

ES&H Manual Pressure and Vacuum Systems Safety Supplement Part 1: General Program Information

# Part 1: General Program Information

## **1.1 Purpose and Scope**

This Supplement describes the detailed specific requirements of the Pressure and Vacuum Systems Safety Program at Jefferson Lab. All revisions to this Supplement must be approved by the Pressure Systems Committee.

The purpose of this program is to ensure that all personnel at Jefferson Lab involved in the construction, repair, alteration and operation of pressure and vacuum systems are cognizant of the hazards associated with these systems and construct, repair, alter and operate these systems in a safe manner. Except as otherwise noted, all references to "pressure system(s)" shall be considered to include both pressure and vacuum systems.

As stated in ES&H Manual Chapter 6151 Pressure and Vacuum Systems Safety Program, a pressure system is defined as any combination of vessels, piping, instrumentation (e.g. gauges), and/or equipment (e.g. pumps or compressors) either containing a fluid under internal pressure or exposed to external fluid pressure. Note that vacuum systems are a subclass of pressure systems.

The requirements of this Supplement apply to all pressure systems and components not explicitly excepted in <u>ES&H Manual Chapter 6151 Pressure and Vacuum Systems Safety Program</u> – **Exceptions** 

## 1.2 General

This document is intended for Jefferson Lab internal use only and shall not be released for any purpose, other than as a reference, to agencies other than Jefferson Lab. This document shall not be considered a design handbook.

The Jefferson Lab Pressure Systems Committee shall assume the duties of the jurisdictional authority. These duties include:

- Arbitration and interpretation of Code and policy issues.
- Provide guidance, formal or informal, when requested.
- Arbitrate and oversee all in-service inspection issues.

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The terms *shall*, *should* and *may* are used throughout this document. *Shall* indicates an action that is required or mandatory with regard to the pressure safety program. Should indicates an action that is considered good practice in most cases, but is not considered mandatory and, in some cases, such action may not be appropriate. The term *may* indicates an action that is fully optional.

## **1.2.1** Overview of Responsibilities for the Design Authority and **System Owner**

All work on pressure systems and/or components considered construction, alteration, or repair shall be performed under the supervision of an assigned Jefferson Lab Design Authority (henceforth known as the DA). The DA shall be responsible for all aspects of the task that has been assigned. The DA may delegate all or part of the work associated with any of these tasks but shall not delegate any responsibility. The DA shall ensure that the overall safety of the public, Jefferson Lab personnel and the environment are the primary consideration of any engineering design. The responsibilities of the DA shall terminate upon completion of all activities related to the assigned task and the system is turned over to an assigned Jefferson Lab System Owner.

Pressure system operation (normal and off normal) and maintenance work shall be performed under the supervision of an assigned Jefferson Lab System Owner. The System Owner is also responsible for ensuring that in-service inspection of pressure systems under their purview are performed and documented at prescribed intervals. In-service inspection of ASME Pressure Vessels, associated relief devices, and Category M equipment shall be coordinated and supervised by the Vessel Inspection Coordinator. The System Owner may delegate all or part of the work associated with any of these tasks but shall not delegate any responsibility.

## **1.2.2 Overview of ASME Code Requirements**

The ASME Boiler and Pressure Vessel Code (BPVC) and B31 Code for Pressure Piping are the core of the Pressure and Vacuum Systems Safety Program. While these specific ASME Codes are usually considered to be codes of construction this program references them for maintenance, operation, design, construction, repair, alteration, etc.

Pressure system design and construction initiated post 2/28/2008 shall comply with the ASME BPV Code and/or B31 Code for Pressure Piping as applicable. Every reasonable effort shall be made to ensure that the requirements of these ASME Codes are met. It is recognized, however, that these Codes may not directly apply to all pressure equipment or components in a system. Where the DA has determined that these Codes do not apply to a given component or system, that component or system shall be considered an Excluded Element.

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For new construction, the Code of Record for a pressure component shall be that version (or Code year) of the most applicable ASME Pressure Code in effect 6 months prior to the start date of the design (a later version may also be used, if available, at the discretion of the DA or if required by building codes). A Code of Record shall be determined for each component regardless of whether or not an ASME Pressure Code can be directly applied.

Repairs shall comply with the original Code of Record (or, if unknown, current code in effect at time of repair), NBIC Part 3, ASME PCC-2 or other suitable post construction code. Alterations shall comply with the ASME Code in effect at time of the alteration, NBIC Part 3, ASME PCC-2 or other suitable post construction code. For repairs and alterations where codes do not directly apply, sound engineering practices and equivalent measures shall be used.

# 1.2.3 Interpretation of ASME Code Functions and Derived Responsibilities

Jefferson Science Associates LLC functions as an Owner/Operator/User under the ASME Pressure Codes in its capacity as the management and operating contractor of Jefferson Lab for the U.S. Department of Energy under Contract No. DE-ACO5-06OR23177; assuming all liability as the legal entity responsible for compliance in accordance with its Federal Contract. As such, JSA/JLAB has the overall responsibility for Code compliance and establishment of requirements for design, construction, examination, inspection, testing, operation, maintenance, alteration, and repair of its pressure systems.

As Owner/Operator, JSA/JLAB will assign specific responsibilities and duties to its employees acting in their capacity as employees of the Owner/Operator; specifically as the Jefferson Lab Design Authority (the DA), Jefferson Lab Inspector, Jefferson Lab System Owner, and fabricator/manufacturer/erector. The DA, System Owner, and Inspectors employed by Jefferson Lab may refer to the Jefferson Lab Pressure Systems Committee for guidance, review or arbitration regarding any aspect of the performance of their duties. In performance of their duties, the DA, System Owner, and Inspectors employed by Jefferson Lab may delegate any fraction of the work, but shall not delegate the responsibility.

## **1.2.3.1** Responsibilities Derived from ASME B31 Piping Codes

The ASME B31 Codes define four organizations and their functions, involved in the design, fabrication, examination, inspection, testing, and operation of pressure piping. These are summarized below:

- 1) The Owner/Operator:
  - i) Has overall responsibility for Code compliance
  - ii) Shall establish requirements for design, construction, examination, inspection, testing, operation, and maintenance.

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- 2) The Designer:
  - i) Is responsible to the owner to ensure that the design complies with Code requirements
- 3) The Fabricator/Erector/Manufacturer:
  - i) Is responsible for providing materials, components, and workmanship in compliance with Code.
- 4) The Owner's Inspector:
  - i) Responsible to the owner to verify that all required testing, examinations, and inspections are complete
  - ii) Verifies the fabricators quality system is acceptable and implemented and that all required certifications and records are complete.

At Jefferson Lab, these concepts are not directly applicable. The organizations and their duties shall be as assigned below:

The duties of the *Owner/Operator* shall be assumed by the Jefferson Lab Design Authority (DA) (assigned to the construction, alteration, or repair) and the Jefferson Lab System Owner assigned to the system. The overall responsibility for compliance with Code and Jefferson Lab policies shall be assumed by the DA. The responsibility for the performance and operability of the system shall be shared by the DA and the System Owner. The DA shall be responsible for establishing the requirements for the engineering design, construction, operation and initial maintenance of the system. The System Owner shall assume full responsibility for the safe operation and long term maintenance of the system. The responsibilities of the DA shall terminate upon completion of the construction, alteration, or repair.

The duties of the *Designer* shall be fully assumed by the DA. The DA shall be fully responsible for ensuring that the engineering design complies with Jefferson Lab policy and Code requirements where applicable.

The DA shall be responsible for ensuring that duties of the *Fabricator/Erector/Manufacturer* are met. The DA shall be fully responsible for ensuring that the fabrication and procurement of all components in the system comply with Jefferson Lab policy and Code requirements. This includes all components fabricated off site.

