Veeco Instruments, Inc.

Note: This list is not intended to be all inclusive. Other suppliers may be approved by the SNL organization involved with the acceptance of the system.

Where to Obtain Catalogs and Information

Guidance

Pressure system personnel may obtain catalogs and information about pressure hardware suppliers through the:

- JIT vendors.
- Information Desk at the Technical Library.
- Pressure Safety Committee.
- Pressure Safety - Resources.

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APPENDIX I – PRESSURE SYSTEM FAILURES

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INTRODUCTION

The concern about pressure system safety is well founded, as evidenced by the following pressure accident reports from various industries. By discussing examples of particular failures, it is hoped to draw attention to those aspects of design, manufacture and operation which require particular attention and care in order to minimize the risk of future failures.

Defects and Failures in Pressure Vessels and Piping by Helmut Thielsch (see

Bibliography) provides a comprehensive discussion of pressure system failures and ways to avoid them. In a nationwide survey of over 12,000 pressure vessels representing over 100,000 operational years, the following conditions were brought to light:

- Failures were of two types:
  1. Catastrophic - required major repair or scrapping of vessel.
  2. Potentially dangerous - defects required repair to prevent dangerous extension.
- 132 failures occurred during the operational years, 7 of these were catastrophic.
- Major causes of the failures:
  1. Excursions from expected design conditions.
  2. 90% of the failures were due to cracks. Most cracks originating at welds.
  3. Failure in associated pressure component. 20% or were pre-existing from manufacture, 25% or were due to fatigue, 30% were due to corrosion.
  4. Most incidences occurred in the first 2 or 3 years of service.\
- Resulting conclusions about pressure safety:
  1. Failure usually results from a combination of more than one cause.
  2. Pressure/overpressure test is important in detecting problems.
  3. Manufacturer and customer share responsibility. They should ensure proper specifications; they should not sacrifice quality for time savings.
  4. Care and surveillance in operation, maintenance and repair of systems should be stressed.

Listed below are some more in-depth descriptions of incidents in which improper pressure safety practices led to pressure system accidents and failures.

Table I-1. Pressure System Accidents and Failures

Pressure System	Improper Pressure Safety Practice	Result
22 ft diameter fermentation vat	Condensation inside vessel resulted in vacuum which formed quicker than vacuum breaker could remove	Vessel buckled catastrophically
Compressor	Fillet weld on support brackets formed abrupt angle instead of blending smoothly into shell	Weld cracked in 15 months
High pressure pipelines in boiler tubes	Carbon steel was misidentified and used in place of Chrome Moly alloy steel	Stress corrosion cracking and pipe burst
Lap joint pipe	Uneven tightening of the flange ring	Fatigue cracking; failure
Water piping system	Improper temperature conditioning and pressure relief	Freezing water, pressure rise, and pipe rupture
Boiler tubes	Insufficient periodic inspection to detect growing defects	Hydrogen embrittlement and pipe rupture

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COMPONENT SAFETY

Requirements

Members of the Workforce shall:

- Not heat a gas-containing vessel unless the vessel is rated for high-temperature work.

- Ensure that vessels rated for high-temperature work have relief protection and temperature controls.
- Protect cylinders from damage.
- Keep cylinders tied down so they cannot fall.
- Keep cylinders capped when they are not in use.

Note: For more information on cylinder safety, see Chapter 5, "Selecting and Assembling Pressure Hardware."

Guidance

Members of the Workforce should use the following information and examples as guidance.

LOW-PRESSURE HAZARDS

The Manufacturing Chemists Association reported that a drum, constructed with a flat head and riveted sides, was supported horizontally on two 12- X 12-in. blocks. The drum was to be checked for possible leaks before being used to store another product. A worker and a foreman proceeded to test the drum by connecting a 100-psi air hose to it. During the air pressure test, the drum exploded, causing the head of the drum to break loose and strike the worker. He was knocked 15 ft, suffering a fractured wrist and painful abrasions.

If the pressure in the 4-ft-diam by 6-ft-long drum was 100 psi, a force of 100 lb was acting on each square inch of its surface (Figure I-1).

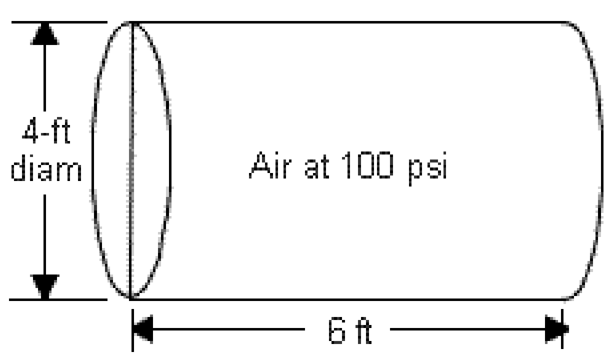

Figure I-1. Test Drum

Total area of head:

$$A = \pi r^2 2$$
$$= \pi (2)^2$$
$$= 4 \pi ft^2$$

Total force on head:

$$F = AP$$
$$= 4 \pi ft^2 \times 100 lb / in.^2 \times 144\ in.^2 / ft^2$$
$$= 181{,}500\ lb\ or\ 90.7\ tons$$