The duties of the *Owner's Inspector* shall be assumed by one or more Jefferson Lab Inspectors meeting the qualifications given in Section 1.4.3. The inspector shall be an employee of the ESH&Q division or a qualified individual that is independent of the fabrication, manufacturing, erection, design, testing, and examination functions.

### **1.2.3.1.1** Use of Subcontractors

The DA (or designee under the supervision of the DA) shall serve as the Subcontracting Officer's Technical Representative (SOTR) for any work contracted to organizations other than

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Jefferson Lab (i.e. subcontractors). The contract shall clearly state the specific Code functions assumed by the subcontracting agency. The DA shall take reasonable measures to ensure that these functions and the related requirements of the Code are fulfilled.

## **1.2.3.2** Responsibilities Derived from ASME BPVC

The ASME BPVC identifies three organizations and their specific responsibilities involved in the design, fabrication, examination, inspection, testing, and operation of ASME Pressure Vessels. These are summarized below:

- 1. The Owner/User
  - a. It is the responsibility of the user or an agent acting on behalf of the user to provide a certified User's design.
  - b. It is the user's responsibility to specify, or cause to be specified, the effective Code edition, Section, and Division to be used in the construction of the vessel.
  - c. The User shall specify the performance requirements of the design specification.
- 2. The Manufacturer
  - a. Is responsible for the structural and pressure retaining integrity of the vessel or part thereof.
  - b. Shall ensure that the requirements in the User's design specification are met.
- 3. The Inspector
  - a. Shall be an employee of an ASME accredited Authorized Inspection Agency (or may be employed by the manufacturer when the manufacturer is also the user).
  - b. Shall perform the specified duties of the ASME BPVC Section and Division used for the vessel construction.

The concepts are directly applicable at Jefferson Lab. The organizations and their duties shall be as assigned below:

The duties of the *Owner/User* shall be jointly assumed by the DA and System Owner. The DA and System Owner shall specify the performance requirements and a certified User's design. The DA shall specify, or cause to be specified, the effective Code edition, Section, and Division to be used in the construction of the vessel.

The *Manufacturer* and *Inspector* shall be as given by the Code Section and Division. Jefferson Lab presently does not manufacture or serve as the ASME Code Inspector for any ASME Pressure Vessel or Boiler.

For vessels that cannot fully comply with the ASME BPVC see Part 3: Equivalent Measures.

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### **1.3 Responsibilities**

This section describes the general responsibilities of individuals and groups with regard to the Pressure and Vacuum Systems Safety Program. In some cases, individuals listed describe functions rather than personnel descriptions. Specific responsibilities are given in applicable sections of this Supplement.

## **1.3.1 Design Authority**

- Shall ensure that the overall safety of the public, Jefferson Lab personnel and the environment are the primary consideration of any engineering design.
- Shall ensure that pressure system construction, alteration, repair and documentation meet the requirements of this Supplement.
- Shall employ, as required, the expertise available through other Design Authorities, the QA/CI Inspector, the Welding Committee and the Pressure Systems Committee as well as the experience and lessons learned documented in the Pressure Systems project files database.
- Shall ensure that adequate overpressure protection is provided.
- Shall initiate pressure system documentation in a project file consistent with the requirements specified in this Supplement and populate those folders with required documentation prior to system startup.
- Shall maintain required training.
- For any new pressure vessel brought onto the Jefferson Lab site or to be operated by Jefferson Lab off site, the DA shall perform the following:
  - Complete required information on vessel registration form (<u>Form PS-4</u>). This form shall be submitted to the Vessel Inspection Coordinator.
  - Complete relief device registration (<u>Form PS-5</u>) for the device(s) protecting the vessel and submit the form to the Vessel Inspection Coordinator.
  - Ensure all pressure vessel documentation has been checked, verified and filed into the appropriate pressure system folder.
- For any existing vessel returned to service:
  - Conduct an operational readiness review and submit a new registration form (Form PS-4) to the Vessel Inspection Coordinator.
  - Complete relief device registration (Form PS-5) for the device(s) protecting the vessel and submit the form to the Vessel Inspection Coordinator.
  - Ensure all pressure vessel documentation has been checked, verified and filed into the appropriate pressure system folder.
- Vacuum systems:
  - DA shall ensure that the vacuum system design, fabrication and testing of Category 3 vacuum systems meets the requirements of this Supplement. The DA shall ensure that thin windows on Category 1 and 2 vacuum systems meet the

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requirements of <u>Part 7: Section 7.7 Requirements for Components with Thin</u> <u>Windows</u>.

- Shall determine the scope and type of test required on new construction and repairs, or alterations to pressure systems based on applicable codes, the engineering design, and sound engineering judgment.
- Shall define the In-service Inspection requirements for a new pressure system under their purview.
- Shall define operational requirements for any new pressure system under their purview.
- Shall define special maintenance requirements for any new pressure system under their purview.

# 1.3.2 ESH&Q Division

- Shall support, oversee and/or supervise, as needed, the QA/CI Inspector.
- Shall monitor current requirements and certifications necessary for mechanical examination personnel.
- Shall provide welding inspection as required by ASME Codes or by engineering requirements.
- Shall monitor current requirements and certifications necessary for welding examination and inspection personnel.
- If requested by the System Owner or DA, the welding inspector shall perform a final system walk-through and verify that required documentation of the pressure system is complete before operation of that pressure system.
- When requested by the DA, the welding inspector shall also serve as the pressure system construction inspector.

# **1.3.3 Facilities Management and Logistics (FML)**

- Shall designate a Vessel Inspection Coordinator.
- Shall support, oversee and/or supervise the Vessel Inspection Coordinator in the performance of the In-service Inspection Program.

# **1.3.4 Vessel Inspection Coordinator**

- Responsible for coordinating the required in-service inspections of all IC4 and IC3 components.
- Maintains a database of the following: (information to be provided by DAs)
  - ASME Boilers/Pressure Vessels and relief devices protecting them.
  - Category M pressure systems and relief devices protecting them.
- Maintains inspection records both current as well as one previous inspection for IC4 and IC3 vessels.

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- Issues CATS for any ASME Boilers or Vessels that have failed or have been condemned.
- Conveys the results of any failed or condemned ASME Boiler or Vessel to the responsible System Owner
- Issues CATS entry for any relief devices on ASME Boilers or Pressure Vessels that have failed and have not been immediately replaced by an acceptable device.
- Conveys the results of any failed relief devices on ASME Boilers or Pressure Vessels to the System Owner.

# **1.3.5 In-Service Inspector**

- Conducts the inspection of all identified in-service pressure equipment.
- Completes and signs the required inspection forms (<u>Form PS-10</u>, <u>Form PS-11</u> and <u>Form PS-12</u>).
- Reviews inspection results with the designated Vessel Inspection Coordinator when appropriate.
- Provides additional testing means and methods as required for vessel inspections.
- Conducts the inspection of all identified relief devices.
- Reviews inspection results with the designated Vessel Inspection Coordinator or the System Owner in the case of relief devices installed to protect piping and Excluded Vessels.

# **1.3.6 Pressure Systems Committee**

- Committee Chair
  - Shall maintain a list of qualified DAs.
  - Shall review and approve safety documents (e.g. OSPs, TOSPs etc.) and perform specific duties given in this Supplement.
  - Shall approve systems where overpressure protection is provided by system design.
  - May enlist the aid of the Pressure System Committee and other subject matter experts as needed.
- General Committee
  - Shall arbitrate issues of conflict related to pressure safety, Code, and Jefferson Lab policies.
  - Shall assume the responsibilities of the jurisdictional authority.
- Designee (located within the Document Control Group)
  - o Assist in the creation of the pressure system identification number
  - $\circ~$  Assist in the creation of pressure system folders and subfolders in the pressure system database

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- Assist in inputting documentation into folders/subfolders as directed by DAs or System Owners
- Update the pressure system database with new information upon notification by a new System Owner in the event of a change in the designated System Owner for a pressure system. If the change involves an IC4 or IC3 component, communicate the change to the Vessel Inspection Coordinator
- Upon notification from a System Owner, update the pressure system database when a pressure system is permanently taken out of service. If the change involves an IC4 or IC3 system, communicate the change to the Vessel Inspection Coordinator.

# **1.3.7 Pressure System Construction Inspector**

- Shall maintain appropriate qualifications
- Shall witness final pressure system tests.
- Shall certify that pressure vessels have passed required pressure testing.
- Shall perform final system walkthrough and issue an inspection report (Form PS-8).
- Shall review system documentation for completeness.

# 1.3.8 Pressure System Technician, Operator, User, Worker

- Shall maintain appropriate training
- Shall design, fabricate, install, operate, maintain, and alter pressure systems and components at the direction of the System Owner or DA.

# **1.3.9 Pressure Test Engineer**

- Shall be qualified and trained as required by the DA.
- Shall determine the stored energy of the pressure test.
- Shall be responsible for determining the need for and preparation of, if required, an OSP, TOSP, or SOP governing the pressure or leak test.
- Shall supervise pressure tests on new construction and repairs or alterations to pressure systems and components.
- Shall witness the pressure system test for all newly constructed systems.
- Shall ensure that all personnel involved in the pressure test are trained and qualified and are cognizant of the hazards associated with the test.

# **1.3.10 Pressure Test Technician**

• Shall maintain appropriate training

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- Shall install the pressure test equipment and perform the pressure test under the direction of the DA or Test Engineer.
- Shall perform required examinations and log data in the required testing documentation and sign the pressure test form (Form PS-7).

# **1.3.11** Responsible Vacuum Engineer

- Shall maintain appropriate training
- Shall ensure that the design, fabrication and testing of Category 1 and 2 vacuum systems meet the requirements of this Supplement. Note that the responsibility for the design of thin windows on Category 1 and 2 vacuum systems shall be assumed by the DA.
- Shall determine the category for each new vacuum system or existing vacuum system requiring repair or alteration.

# 1.3.12 System Owner

- Shall maintain appropriate training.
- Shall ensure that systems under their purview have a valid Pressure System number/title and an identified Inspection Category.
- Shall ensure that ASME vessels and the associated relief devices under their purview are identified in the Vessel Inspection Coordinators database.
- Shall ensure that systems under their purview are maintained and operated by qualified personnel.
- Shall ensure that pressure systems under their purview are inspected and/or tested in compliance with this Supplement.
- Shall ensure that pressure systems under their purview continue to be maintained and operated in a safe manner compliant with this Supplement.
- Notifies Pressure Systems Committee Designee if a system is taken out of operation permanently or if system ownership changes.
- Notifies Vessel Inspection Coordinator of a change in status of any existing IC4 or IC3 pressure vessels such as "Removed from Service", relocation, or changes in operational parameters (e.g. change of fluid service).
- When notified by the Vessel Inspection Coordinator of a vessel that has been condemned by an inspector, removes the vessel from service as soon as safely possible.
- Maintains the integrity and placement of vessel identification markings.
- Shall work with the Vessel Inspection Coordinator to complete in-service inspections of IC4 and IC3 systems.
- Shall ensure that in-service inspections of IC2 and IC1 systems are completed and documented.
- Maintains test and inspection records of relief devices.

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- Notifies Vessel Inspection Coordinator of a change in status of any relief device actively providing overpressure protection for an ASME Boiler or Pressure Vessel.
- Shall ensure that corrective action is taken when notified of deficient relief devices.
- Shall develop operational procedures and inspection/maintenance plans as necessary.

# 1.3.13 Vacuum Technician

- Shall determine the category for each new vacuum system or existing vacuum system requiring repair or alteration.
- Responsible for the design and fabrication of Category 0 vacuum systems.
- Shall maintain appropriate training.

# 1.4 Qualifications

This section describes the qualifications for personnel designing, fabricating, inspecting, operating, repairing, altering, and testing pressure systems or pressure components. Owners of pressure systems shall also be qualified as described in this section.

# **1.4.1 Design Authorities**

Design Authorities (DAs) must demonstrate the ability to design and supervise construction of pressure systems according to the applicable ASME Codes. The qualifications and experience required of the DA shall depend on the complexity and criticality of the pressure system and the nature of the individual's experience. All Design Authorities shall be trained in the application of the policies and procedures contained in this Supplement, the <u>ES&H Manual Chapter 6151</u> <u>Pressure and Vacuum Systems Safety Program</u>, and the <u>ES&H Manual Welding and Brazing</u> <u>Program Supplement</u>. Design Authorities shall maintain Pressure System Hazard Awareness SAF 130A and Pressure System Safety for Design Authorities SAF 130B and Pressure System Owner Training SAF130C. Approval of the Jefferson Lab Engineering Manager is required if the individual does not meet at least one of the following criteria:

- Completion of an engineering, physics or chemistry degree, requiring four or more years of full-time study, plus a minimum of five years of experience in the design of related pressure vessels or piping.
- Professional Engineering registration, recognized by any state or territory within the United States, and experience in the design of related pressure vessels or piping.

## 1.4.2 Examiners

Examiners shall have training and experience commensurate with the needs of the specific examinations as determined by the specified ASME Code, engineering design, and the DA.

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## 1.4.2.1 Welding

All examiners that are Jefferson Lab employees shall be approved by the Jefferson Lab ASNT Level III or Level III designate within ESH&Q (QA/CI Inspector).

All visual examiners shall have at least one of the following qualifications (specific to the specified examination process):

- Shall be certified to ASNT SNT-TC-1A Level II.
- Shall meet the requirements of Jefferson Lab procedure NDT-PQ-100.

### 1.4.2.2 Mechanical

Mechanical examiners shall be Jefferson Lab employees approved by ESH&Q. These examiners shall meet the requirements of the Jefferson Lab procedure NDT-PQ-100 or shall be certified to ASNT SNT-TC-1A Level II.

## **1.4.3 Inspectors**

## **1.4.3.1 Pressure System Construction Inspectors**

For pressure systems used at Jefferson Lab, the Inspector shall be designated by Jefferson Lab and shall be an employee of Jefferson Lab, an employee of an engineering or scientific organization, or of a recognized insurance or inspection company acting as Jefferson Lab's agent. The inspector shall be independent from the design, manufacturing, erection, testing, or examination processes. Jefferson Lab employee inspectors shall have one or more of the following qualifications:

- DA with specific approval by Pressure Systems Committee.
- CWI (certified welding inspector) or senior CWI, possessing a valid certificate as defined by AWS QC1, with approval by Pressure Systems Committee.
- Authorized piping inspector with 5 years of experience as defined in ASME B31.3 340.4(b) 4 with approval by Pressure Systems Committee.

Inspectors employed by other agencies shall be qualified as given by the code of construction. Outside Inspectors of Excluded Elements and Vessels shall meet the qualifications given in ASME B31.3 340.4. See the following references.

- ASME B31.1 136.1.4
- ASME B31.3 340.4
- ASME B31.5 537.4

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- ASME B31.9 (no specific requirements)
- ASME B31.12 GR-4.2.3

## **1.4.3.2** In-Service Inspectors

## 1.4.3.2.1 Boilers

Inspectors of ASME boilers in operation shall be qualified as follows:

• Commonwealth of Virginia certified inspector as qualified in the Commonwealth of Virginia Boiler and Pressure Vessel Rules and Regulations.