Low-pressure hazards are often underestimated. Vessels such as drums and glassware that are not designed to contain pressure must be used with extreme caution when internal pressure is applied - even if the pressure is only a few psi. Therefore, Members of the Workforce should take the following precautions:

A. When possible, use liquid as the pressure medium; use relief protection to prevent overpressurization.

B. When gas must be used:

   - Regulate pressure.
   - Provide relief protection to prevent overpressurization.
   - Shield personnel from exposure

OVERPRESSURIZATION

Nothing is more likely to cause a pressure accident than overpressurization. The following incidents describe how overpressurization occurs.

Incident 1. A State of California publication reported the following incident about a repairman who was purging a system with nitrogen. Pressure in the system was increased to the bursting point; there was no relief valve. The repairman was killed when he was hit by the top half of the housing. Although a reducing valve with a built-in relief device was available, it was not used.

Incident 2. Another overpressure accident is described in the following case history. Gas pressure from a commercial nitrogen cylinder was used in an attempt to force fluid from a gas reservoir into an assembly. No regulator was used and no relief protection was provided. Pressure regulation was attempted with a needle valve between the cylinder and the reservoir. Although it was estimated that a pressure of 10 psi was required to move the fluid, 2000 psi was being used, and the reservoir failed between 60 and 80 psi.

Incident 3. The National Safety Council reported a similar incident about an employee who used a bypass line from the cylinder rather than from the regulator. High-pressure nitrogen was admitted to a low-pressure vessel, and no relief protection was provided. When the vessel failed, it caused serious injury.

Incident 4. Because of regulator failure, a freon pressure vessel ruptured during a system test conducted under remote operating conditions. Freon gas was being compressed into the vessel through a regulator set to limit pressure to 750 psi, and no relief protection was provided. After the test was started, the regulator failed, permitting gas pressure to build up to about 1240 psi. When the tank ruptured, tank and equipment fragments were scattered around the entire area. A large commercial scale about 50 ft away from the tank was knocked over and thrown about 10 ft. Tank sections were found almost 100 ft from the test area.

Overpressurization can be prevented by:

- Limiting the pressure source. If only 20 psi is needed, a 2000-psi pressure source should not be used.
- Providing adequate relief protection. When a pressure source higher than required is used or when pressure can be increased from some other cause, relief protection must be provided. A regulator is not considered positive overpressure protection.

COMPRESSED FLUIDS CONTACTING THE BODY

Fluids (both gases and liquids). when under pressure, can cause injury.

Incident 1. An employee's left index finger was punctured and his left forearm inflated while he was working with high-pressure helium gas. The injury occurred when he put his finger on the end of a high-pressure helium line to determine if the 0.007-in.-i.d. line was plugged. He said he knew high-pressure gas was dangerous if it came into contact with the body, but felt there would be no hazard because of the very small opening. The pressure in the line was about 6000 psi, and gas was flowing at a sonic velocity of about 2870 fps. The flow of gas from the orifice was, therefore, about 0.1 cfs, which compares with an M-1 rifle muzzle velocity of 2800 fps. Luckily, the inflation in the employee's arm progressively subsided, and he regained normal use of his arm.

Incident 2. A mechanic who boasted of his strength decided to prove it by using the palm of his hand to prevent a pneumatic grease gun from operating. He placed his hand over the nozzle, and pulled the trigger. As a result, grease was blasted under his flesh, and even deep therapy has failed to restore normal use of his hand.

Letting compressed fluids contact the body can have serious consequences. The National Safety Council reports: "Internal organs have been ruptured and death has resulted, after hours of suffering. Workers have ruptured their ear drums while blowing dust from their clothing and out of their hair."

COMPRESSED-GAS CYLINDERS

Although jetting cylinders rarely become airborne, the following reported incidents indicate what has happened in the past:

Incident 1. The NCS Construction Section Newsletter of March 1959 reports, "The Industrial Commission of Ohio has on record one instance of a valve being broken off while a cylinder was being moved with the protective cap not in place. The cylinder traveled approximately 30 ft, striking the luggage compartment of an automobile and coming out through the roof just above the windshield. It continued to travel a distance of 1500 ft over the top of two houses and made a hole in the foundation of a third building when it landed."

Incident 2. The National Safety Council Power Press and Forging Section Safety Newsletter of March 1959 reports, "One person was killed and two were injured by a heavy oxygen cylinder that ricocheted through a street. The cylinder had fallen from a truck. The valve had broken off, releasing the highly compressed oxygen. The first blast knocked a boy and girl through a shop window, inflicting serious injuries to both. The cylinder took off like a rocket, hit a stone embankment, shot 100 ft in the air, killed a woman when it crashed down, then thundered down a main street. The cylinder battered automobiles, scattered parked bicycles and sent people diving into doorways before its oxygen supply was spent."

Incident 3. While servicing a large plane inside a hangar, an employee used a Jeep to transport an uncapped carbon-dioxide cylinder across the hangar floor. As he made a turn, the cylinder fell off the Jeep, and the valve was smashed when it hit the floor. The cylinder then took off like a jet-propelled missile, tore through several plane wings and fuselages, and struck and broke the sprinkler system in several places, starting a flood and, putting the sprinkler system out of commission. They cylinder finally streaked across the hangar floor and through a concrete block wall to the outside, where it stopped. In a matter of seconds, one seemingly minor but unsafe practice resulted in over a half-million dollars in damage.

Incident 4. A similar accident occurred in a large chemical plant when a welder failed to secure his oxygen and acetylene cylinders. The oxygen cylinder fell over due to a pull on the hose, and the valve struck the wall and sheared off. The oxygen cylinder took off like a rocket, tearing out process lines and equipment and releasing flammable solvents, which ignited and started a raging fire. After ricocheting around the building, the cylinder finally drove itself through two brick walls and traveled a distance through the air before it finally lost its force and stopped.

Although these accidents only describe what has happened when valves were knocked off, overheating of a cylinder or any vessel can also have disastrous results. The following describes what happened in one fire:

Incident 5. A fire started in a building that was being demolished. When the fire reached an oxygen cylinder, the cylinder heated and ruptured due to the excess pressure inside it. Simultaneously, the released oxygen fed the existing fire, causing an explosion. Windows were blown out of buildings several hundred feet from the fire. Fortunately, no one was seriously injured, but everyone who saw the damage was astonished at the destruction caused by just one cylinder of oxygen.

When a cylinder is placed too close to a heater, furnace, or oven or is exposed to a burning torch, it may also build up enough pressure to cause failure. Even if the cylinder doesn't fail, the pressure buildup may cause the relief device to vent, and the escaping gas may cause injury or fire.

PRESSURIZED SPRAY CANS

This discussion of overheating should mention the aerosol dispensers used extensively in business and in homes. These little containers are normally pressurized at less than 50 psi; however, when heated, they can build up pressures that cause them to explode. This is true even in cans that appear empty; that is, after all liquid has been dispensed.

An article in *Popular Mechanics* describes several serious injuries and fatalities from spray can explosions:

Incident 1. "An attendant at an incinerator opened the door to stoke the fire. An empty aerosol can 'went off' and a piece destroyed one of his eyes."

Incident 2. "A youngster was spraying canned snow on his Christmas tree. When the spray died down, he warmed up the can in hot water to 'jack up the propellant. He lost an eye and part of his jaw when the can exploded."

Incident 3. "A 40 yr. old housewife tossed an empty bug-spray can into a waste paper fire. The can exploded and severed her jugular vein. She died within 15 min."

"JURY-RIGGING" OR IMPROVISING

Because the proper pressure equipment, tools, or special fittings are not always available, "jury-rigging," or improvising, is sometimes necessary. However, unless improvising is thoughtfully done, an accident-producing situation may be built into a system. When improvised setups go wrong, it is usually because people lack pressure experience. They use a fitting that "looks like it can hold the pressure," or they assemble components that "look like they fit together," but don't hold under pressure.

Improvisation is sometimes necessary; whenever it is, the improvised parts or system should be inspected and tested prior to manned-area operation under pressure.

CONCLUSIONS

This review of pressure system failures is intended to be a reminder of what safety hazards are posed by pressure systems and to show why constant awareness is necessary to avoid accidents. Although we have not discussed all the types of accidents one might expect with pressurized fluids, we have pointed out that accidents can happen unless all persons concerned with pressure systems exercise extreme care. Pressure accidents can be prevented by:

- Practical engineering design
- Reliable manufacturing methods and quality control
- Careful assembly of components
- Proper operation in accordance with approved operating procedures
- Adequate maintenance

The role you play in any of these five areas is extremely important. Your well being, and that of your fellow employees depends heavily on how well you do your job. For assistance with pressure problems contact your Pressure Advisor or the Environmental, Health & Safety Organization (see Ch. 2).

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Pressure Safety Manual

*APPENDIX J – PRESSURE-RELIEF VALVE TEST PROCEDURES AND POLICIES

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INTRODUCTION

Requirements

Pressure relief valves (PRVs) are an important component for safe operation of a pressure system. Periodic evaluations are required to confirm proper operation of these devices.

Line organizations are responsible for the proper application and maintenance of PRVs. These responsibilities include:

- Identification (tagging) and tracking.
- Visual inspections.
- Operational checks.
- Testing/certification.
- Determining replacement intervals.

This appendix describes accepted policy and procedures on the testing and certification of PRVs in use at SNL.