## 1.4.3.2.2 Pressure Vessels

Inspectors of pressure vessels, other than boilers, shall be designated by Jefferson Lab and shall be an employee of Jefferson Lab, an employee of an engineering or scientific organization, or of a recognized insurance or inspection company acting as Jefferson Lab's agent. Inspectors shall have one or more of the following qualifications:

- A Commonwealth of Virginia certified inspector as qualified in the Commonwealth of Virginia Boiler and Pressure Vessel Rules and Regulations.
- Properly trained and certified API 510 inspector.
- DA with specific approval by Pressure Systems Committee.
- Authorized piping inspector with 5 years of experience as defined in ASME B31.3 340.4(b) 4.

# 1.4.3.2.3 Relief Devices

Inspectors of relief devices shall be designated by Jefferson Lab and shall be an employee of Jefferson Lab or an employee of an organization holding a valid "VR" or other similar National Board stamp. Inspectors shall have one or more of the following qualifications:

- A Commonwealth of Virginia certified inspector as qualified in the Commonwealth of Virginia Boiler and Pressure Vessel Rules and Regulations.
- Authorized piping inspector with 5 years of experience as defined in ASME B31.3 340.4(b) 4.
- Properly trained and certified API 510, 570 or 576 inspector.
- DA with specific approval by Pressure Systems Committee.
- Visual Examiner meeting the requirements of Jefferson Lab procedure NDT-PQ-100 and approved by the Pressure Systems Committee.

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# 1.4.3.2.4 Piping

Inspectors of piping shall be designated by Jefferson Lab and shall be an employee of Jefferson Lab or an employee of an organization holding a valid National Board stamp. Inspectors shall have one or more of the following qualifications:

- A Commonwealth of Virginia certified inspector as qualified in the Commonwealth of Virginia Boiler and Pressure Vessel Rules and Regulations.
- Authorized piping inspector with 5 years of experience as defined in ASME B31.3 340.4(b) 4.
- Properly trained and certified API 570 inspector.
- DA with specific approval by Pressure Systems Committee.
- Visual Examiner meeting the requirements of Jefferson Lab procedure NDT-PQ-100 and approved by the Pressure Systems Committee.

# **1.4.3.3** Welding and Brazing Inspectors

Inspections of welds and brazes, where required by Code or the engineering design, shall be performed by personnel meeting one or more of the following:

- An employee of the ESH&Q division designated as the QA/CI Inspector with CWI or senior CWI certification, possessing a valid certificate as defined by AWS QC1, with at least 5 years of experience.
- Inspectors employed by outside organizations to inspect welds or brazes performed by Jefferson Lab employees
  - CWI or senior CWI, possessing a valid certificate as defined by AWS QC1, with at least 5 years of experience.
- Inspectors employed by outside organizations to inspect welds or brazes performed by outside organizations shall be qualified as given by the code of construction or post construction.

Note: Inspections are not examinations (see Part 2: Section 2.8 Fabrication by Welding, Brazing, and Soldering).

# **1.4.4 Operators and Users**

Operators of pressure systems shall meet the following requirements.

• Operators of pressure systems shall have hazard awareness training that includes basic principles of pressure technology and pressure safety (SAF 130A Pressure System Hazard Awareness Training).

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- Shall maintain system specific training required by the System Owner(s). This training shall include implementation of standard and emergency operating strategies.
- Shall meet additional qualifications and maintain training as required by supervisor.

# **1.4.5 Pressure System and Test Technicians**

Fabricators of pressure systems and components shall meet the following qualifications:

- Shall have experience working with pressure equipment as required by supervisor; this may include on the job training.
- Personnel performing assembly and testing of pressure equipment shall maintain Pressure System Hazard Awareness Training SAF 130A.
- Personnel performing any work on energized systems shall maintain Pressure System Hazard Awareness Training SAF 130A.
- Shall meet any additional qualifications and maintain training as required by the DA responsible for the system, the System Owner, and the work supervisor/coordinator.

# **1.4.6 Responsible Vacuum Engineers**

- Shall maintain Pressure System Hazard Awareness Training SAF 130A
- Shall have experience with the design and fabrication of vacuum systems and vessels.
- Additional qualifications shall be determined by the individual's supervisor.

# 1.4.7 System Owners

- Owners of pressure systems shall fully understand the function and operation of pressure systems under their purview.
- Owners shall be aware of the requirements of this Supplement and maintain Pressure System Hazard Awareness Training SAF 130A and Pressure System Owner Training SAF 130C.

## 1.4.8 Vacuum Technicians

• The qualifications of the competent technical individual shall be determined by the individual's supervisor; each individual shall, as a minimum, complete Pressure System Hazard Awareness Training, SAF130A.

# **1.4.9 Welders and Brazers**

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Welders and brazers of pressure equipment employed by Jefferson Lab shall maintain the following training and qualifications:

- SAF 130A (Pressure System Hazard Awareness)
- SAF 150 (Welding Safety).
- Shall maintain certifications detailed by the DA and line management for the appropriate welding and brazing procedures and processes.
- Shall have knowledge of their individual certifications.
- Shall meet additional or superseding certifications given in ASME Codes of construction or post construction (e.g. ASME BPVC Section IX and ASME B31.3. ¶ 333).
- Shall meet the requirements given in the <u>ES&H Manual Welding and Brazing</u> <u>Supplement</u>.

Welders and brazers of pressure equipment fabricated off site for use at Jefferson Lab shall be certified as required in the specified ASME Code of Construction. These certifications shall meet the requirements of ASME BPVC Section IX (except where superseded by the code of construction or the engineering design) with regard to WPS/PQR, WPQ/BPQ, and documentation. These certifications shall be detailed in a SOW where appropriate. Where ASME Codes are not applicable, procedures, welders, and brazers shall be qualified as given in Part 2: Section 2.8.2 Qualification of Procedures and Part 2: Section 2.8.5 Unlisted Materials. This shall be detailed and documented as required by a SOW where welding or brazing is to be performed by agencies other than Jefferson Lab.

### **1.5 Required Documentation**

### **1.5.1 General Requirements**

This section describes the required and recommended documentation for pressure system construction, repair, alteration, maintenance, in-service inspection, and operation.

For each new pressure system, the DA shall consult with the Pressure Systems Committee Designee to create a unique identification number. The naming/numbering convention for all pressure systems shall be as given in <u>Part 1: Section 1.5.2 Numbering Convention</u>.

The DA shall create a corresponding title for the pressure system which includes clear terms describing the system and its location, if relevant.

The DA shall create a Project Folder within the Pressure Systems database with assistance from the Pressure Systems Committee Designee as required. Each pressure system shall have a top folder, labeled with the pressure system number and title, in the pressure systems database. This

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database may be accessed from the Pressure Systems webpage. The sub-folder structure and contents shall be as given in <u>Part 1: Section 1.5.5 Folder Content</u>.

Given the diverse and unique nature of pressure systems and the work performed on them at Jefferson Lab, it is recognized that not all documentation requirements are applicable. The DA (for construction, alterations, or repairs) or System Owner shall determine the extent of the documentation required by Code, the engineering design, and this Supplement. If it is determined that a certain document is required then it shall be filed as given in <u>Part 1: Section 1.5.5 Folder</u> <u>Content</u> (this will facilitate review of this documentation). Documentation packages (e.g. vendor documentation for a purchased compressor skid) for well-defined subsystems may be filed as a single document in the *Fabrication and Procurement* folder. If this package contains design drawings, calculations, etc. it shall also be filed or linked in the *Engineering* folder. Note also that some documentation listed below is optional.