DESIGNATED PRV TESTING STATIONS AT SNL

Requirements

For PRV tests conducted at SNL, Members of the Workforce shall:

- Follow the test procedures, acceptance and rejection criteria, and data requirements in this section.

- Ensure that ASME Code valves are tested, repaired, and adjusted according to ASME Code at an approved Code shop to maintain ASME Code status.

  Note: SNL does not provide ASME-approved repair or recertification functions. Only a functional check of the cracking and re-seating pressures of ASME code valves can be performed by SNL.

Customer Service Organization

Guidance

Members of the Workforce should refer PRV testing to the Onsite Calibration & Maintenance Department (2541-1), which is the customer service organization at SNL/NM that performs PRV testing. They will perform tests and supply the data needed by the line to certify PRVs for use. This appendix sets forth the procedures to be used by the Materials Mechanics Engineering Department and all other line organizations that have testing capabilities of valves at SNL.

New PRVs

Requirements

Members of the Workforce shall:

- Purchase PRVs from reputable suppliers having QC programs and calibrated testing procedures (see Appendix H, “Suppliers of Quality Pressure Hardware”).

  Be aware that new valves purchased from such suppliers are acceptable for use at SNL for an initial interval without further testing.

  Perform a visual inspection of new valves to confirm that no damage or contamination has occurred during packaging and shipment.

  Note: The valve should be operated manually as part of the inspection, provided this would not present a hazard to personnel nor degrade the valve or system performance.

- Return any valves that show damage or contamination or that malfunction to the supplier for replacement.

Tagging and Tracking

Requirements

Members of the Workforce shall:

- Be responsible for identifying, documenting (tagging) and tracking relief valves for retest. Test tags applied by valve vendors signify that the valve meets manufacturer's specifications.
- When using new valves for special applications, confirm that the manufacturer's testing properly addresses the relevant parameters of valve performance (e.g., valves on toxic gas systems). Testing of only the routine parameters of cracking and re-seating pressures is not adequate; a stringent leak check should also be performed.
- Ensure that valves not subjected to adequate manufacturer's or vendor's testing procedures are adequately tested at SNL before being placed into service.

Documentation

Requirements

Members of the Workforce in line organizations that test their own PRVs shall use an authorized test station and follow the approved test procedures. See SF 2001-PRV, Sandia Designated Pressure Relief Valve Test Station (Word file/Acrobat file), for the necessary approvals and validations required for test stations and operators.

Note: A manufacturer's original specifications and testing data or alternate test procedures and schedules may be acceptable documentation in applications where the normal test intervals and procedures could adversely affect continued valve performance or the overall safety and operation of the system. For complete details on special applications, see Special Cases - Nonroutine Testing Procedures.

HARDWARE FOR PRV TEST STATIONS

Requirements

The line Pressure Advisor and Safety Engineering shall inspect and approve all SNL-authorized PRV test stations. See SF 2001-PRV Sandia Designated Pressure Relief Valve Test Station (Word file/ Acrobat file). As a minimum, the following requirements shall be met.

Pressure Indicators

Requirements

Sources for pressure gauge calibration are acceptable if the source meets the requirements of CPR100.3.1, *Standards and Calibration*. The range, accuracy, and precision of the pressure indicator used for testing shall be commensurate with the valve's set pressure and its tolerances for acceptance or rejection. Follow the guidelines on assembling pressure hardware in Chapter 5, “Selecting and Assembling Pressure Hardware.”

Safety Manifolds

Requirements

A properly configured safety manifold system shall be provided for all test stations. Attention should be given to the proper use of relief valves to protect system components (gauges, etc.) from overpressure, and the vent valves should be located properly to receive pressure from system components after testing. Follow the guidelines described in Chapter 5, "Selecting and Assembling Pressure Hardware," on assembling pressure hardware.

Test Stations

Requirements

SNL test stations shall be capable of performing these functions, and the operators must be able to meet these requirements:

a. Visually inspect valves for evidence of external leakage, corrosion, or other types of damage or evidence of usage conditions that may cause the valve to malfunction.

b. Perform the actual testing of the valve according to the procedures in the following section, PRV Testing Procedures.

c. Set the pressure for adjustable relief valves following guidelines in the following section, PRV Testing Procedures.

d. Tag valves accepted for certification. Certification requires line (pressure system installer) approval signature and shall consider test results and the valve's application.

PRV TESTING PROCEDURES

Note: PRV testing consists of making repetitive excursions through the cracking and re-seating pressures and recording those pressure values.

Testing Environment

Requirements

Members of the Workforce shall:

- Perform valve testing at room temperature.

- Use only clean, inert fluids to test valves.
- Test valves when discharging to atmosphere, with no appreciable backpressure.
- Consider the performance characteristic effects of temperature and backpressure for proper application of the PRV.

  Note: The Onsite Calibration & Maintenance Department (2541-1) will use dry nitrogen for valves tested with gas and de-ionized water for hydrostatic valve testing. Other media may be used if approved by the valve owner and line Pressure Advisor .

In Situ Testing

Caution: Members of the Workforce shall **not** allow system maximum allowable working pressure (MAWP) to be exceeded during in situ tests.

Note: Because of wide tolerances or first-pop effects, a PRV set at MAWP may need to exceed MAWP by some percentage before cracking open. In situ testing would **not** be allowed for these cases. The detrimental effects of fatigue caused by pressure cycling to MAWP should also be considered when choosing to test PRVs in place.

Guidance

Members of the Workforce may test valves in-situ if the line Pressure Advisor approves the test setup and proposed procedures.

Adjustable PRVs

Requirements

Members of the Workforce shall:

- Retest and certify a valve before use when there has been any adjustment of the set pressure of an adjustable PRV.
- Ensure that adjustable PRVs are adjusted to the desired pressure and locked in place.
- Ensure that the set pressure remains within the range specified in the manufacturer's data.
- Confirm cracking and re-seating pressures after all adjustments have been made and locked in.

Testing Valve Parameters

Guidance

Members of the Workforce should consult the Onsite Calibration & Maintenance Department (2541-1), or other designated test stations, which can test valves for cracking, popping, and re-seat pressures using the specific test procedures described in this section. Other valve parameters, such as leakage, may need to be tested at other facilities by the user. Contact the Pressure Advisor for assistance in testing these other parameters.

ASME Certification

Guidance

Members of the Workforce should be cognizant that:

- SNL does **not** provide ASME certification of PRVs or perform flow measurements.
- The flow characteristics of a properly operating, non-corroded valve are assumed to be the same as those originally specified by the manufacturer.
- The line organization determines if ASME certification is needed.
- Recertification must be performed at an ASME Code Shop to maintain ASME status.

Cleaning and Repairing Valves

Requirements

Because the Onsite Calibration & Maintenance Department (2541-1) will **not** clean or repair valves, Members of the Workforce performing these functions shall:

- Use proper replacement parts and follow the manufacturer's repair and assembly procedures.
- Retest repaired valves to ensure proper operation.

Burst Disks

Requirements

Members of the Workforce shall not have burst disks tested by the Onsite Calibration & Maintenance Department (2541-1); they are lot-tested by the manufacturer.

Guidance

Members of the Workforce who use burst disks should specify inspection and replacement intervals for burst disks in the system data package.

Specific Test Procedures

Requirements

Operators of PRV test stations shall follow this testing procedure:

1. Steadily increase the pressure on the PRV, slowing the rate of increase as you approach the set pressure. A slow rate of increase is needed to accurately determine the cracking pressure. A metering valve may help control the rate of pressure increase.
2. Record the initial cracking pressure. Measuring and recording popping pressures is optional. After reducing the pressure, record the initial re-seat pressure. Cracking, popping, and re-seat effects can be detected visually on the test gauge, by sound, or by monitoring flow. Record operator-observed valve leakage upon re-seat on the test data sheet.
3. Record and report unusual first-pop effects to the user, as this may help determine the adequacy of the line's periodic inspections and may call for more frequent manual operations of the valve. Valves that will not settle in and give repeatable cracking or popping pressures (within 5% of previous readings) should be considered unreliable and therefore should be rejected. The user or line Pressure Advisor shall make this determination.
4. Repeat this procedure to get at least two additional measurements of cracking, popping and re-seat pressures.
5. Compute the average of the above measurements.

   Note: If the first set of test pressures were significantly different than the repetitive values, do not include them in the average. Use an average of three or more readings taken when the valve has been exercised.
6. Record and report to the user any other valve characteristics observed.
7. Compare the average value determined in step 5 to the valve's nominal set pressure and refer to the tolerance charts in Table J-1 or the manufacturer's specifications.
8. Note any operational conditions such as leakage or chatter upon re-seat in the comments section of the test data sheet.
9. Certify and tag a valve based on its operational test results **and** the application. The approval for certification shall be made by the system's Pressure Installer or line Pressure Advisor.
10. Consult Table J-1, Tolerances Guidelines for PRV Testing, when determining operational characteristics and acceptance of a PRV.

Table J-1. Tolerance Guidelines for PRV Testing

Nominal Cracking Pressures (psig)	Non-ASME Code Valves (% tolerance)	ASME Code Valves (% tolerance)
0 to 5	±25%	Consult the applicable ASME Code
5 to 10	±15%	
10 to 25	±10%	
25 to 500	±5%	
500 to 2000	±4%	
Over 2000	±3%	

Notes:

1. In all cases, the application of a PRV influences the parameters tested, procedures required, and the acceptance/rejection criteria. The line organization shall make the above determinations under the guidance of the system Pressure Installer or Pressure Advisor.