# 1.5.1.1 Exemption for ASME B31.5, B31.9, B31.3 Category "D" and Vacuum Systems

For systems where the Code of construction is either ASME B31.3 Category "D", B31.5 or B31.9, the DA responsible for the system or the System Owner may choose not to use the standard subfolders as a filing system. The DA is still responsible for creating the unique identification number as given in <u>Part 1: Section 1.5.2 Numbering Convention</u> and a Project Folder within the Pressure Systems database with a top folder, labeled with the pressure system number and title, in the pressure systems database. A note shall be added to the folder description that identifies the alternate location of the applicable documentation. All applicable mandatory forms shall be stored in a subfolder labeled *Pressure Systems Forms*. The DA shall determine the extent and type of documentation required to meet the applicable Code of construction and is responsible for maintaining that documentation. This documentation shall be made available, for review or reference, within 5 working days upon request of the Pressure Committee Chair.

The extent of required documentation for Category 0, 1, and 2 vacuum systems is given in <u>Part</u> <u>7: Vacuum Systems</u>. The Responsible Vacuum Engineer, Vacuum Technician or System Owner may choose to file documentation for Category 0, 1, and 2 vacuum systems in the pressure system database at their discretion. Documentation for Category 3 vacuum systems shall follow the requirements detailed in this Part.

# **1.5.2 Numbering Convention**

The numbering convention for pressure systems shall be as shown in Figure 1-1: Pressure System Identification Number. The initial two letter designation "PS" shall apply to all systems. The following two or three letter designation "AB(C)" is the group designator and shall indicate the owner group or system type. This is followed by the year designator which is a two digit designation for the year the design of the system was initiated or "XX" for systems in operation

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prior to February 28, 2008. The final three digits shall increment from 001 to 999 as needed for each system designed in the given group and year. This sequence shall typically reset to 001 for each year and group. A group may use these three digits to codify their particular pressure systems according to a written procedure maintained and documented by that group. In these special cases, the final digit shall reset to 1 for each year, group and system.

*Group Designation	**Year of Initial Construction	***Sequential Number
ACC – Accelerator	(XX if Unkown)	From 001 to 999
AT – Acid Transfer		
CG – Compressed Gas		
CRM – Cryomodule		
CRY – Cryogenics		
DCW – Domestic Chilled Water		
DIA – Diagnostics		
DMP – Dump		
FAC – Facilities		
FEL – Free Electron Laser		
FS – Fire Suppression		
HallA – Hall A		
HYD – Hydraulic (Oil)		
LCW – Low Conductivity Water		
LHE Liquid Helium		
MAG – Magnet		
OPT – Optical		
PHY – Physics		
SPT – Support		
SRF – Superconducting RF		
STK – Structural Shapes		
TGT – Target		
UTL – Utilities		
VAC - Vacuum		

#### PS-ABC\*-XX\*\*-123\*\*\*

Figure 1-1: Pressure System Identification Number

## **1.5.3 Mandatory Forms**

These forms are standardized forms that shall be used when applicable for pressure system documentation. These forms are available on the Pressure Systems webpage.

• Form PS-1 Pressure System Project Cover Sheet (Applicable for each pressure system.)

<u>pdf | docx</u>

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Form PS-2 Overpressure by System Design Approval (Applicable if pressure relief devices are not in the design, see <u>Part 4: Section 4.8 Overpressure Protection by System Design</u> for exclusions.)

<u>pdf | docx</u>

- Form PS-3 Technical/Peer Review Record (Applicable for each pressure system. For pressure systems built on-site by subcontractors, the DA/SOTR may use an alternate.)
   <u>pdf</u> | docx
- Form PS-4 Pressure Vessel Registration (Applicable for each ASME Boiler, ASME Pressure Vessel or Excluded Vessel.)
   <u>pdf</u> | docx
- Form PS-5 Pressure Relief Device Data Sheet (Applicable for each relief device protecting an ASME Boiler, ASME Pressure Vessel, Excluded Vessel, Category M pressure system or piping larger than NPS 6.)
   <u>pdf</u> <u>docx</u>
- Form PS-6 Final Mechanical Examination (Applicable for each pressure system. For pressure systems built on-site by subcontractors, the DA/SOTR may use an alternate.)
   <u>pdf</u> | docx
- Form PS-7 Pressure/Leak Test Record (Applicable for each pressure system unless additional NDE is performed in lieu of a leak/pressure test. For pressure systems built on-site by subcontractors, the DA/SOTR may use an alternate.)
   pdf | docx
- Form PS-8 Final System Walkthrough and Documentation Review (Applicable for each pressure system.)
   pdf | docx
- Form PS-9 Pressure System Turnover (Applicable for each pressure system.) pdf | docx
- Form PS-10 Pressure System Equipment In-Service Inspection Data Sheet (Applicable for IC3 Category M Pressure Systems and IC1 pressure equipment.) <u>pdf | docx</u>
- Form PS-11 Vessel In-Service Inspection (controlled by Ron Bartek) (Applicable for each IC4 and IC3 ASME Boiler or ASME Pressure Vessel and their relief devices.)

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• Form PS-12 Pressure Relief Device Testing and Inspection Data Sheet (Applicable for IC2 relief devices protecting Excluded Vessels and piping larger than NPS 6; and IC3 relief devices on Cat M systems.)

<u>pdf</u> | <u>docx</u>

## **1.5.4 Folder Structure**

The following list details the subfolder structure and content for each pressure system. Detailed content is described in the following section.

- Engineering:
  - Design Calculations
  - o Reviews
  - Design Drawings
  - Overpressure Protection
  - o SOW
- Fabrication and Procurement
  - o Procurement
  - Welding, Brazing, and Soldering
  - Material and Instrument Certifications
  - Mechanical Examinations
  - Leak and Pressure Testing
  - o Vessels
  - o Overpressure Protection
- Final Walkthrough
- Operation and Maintenance
  - o System Turnover
  - Operations
  - o Maintenance
- Alterations
  - o Alteration 1...
  - o Alteration 2...
- Repairs
  - o Repair 1...
  - o Repair 2...
- In-Service Inspections
- Miscellaneous

## **1.5.5 Folder Content**

Each pressure system in the database shall have a top folder with the structure or sub-folders as described in this section. The documentation to be stored in each subdirectory is also given in

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this section. The Pressure Systems Committee Designee is available to help with the input of documentation into appropriate folders.

- Engineering-Design Calculations
  - Design Calculations
- Engineering-Reviews
  - Technical Reviews of all Code calculations and Engineering Design (Form PS-<u>3</u>)
  - Peer Reviews of all equivalent measures for all Excluded Vessels or Elements (Form PS-3)
  - Other reviews such as Division Safety Reviews (optional).
- Engineering-Design Drawings
  - All drawings and sketches relating to the pressure system. A list of Jefferson Lab drawing numbers including revision level for all unaltered drawings filed in the document control system is acceptable. Copies of initialed redline drawings are also acceptable.
  - A copy of the system P&ID shall be filed.
- Engineering-Overpressure Protection
  - Calculation showing the determination of the required relief capacity and the adequacy of the overpressure protection system.
  - Description of the overpressure protection subsystem
  - Relief device data sheets (<u>Form PS-5</u>) for all relief devices providing overpressure protection.
  - For systems where overpressure protection is by system design, all documents required in <u>Part 4: Section 4.8 Overpressure Protection by System Design</u> shall be filed in this folder including <u>Form PS-2</u>.
- Engineering-SOW
  - Completed Form PS-1: System description and statement of work or project description that contains the following:
    - Date design was initiated
    - Define the responsible DA and System Owner,
    - List of all applicable codes
    - List of elements for which ASME Codes do not apply
    - P&ID number(s)
  - Statements of work for specific procurement or in house activities
  - Engineering change orders
- Fabrication and Procurement-Procurement
  - Purchase orders
- Fabrication and Procurement Welding, Brazing, and Soldering
  - WPS/BPS/PQR for all welding/brazing procedures (Jefferson Lab and other fabricators). Listing the procedure numbers and where they are stored within the QA/CI documentation system is acceptable.

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- o Weld/braze maps or traceability documents
- WPQ/BPQ for all welders and brazers performing welding and brazing on any pressure component. Listing the qualification numbers and where they are stored within the QA/CI documentation system is acceptable.
- Weld/braze examinations
- Weld/braze inspections
- Fabrication and Procurement Material and Instrumentation Certifications
  - MTRs: mill test reports
  - CMTRs: certified mill test reports
  - o COCs: Certificates of conformance or compliance
  - Relevant material testing reports (i.e. impact test reports).
  - Instrumentation calibrations/certifications.
- Fabrication and Procurement Mechanical Examinations
  - All examinations other than welding (<u>Form PS-6</u>)
- Fabrication and Procurement Leak and Pressure Testing
  - Pressure/leak test forms (Form PS-7)
  - OSPs, TOSPs etc. (optional)
  - If additional NDE is performed in lieu of a leak/pressure test, the results of these examinations shall also be filed. A justification for using NDE instead of standard leak/pressure testing should also be filed.
- Fabrication and Procurement Vessels
  - Form U-1, U-1A, etc. shall be filed for each ASME Pressure Vessel in the system.
  - Form PS-4 for each vessel
- Fabrication and Procurement Overpressure Protection
  - Relief device data sheets (<u>Form PS-5</u>) for all relief devices providing overpressure protection.
- Final Walkthrough
  - The results of the final system walkthrough as described in <u>Part 2: Section</u> <u>2.10.1 Final System Walkthrough</u> Error! Reference source not found. and documented in Form PS-8.
- Operation and Maintenance System Turnover
  - Completed <u>Form PS-9</u>
- Operation and Maintenance Operations
  - All contents of this folder are optional
  - Operational procedures and manuals
  - Operations logs etc.
- Operation and Maintenance Maintenance
  - All contents of this folder are optional
  - All maintenance related documentation describing work performed on the system. Including the following:
    - Corrosion protection

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- Painting
- Valve seat replacement
- *Alterations-Alteration 1* (A separate folder shall be created for each alteration)
  - Brief description of the alteration and a procedure for performing the alteration.
  - Relevant calculations
  - Welding documentation
  - Welding/brazing procedures used as needed
  - Welder/brazer qualifications for each welder/brazer performing the alteration
  - o Weld maps or traceability documents
  - Weld examinations and inspections
  - Drawings as needed. Pictures of the alteration may also be stored here.
  - A copy of the altered system P&ID shall be filed
  - SOWs for work performed by organizations other than Jefferson Lab.
  - Procurement documentation as determined by the responsible DA.
  - Material certifications and additional test such as impact testing (if required)
  - Any additional NDE and testing to return the system to service.
  - Other pertinent documentation as determined by the System Owner or DA responsible for the alteration.
- *Repairs-Repair 1* (A separate folder shall be created for each repair)
  - o Brief description of the repair and a repair procedure if needed
  - Relevant calculations as described
  - Welding documentation as needed
  - Welding/brazing procedures used
  - Welder/brazer qualifications for each welder/brazer performing the repair
  - Weld maps or traceability documents
  - Weld examinations and inspections
  - Material certifications and additional test such as impact testing (if required)
  - Drawings as needed. Pictures of the repair may also be stored here.
  - SOWs for work performed by organizations other than Jefferson Lab.
  - Procurement documentation as determined by the responsible DA.
  - Any additional NDE and testing to return the system to return the system to service.
  - Other pertinent documentation as determined by the System Owner or DA responsible for the repair.
- In-Service Inspections
  - Inspection procedures and requirements
  - All in-service inspection reports (<u>Form PS-10</u>, <u>Form PS-11</u> and <u>Form PS-12</u>) for any system component other than ASME Vessels and Boilers. These may be filed in separate folders as needed for organizational purposes.
  - Form PS-11 for ASME Vessels and Boilers shall be stored in a separate database on the Pressure Systems webpage
- Miscellaneous
  - Vendor manuals or information

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- Any documentation deemed useful by the System Owner or DA
- All contents of this folder are optional.

NOTE: Not all documentation is applicable. The system DA or System Owner shall determine the extent of documentation to be filed in the pressure system subfolders for each system.

## **1.6 Definitions**

### 1.6.1 Acronyms

- AHA: Activity Hazard Analysis
- API: American Petroleum Institute
- ASCE: American Society of Civil Engineers
- ASHRAE: American Society of Heating Refrigeration and Air conditioning Engineers
- ASME: American Society of Mechanical Engineers
- ASNT: American Society of Nondestructive Testing
- ASTM: American Society for Testing and Materials
- AWS: American Welding Society
- BPQ: Brazer Performance Qualification
- CATS: Corrective Actions Tracking System
- CE/PED Conformité Européene (European Conformity)/Pressure Equipment Directive Pressure Equipment Directive 97/23/EC of the European Union outlining standards for the design and fabrication of pressure equipment.
- CMTR: Certified mill test report
- COC: Certificate of Conformance (or compliance)
- DA: Jefferson Lab Design Authority
- FMECA: Failure Mode Effects and Criticality Analysis
- FML: Jefferson Lab Facilities Management and Logistics
- LHe: Liquid helium
- LN2: Liquid nitrogen
- MDMT: Minimum Design Metal Temperature
- MAWP: Maximum Allowable Working Pressure
- MTR: Mill test report
- NBIC: National Board Inspection Code (NB-23)
- NDE: Non-destructive examination
- NDT: Non-destructive test
- NPS: Nominal pipe size
- OSP: Operational safety procedure
- PQR: Procedure Qualification Record
- PT: Liquid penetrant test

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- QA: Quality Assurance
- QC: Quality Control
- RT: Radiographic test
- SOP: Standard Operating Procedure
- SOW: Statement of work
- SOTR: Subcontracting Officer's Technical Representative
- TOSP: Temporary operational safety procedure
- USDOT: US Department of Transportation
- UT: Ultrasonic test
- VR: Valve Repair
- VT: Visual test
- WBS: Jefferson Lab Welding and Brazing Supplement
- WPQ: Welder/Operator Performance Qualification
- WPS: Welding Procedure Specification

# **1.6.2 Definitions**

- *Accumulation*: pressure increase above the MAWP or Design Pressure of a system, vessel, or component realized during a relief event
- *Alteration*: any work performed on an existing system that may change any aspect of the design specification or fluid service; this includes changes to the structural supports for piping or vessels and extension to piping.
- *ASME Pressure Code*: Any one of the following ASME Codes:
  - ASME Boiler and Pressure Vessel Code
  - ASME B31 Pressure Piping Code
  - o ASME PCC-2 Repair of Pressure Equipment and Piping
- *ASME Pressure Vessel*: Any vessel designed and fabricated in compliance with ASME BPVC bearing an ASME Code stamp (e.g. a U stamp for a Section VIII Div 1 vessel).
- *Blow Down*: Difference between opening pressure and closing pressure of a relief device.
- *Category D Fluid Service*: A fluid service, defined in ASME B31.3, in which all of the following apply:
  - $\circ\,$  The fluid handled is nonflammable, nontoxic, and not damaging to human tissues as defined in § 300.2
  - The design gage pressure does not exceed 150 psi.
  - $\circ$  The design temperature is not greater than 366°F
  - $\circ\,$  The minimum fluid temperature caused by anything other than atmospheric conditions is not less than  $-20^\circ {\rm F}$
- **Category M Fluid Service**: a fluid service, defined in ASME B31.3, in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce

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serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken.