2. The tolerances listed above represent general guidelines for acceptable test results as developed with time and experience in PRV testing. Test results outside the above tolerances may indicate unusual valve performance and may be cause for rejection of the valve. In these cases, consult the manufacturer's specifications for tolerances relevant to that particular valve and justify the acceptance or rejection of a valve's performance in the comments section of the "PRV Test Data Sheet" (Word file/ Acrobat file) of SF 2001-PRV, Sandia Designated Pressure Relief Valve Test Station.

3. In cases where valve leakage upon re-seat is noted, the application of the valve and the significance and safety implications of its leakage shall be considered by the line when determining acceptance or rejection.

DATA RECORDING AND RECORD KEEPING

Interpreting and Recording Test Data

Requirements

The operators of PRV test stations shall provide a copy of the test data to the line.

The line representative (system Pressure Installer or Pressure Advisor) shall be responsible to:

- Interpret test results and determine the acceptance or rejection of the valve based on these test results and the valve's application.

- Include this information in the system data package and maintain it for the lifetime of the valve in order to analyze continued valve performance.

Tagging

Requirements

The operators of PRV test stations shall tag valves that have been tested and certified for use. (Tagging indicates line acceptance of the test results for the valve's application.)

Note: Vendor-applied tags on new valves indicate that the valve meets manufacturers' specifications.

Members of the Workforce who purchase new valves directly from qualified vendors who do not supply tags, shall tag or otherwise identify and track these valves.

Test Data Sheet

Requirements

The operators of PRV test stations shall:

- Complete a PRV test data sheet (see the Pressure Relief Valve (PRV) Test Data Sheet of SF 2001-PRV, Sandia Designated Pressure Relief Valve Test Station (Word file/Acrobat file). Alternate data sheet forms may be used at the discretion of the tester, provided that the alternate forms address all the data requirements.

- Retain a copy of the test data sheet at the testing station for a minimum of three years.

Rejected Valves

Requirements

The operators of PRV test stations shall return rejected valves to the valve owner along with the test results.

The valve owner shall:

- Either repair a rejected valve according to manufacturer specifications and procedures and submit it for re-test, or dispose of it.

- Dispose of valves having corrosion from exposure to hazardous materials according to CPR4000.1.1/MN471001, *ES&H Manual*.

SPECIAL CASES - NONROUTINE TESTING PROCEDURES

Note: In some cases, performance of the routine test procedures at stated intervals (see PRV Testing Procedures) would degrade valve performance or adversely affect the overall safe operation of a system. In such cases, special test procedures or intervals are then necessary.

Requirements

Members of the Workforce shall:

- Document the safety and reliability of the PRV and the associated pressure system in the system data package that is then approved by the manager and reviewed by the line Pressure Advisor.
- For monitoring purposes, inform the safety engineering representative or the appropriate Division ES&H Team member, in writing, of these special cases of nonroutine testing.

Guidance

For special cases, Members of the Workforce should consider the following topics of this section.

Documentation of Incompatibility

Document the reasons that the valve in question is not compatible with routine test procedures and/or intervals.

Alternate or Redundant Safety Measures

Alternate or redundant safety features of a system (excess flow valves, microprocessor control of interlocks, etc.) should be emphasized and included in the system data package. The acceptance or rejection criteria for the PRV may be influenced by these alternate safety features.

Original Equipment Manufacturer (OEM) Specification and Testing

OEM specifications and testing from a known, reputable manufacturer are acceptable in lieu of in-house testing to certify a valve for service for an initial interval. The manufacturer must, as a minimum, perform 100% testing of set and re-seat pressures. Other tests may also be required depending on the valve's application. Members of the Workforce should consult Appendix H, “Suppliers of Quality Pressure Hardware,” their Pressure Advisor, or the Safety Engineering SMEs for guidance on the acceptance of new PRVs.

Inspection and Replacement Intervals

Requirements

- The user shall state, in the Pressure Data Package, inspection and replacement or retest intervals for the valve and document any alternate tests or procedures that are performed. Criteria for rejection shall be listed.

RECALL OF PRVs AND MONITORING OF TEST INTERVALS

Requirements

Members of the Workforce shall be responsible for monitoring test intervals of relief valves within their cognizance. See Chapter 8, "Servicing Pressure Vessels and Components," for a complete listing of the responsibilities concerning relief valves.

Test Date Recorded on Valve Tag

Requirements

Members of the Workforce shall enter the test date on the valve tag. The expiration date is a function of the usage of the valve. See Chapter 8, "Servicing Pressure Vessels and Components", for further details.

Replacement Valves

Requirements

Members of the Workforce shall have replacement PRVs tested and ready for use before shutting down a system to replace valves due for retest. The valve needing re-test may leak or for some reason fail its re-test. Without replacement valves, the system must then be shut down until a suitable replacement valve can be procured.

Note: Lockout/Tagout procedures may need to be followed where systems would be left unprotected.