- *Construction*: (or new construction) refers to any and all of the following activities performed on a new system: Design, Review, Purchasing, Fabrication, Assembly, Installation, Examination, Inspection, Testing, and Documentation.
- *Credible Pressure Source*: Any source of fluid pressure derived from normal operating conditions or reasonable failure mode such as fire or rupture of thin walled vessel. Other sources of pressure include condensed or plated room temperature gasses on cryogenic surfaces located inside an insulating vacuum chamber.
- *Employee of Jefferson Lab*: For the purposes of this Supplement employee shall refer to any employee of Jefferson Lab or temporary contract labor.
- *Engineering Design*: The detailed design governing a pressure system developed from process and mechanical requirements, conforming to Code requirements, and including all necessary specifications, drawings, and supporting documents.
- *Examination:* The observation, by suitable technique, of whatever portions of components, joints, and other elements that are exposed to such observation either before, during, or after manufacture, fabrication, assembly, erection, inspection, or testing. This examination may include verification of the applicable requirements for materials, components, dimensions, joint preparation, alignment, welding or joining, supports, assembly, and erection. Examinations are performed without damaging the test object.
- *Excluded Element*: Pressure component for which there are no directly applicable ASME Codes.
- *Excluded Vessel:* A pressure vessel not in full compliance with the requirements of the ASME BPVC.
- *Hot Tapping:* The method of making a connection or tie-in to existing piping or pressure vessels while the piping or vessel is on-stream and under pressure.
- *Hydro-Pneumatic Test*: A pressure or tightness test where the test fluid is a combination of gas and liquid.
- *Hydrostatic Test*: A pressure or tightness test where the test fluid is liquid.
- In-Service Inspection Category:
  - *IC4*: ASME boilers and relief devices protecting them.
  - *IC3*: ASME Section VIII Pressure Vessels and Category M systems and relief devices protecting them.
  - *IC2*: Relief devices providing overpressure protection on Excluded Vessels or piping larger than 6 NPS.
  - *IC1*: All other pressure equipment (e.g. piping, turbo and reciprocating machinery, Excluded Vessels, vacuum equipment such as insulating jackets, etc.).
- *Inspection:* Denotes the activities, performed by an Inspector, to verify that all required examinations and tests have been completed, and to ensure that all the documentation

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for material, fabrication, and examination conforms to the requirements of the applicable Code and the engineering design.

- *Leak Test:* A test that is performed post fabrication and prior to initial operation of a piping system to verify that the piping system is leak free.
- *Listed Material*: Any material with an accepted published specification, such as ASTM B209 for aluminum alloys.
- *Low Temperature Cryogenic Component*: Component with a MDMT of less than 77K (321F) or
- *May*: indicates an action that is permitted but not required with regard to the pressure safety program
- *New Construction*: See Construction
- *Normal Fluid Service*: fluid service, defined in ASME B31.3, as a service other than Category D or M.
- *Peer Review*: Review of work performed on a pressure system or component that is performed by one or more design authorities or subject matter experts from an organization or group that is not involved in the design or construction of the system or component. These reviews are required for any component where it is determined, by the system DA that national consensus codes do not directly apply.
- *Pneumatic Test*: A pressure or tightness test where the test fluid is a gas.
- *Pressure System*: any combination of vessels, piping, instrumentation (e.g. gauges), and/or equipment (e.g. pumps or compressors) either containing a fluid under internal pressure or exposed to external fluid pressure. Note that vacuum systems are a subclass of pressure systems.
- **Pressure System Maintenance**: any work performed on an existing system that does not change the fluid service or any aspect of the design and does not require welding or brazing. These activities include inspection, painting, corrosion control, gasket replacement, relief device maintenance, replacement of filter cartridges, etc.
- Pressure System Modification: See alteration
- *Pressure System Operator*: Operator or user of pressure equipment for any purpose other than testing.
- *Pressure System Owner*: Individual responsible for the operation, maintenance and inservice inspection of a pressure system.
- *Pressure System Technician*: Individual that performs various work functions for the construction, testing, operation, maintenance, inspection, repair and alteration of a pressure system. This work can include designing, welding, pipe fitting, installation, flange bolting, valve repacking, etc.
- **Pressure Test**: A test performed to ensure the gross integrity of a pressure system or component. This test may be performed on new construction or on systems and/or components where the pressure boundary has been altered or repaired.
- *Pressure Vessel*: A container that contains a fluid under internal or external pressure not used for the sole purpose of conveying fluid from one point to another.

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- *Repair*: any work performed on an existing system that does not change the fluid service or any aspect of the original design specifications including MAWP or design pressure, maximum/minimum design temperatures, piping/vessel routes and locations, sizes, and supports. Work not expressly considered an alteration shall be considered a repair.
- **Responsible Vacuum Engineer**: Individual responsible for the design, fabrication, documentation, etc. of Category 1 and 2 vacuum systems. The qualifications of these individuals shall be determined by their supervisors.
- *Shall*: indicates an action that is required or mandatory with regard to the pressure safety program
- *Should*: indicates an action that is considered good practice in most cases but, is not considered mandatory. In some cases, such action may not be appropriate.
- *Stored Energy*: Energy contained in the system fluid(s) considering pressure and chemical energies only.
- *Technical Review*: A review of design calculations or specifications to verify accuracy and compliance to predetermined requirements; national consensus codes; industry standards; or common scientific, engineering practice. This review shall be completed by a DA other than the DA responsible for the design.

### 1.7 References

- <u>ES&H Manual Chapter 6122 Hot Work (i.e. Welding, Brazing, Cutting and Grinding)</u> <u>Safety Program.</u>
- ES&H Manual Chapter 6151 Pressure and Vacuum Systems Safety Program
- American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code Section VIII: Rules for Construction of Pressure Vessels, Divisions I & II and Sections I, IV, and VI
- ASME B31 Code for Pressure Piping:
  - B31.1 Power Piping: applicable to piping generally found in electric power production and district heating plants
  - B31.3 Process Piping: General piping code most applicable for piping systems at Jefferson Lab not associated with building services.
  - B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
  - B31.5 Refrigeration Piping and Heat Transfer Components: Applicable to HVAC systems.
  - o B31.8 Gas Transmission and Distribution Piping Systems
  - B31.9 Building Services: Applicable to piping carrying nonhazardous fluids at moderate temperatures typical in building services such as hot and cold water as well as instrument air systems.
  - B31.11 Slurry Transportation Piping Systems
  - B31.12 Hydrogen Piping and Pipelines

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### **Part 1: General Program Information**

- ASME Boiler and Pressure Vessel Code Case 2286, July 17, 1998
- Vacuum Systems Consensus Standard for Department of Energy Accelerator Laboratories, July 20, 2008 Draft.
- J.L. Western, Technical Memo 1380 Brookhaven National Laboratory
- W.C. Young, Roark's Formulas for Stress and Strain, Sixth ed. (1988).
- S. Timoshenko and S. Woinowsky-Krieger. Theory of Plates and Shells (1959).
- American Petroleum Institute (API)
  - API 576 Inspection of Pressure Relieving Devices.
  - o API 520 Sizing Selection and Installation of Pressure-relieving Devices
  - API 521 Guide for Pressure-relieving and Depressuring Systems
- American Society of Mechanical Engineers (ASME) PTC-25
- National Board Inspection Code Parts 1, 2, 3 and 4 (NB-23)
- Jefferson Lab Welding and Brazing Supplement.

### **1.8 Revision Summary**

Revision 1.1 - 01/10/19 - Updated Section 1.7 to comply with January 2019 DOE revisions to 10 CFR 851. Remove years associated with standards.