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Pressure Safety Manual

GLOSSARY

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ANSI - American National Standards Institute

ASME - American Society of Mechanical Engineers

Burst test (destructive) - A pressure test of a component or system to determine the actual failure mode and pressure.

Capacity - The flow rate that a device will pass at some pressure. For safety and relief valves made in accordance with Section VIII, Division 1, of the *ASME Code*, the maximum capacity is the flow rate through the valve at a pressure of no more than 110% of the set pressure. [ASME Code]

DOT - Department of Transportation

Ductile vessel - A pressure vessel fabricated from materials known to fail plastically in the presence of flaws at any temperature within the specified working temperature range of the vessel.

ESHIC - Environmental Safety & Health Implementation Committee

Factor of safety for a pressure vessel - The ratio of computed material ultimate strength to maximum stresses.

Just-in-Time (JIT) - Sandia procurement contract

Leak test - A pressure or vacuum test to determine the rate or location of a leak.

Manned area operation - A pressure operation in an environment where system failure could cause personal injury.

Maximum Allowable Working Pressure (MAWP) - The maximum gage pressure permissible in a component or system.

Operating pressure - The actual pressure, including normal surges, at which a system operates or is to be operated. The operating pressure must **never** be greater than the MAWP, and is usually at least 15% below MAWP.

Operational leak test - A leak test in which the system is pressurized to MAWP and allowed to rest for a period predetermined by consultation with the system designer and others. If the pressure does not drop by more than a reasonable percentage (usually 2% or 3%), the system is judged to be a good system.

Overpressure test (nondestructive) - Testing with liquid or gas to an overpressure to demonstrate that a vessel or system should function as designed (may be different from the definition in *ASME Code*, Section VIII, Division 1).

Pressure Advisor (PA) - A person appointed by supervision to assist in implementing and monitoring the pressure safety program for a designated center. Pressure advisors are the primary contacts for questions or guidance regarding any aspect of pressure system safety (e.g., configuration, ratings, procurement, and documentation). Advisors maintain an active knowledge of pressure systems, including:

- Proper assembly and setups.
- Typical pressure safety hazards.
- Standard practices as set forth in CPR400.1.1.27/MN471000, *Pressure Safety Manual*.
- Basic pressure system design.

Pressure cycle - A cycle involving pressure changes greater than 20% of MAWP.

Pressure Installer (PI) - The person who acts as the lead point of contact for issues related to the pressure system. The PI designs, performs original installation, modifies, operates and maintains the pressure system without supervision, selects and procures pressure hardware, and provides guidance to other personnel involved with the pressure system.

Pressure Operator (PO) - The person who uses and operates the pressure system. The PO is responsible for:

- Awareness of hazards of the system.
- Operating the system safely and within its design parameters.
- Seeking advice when needed.
- Verifying that the pressure safety requirements regarding operation and documentation have been met.

The PO does **not** design, modify, or install presure hardware, with the exception of routine operations (such as changing out gas cylinders).

Pressure system - An integrated array of pressure-containing components typically consisting of pressure vessels, piping, valves, pumps, gauges, etc., which is capable of maintaining fluid (liquid or gas) at a pressure different than atmospheric.

Pressure system personnel - Members of the Workforce whose job duties routinely involve working with pressure systems that have positive (greater than atmospheric) pressure.

Pressure vessel - A container capable of maintaining a fluid at a pressure different from atmospheric.

Pressure Safety Analysis Report (PSAR) - The Pressure Safety Analysis Report documents the reasons for deciding that a hazardous system is safe to operate.

PSC - Pressure Safety Committee

PSM - Pressure Safety Manual

Relief valve - An automatic pressure-relieving device actuated by the static pressure upstream of the valve. The valve opens in proportion to the increase in pressure over the opening pressure. [ASME Code]

Rupture disc - An automatic device that bursts at some specified pressure. [ASME Code]

> **Note:**See Section VIII, Division 1, paragraphs UG-125 through UG-136 of the current *ASME Code*for information on pressure-relief devices.

Safety relief valve - An automatic pressure-actuated relieving device suitable for use as either a safety or relief valve, depending on application. [ASME Code]

Safety valve - An automatic pressure-relieving device actuated by the static pressure upstream of the valve. The device is characterized by rapid full opening or by pop action. [ASME Code]

Service log - A record of pressure system operation, maintenance, and test.

Set pressure (of an automatic pressure-relieving device) - The pressure at which the device is intended to open. This is the test pressure listed on the relief device tag. Important: The set pressure must be less than or equal to the MAWP of the pressure hardware it protects. (See Table 7-1 for required testing intervals.) [ASME Code]

SOP - Standard Operating Procedure. A document requiring review and approval by specified persons before a pressure system is placed in operation.

Unmanned area operation - A pressure operation in an environment where system failure could not cause personal injury.

Caution: Terms such as "Working Pressure (WP)," "Service Pressure," "Rated Pressure," and "Design Pressure" are ambiguous. Their use is discouraged.

Vacuum - A condition of a space where gas pressure is below ambient atmospheric pressure. A vacuum system includes all of the components, e.g., the main vacuum vessel, plumbing, and pumps.

Vacuum system personnel - Members of the Workforce whose job duties routinely involve working with pressure systems that have negative (less than atmospheric) pressure.

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OFFICIAL BUSINESS RULE

SAMPLE PRESSURE SYSTEM REEVALUATION CHECKLIST

This is meant to be a guideline for conducting your reevaluations. It is not to be filled in "blindly" without keeping the aspects of your specific system in mind.

Location of System ______________________ Owning Organization ______________________

System Owner ____________________ Sandia Registry # (if PSAR required) _________________

Reevaluation Date _________________

Data Package Review:

1. Have the mechanisms of degradation been determined? ___________________________________
   What are they? ____
   What are the consequences of a failure due to these mechanisms?___________________________
2. What is the Maximum Allowable Working Pressure (MAWP)? ______________________________
3. What does the system contain? ____
4. What hazards are associated with this system? ____
   Have the hazards been contained or mitigated? ____
5. What type of inspection is required at this time? ____________________________________
6. What have been the findings of previous inspections? ________________________________
7. Does the associated SOP require updating? ____
8. What maintenance, calibration, or replacement intervals are addressed/required?
   ____
9. Is a pressure relief valve inventory needed? ____
10. If you have a log book, how many cycles has the vessel undergone? ________________________
    What was the maximum operating pressure applied? _____________________________________

Visual External Inspection:

1. Have the deficiencies from previous inspections been corrected? ________________________
   When and by whom? ____
2. Have there been any changes to the system since the last inspection? ______________________
   When and by whom? ____
   Describe changes ____
   Are changes significant enough to warrant recertification? ______________________________

SAMPLE PRESSURE SYSTEM REEVALUATION CHECKLIST (Cont'd)

3. Are all of the components rated for the system operating pressure? ____________________
   Is the material compatible with the system contents? ____________________
4. Are all of the components working properly? ____________________
5. When do the relief valves require re-certification? ____________________
6. Are the pressure gages working properly? ____________________
   Do they require calibration or re-calibration? ____________________
   Are the pressure gages of the proper range, at least 1.2 times
   the relief valve set pressure? ____________________
   Are the gage guards required? ____________________
7. Is the system properly assembles with the necessary components? ____________________
8. Is the system securely mounted? ____________________
   Do flexible lines require tiedowns? ____________________
9. Is there any sign of leakage? ____________________
10. Is there any sign of external corrosion? ____________________
    Is the corrosion severe enough to require further analysis? ____________________

Visual Internal Inspection:

Before performing an internal inspection, answer the following questions:

Is the system properly locked and tagged out of service? ____________________
Is all the pressure drained from the components of the system? ____________________
Are hazardous materials removed or purged from the system? ____________________

Open the system for visual inspection:

1. Are there any signs of internal corrosion? ____________________
   signs of internal erosion? ____________________
   signs of chemical attack? ____________________
2. Are there signs of blistering or cracks? ____________________
3. Are openings and sealing surfaces in good condition? ____________________
   Are flange surfaces clean and uniform? ____________________
   Are gasketted surfaces clean and uniform? ____________________
   Are ground joints smooth and free of scratches or debris? ____________________
4. Is further investigation or nondestructive evaluation (NDE) needed? ____________________

SAMPLE PRESSURE SYSTEM REEVALUATION CHECKLIST (Cont'd)

General Question:

1. Is all the hardware properly rated for the pressure source(s)? does the system have a fail safe mode (i.e., protected by pressure relief valves or it is not possible to overpressurize)?

2. Are pressure relief valves properly set below MAWP? Do they require recalibration?

3. Is the system properly documented?

4. Have all aspects of *your* reevaluation program been accounted for or are there other considerations?

If you are uncertain or unable to answer any of the above questions, further investigation will be necessary. Contact the appropriate Testing or Materials organization as listed in Appendix F of the Pressure Safety Manual for further analysis.

Post Inspection Report:

1. Is the system in satisfactory condition? ____
2. Can the system operate at the designed pressure, temperature, and working fluid?
   ____
3. What repairs did the system require? ____
   Who performed the repairs? ____
4. If NDE was performed, what were the results? ____________________________________
5. When is the next inspection required? ____
   What will it consist of? External? Internal? NDE? Calibration? ______________________
6. Summary of Reevaluation Findings ____
   ____
7. ADD ALL REEVALUATION DOCUMENTATION TO DATA PACKAGE.

SAMPLE PRESSURE SYSTEM REEVALUATION CHECKLIST (Cont'd)

Inspection performed by ______________________________ Division: ____________________

Review by ______________________________ Division: ____________________
Pressure Advisor

______________________________ Division: ____________________
Line Supervisor

______________________________ Division: ____________________
System Owner

______________________________ Division: ____________________
System User(s)