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ES&H Manual Pressure and Vacuum Systems Safety Supplement Part 2: Pressure System Construction

## Part 2: Pressure System Construction

## 2.1 General

Pressure systems with a design initiated on or after January 4, 2016 shall meet the requirements of Part 2 of this Supplement. For pressure systems under construction prior to the above start date, the assigned DA shall choose to either follow Part 2 of this Supplement or continue following Revision 3.4 of <u>ES&H Manual Chapter 6151 Pressure and Vacuum Safety Program</u> and its Technical Appendices. If Revision 3.4 is followed, the DA must still complete <u>Form PS-1</u>, <u>Form PS-4</u> and <u>Form PS-5</u> of this Supplement; create and file a P&ID; and complete the steps defined in <u>Part 2: Section 2.10 Inspections</u> and <u>Part 2: Section 2.11 System Turnover</u>.

The tasks associated with new construction are as follows:

- Design
- Technical Review or Peer Review
- Purchasing
- Fabrication
- Assembly
- Installation
- Examination
- Inspection
- Testing
- Documentation

Note that alterations and repairs are not considered new construction and are considered in <u>Part</u> <u>5: Repair and Alteration</u>.

The DA assigned to new construction shall determine which requirements are applicable and ensure that they are met. In all cases, the DA shall ensure that adequate overpressure protection is provided. The DA is encouraged to consult other DAs and the Pressure Systems Committee for guidance. The responsibilities of the DA shall terminate upon completion of all construction activities and the pressure system is turned over to a System Owner.

For pressure systems built on-site by subcontractors, the DA/SOTR is responsible for ensuring that the contract includes requirements for personnel to be appropriately trained and qualified to

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perform the work as well as trained in the hazards of pressure if exposed. Training and qualification through the subcontractor is acceptable.

This Part does not apply to Category 0, 1, and 2 vacuum systems or components. These components shall meet the requirements of Part 7: Vacuum Systems.

### 2.2 Pressure Vessels

Pressure vessels not excepted from the Pressure and Vacuum Systems Safety Program shall be designed and fabricated, to the greatest extent that is reasonably possible, in full compliance with the ASME BPVC. Vessels shall be categorized as follows:

- ASME Pressure Vessels: Vessels which have been designed and constructed in full compliance with the ASME Boiler and Pressure Vessel Code.
- Excluded Vessels: Vessels that cannot be designed and/or constructed in full compliance with the ASME Boiler and Pressure Vessel Code.

Vessels that are in full compliance with the ASME BPVC must bear the required marking or "Code Stamp". A Code Stamp may only be affixed by an organization possessing a valid ASME Code Stamp and a valid Certificate of Authorization from the ASME. ASME Pressure Vessels may be designed by Jefferson Lab but shall not be fabricated by Jefferson Lab.

## 2.2.1 Applicable Code

The applicable Code for all vessels shall be the ASME Boiler and Pressure Vessel Code. Every reasonable effort shall be made to design and construct pressure vessels in full compliance with the Code. In cases where an ASME BPVC Section cannot be directly applied or is expressly excluded (cf. ASME BPVC VIII D1 U-1(c)(2)), in any aspect of design or fabrication, the DA shall employ sound engineering principles and select a Division and Section (if applicable) of the Code that is most applicable. The selected Code is known as the **most applicable ASME Code**. All vessels where the Code cannot be directly applied shall be considered an Excluded Vessel. The requirements for Excluded Vessels are given in Part 2: Section 2.2.3 Excluded Vessels.

Below is a list of the codes and standards that may be applicable to Jefferson Lab pressure vessel construction and installation (included are brief descriptions of where these Codes may be applicable):

Pressure vessels:

- ASME Boiler and Pressure Vessel Code
  - Section I: Rules
  - Section II: Specifications for materials including tables of allowable stresses.

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- o Section IV: Rules for Construction of Heating Boilers
- Section V: Specifications for non-destructive testing
- Section VIII: Rules for construction of pressure vessels. This Section is split into 3 divisions.
  - Division 1 is the standard set of rules.
  - Division 2 is alternative rules where more detailed analysis is required but, lower factors of safety are allowed.
  - Division 3 consists of rules for high pressure vessels.
- Section IX: Welding and Brazing Qualifications

Pressure-Relieving Devices:

- American Petroleum Institute (API)
  - API 520: Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries applies to the sizing and selection of pressure relief devices used in refineries, chemical facilities and related industries and gives excellent guidance for selecting relief devices
  - API 521: Guide for Pressure-relieving and Depressuring Systems. This Code gives guidance for determining the causes of overpressure and mitigating measures that can be taken.

Installation:

- National Board Inspection Code (NBIC) / NB-23
  - Part 1: Installation
  - Part 2: Inspection
  - Part 4: Pressure Relief Devices

## 2.2.1.1 New Construction

For all new construction, the **Code of Record** for a pressure vessel shall be that version (or Code year) of the most applicable ASME BPVC Division in effect 6 months prior to the start date of the vessel design (a later version may also be used, if available, at the discretion of the DA or if required by building codes). A **Code of Record shall be determined for each vessel regardless of whether or not the Code can be fully applied**.

### **2.2.2 ASME Pressure Vessels**

ASME Pressure Vessels shall be categorized as follows:

- Vessels of a unique design built for a specific Jefferson Lab purpose.
- Standard or off the shelf vessels such as air compressor tanks, propane vessels, and others considered to be of standard design.

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## 2.2.2.1 Vessels of Unique Design

### 2.2.2.1.1 Basic Requirements

The DA shall specify (or cause to be specified) the applicable Division and Section of the Code and all critical aspects of the engineering design as given below:

- Basic use requirements
  - Fluid Service such as lethal or flammable service
  - Metal temperatures (minimum and maximum)
  - o Maximum internal pressure and coincident temperatures
  - o Maximum external pressure and coincident temperatures
  - $\circ$  Function
  - o Geometry
  - o Insulation
  - o Supports
  - o Nozzle and piping attachments
- Material requirements
  - Special environmental conditions such as exposure to rain, wind, snow, ice, magnetic fields
  - Corrosion allowances
  - Hydrogen or hydrocarbon exposure
- Loading
  - Wind, rain, seismic, etc. loading
  - Cyclic loads
  - Loads from attachments such as ancillary piping and compressors.
  - Thermal gradients and other loads
- Overpressure protection
  - Type and capacity
  - Consider all credible failure modes.

Additional guidance can be found in ASME BPVC Section VIII D1 Appendix KK.

# 2.2.2.1.2 Design

ASME Pressure Vessels may be designed by Jefferson Lab or another organization. The associated calculations shall be reviewed by the system DA and the Authorized Inspector (AI) as

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required by Code. A Jefferson Lab technical review (see <u>Part 2: Section 2.5.1.1 Technical</u> <u>Review</u>) shall also be performed.

# 2.2.2.1.3 Fabrication

Fabrication of vessels of unique design shall be performed by an agency possessing a valid ASME Stamp as required by the Code of Record.

# 2.2.2.1.4 Documentation

The following documentation shall be required (or recommended as noted)

- Design drawings
- Design calculations and associated reviews
- Welding documentation (recommended only)
  - Weld maps
  - Welding and Brazing PQR and WPQ/BPQ
- Material certifications (recommended only)
- Testing records (recommended only)
- Manufacturers Data Report (i.e. Form U-1 or U-1A etc.)

•

The DA shall ensure that this documentation is filed in the appropriate folder in the Pressure Systems database as required in <u>Part 1: Section 1.5 Required Documentation</u>.

# 2.2.2.2 Standard Vessels

A nameplate bearing an ASME stamp (e.g. U or UM stamp) must be affixed to all vessels meeting the full requirements of the Code. The DA shall ensure that the manufacturer's data report (e.g. Form U-1 or U-1A) is obtained from the manufacturer and filed in the appropriate folder in the Pressure Systems database as required in in <u>Part 1: Section 1.5 Required Documentation</u>. Form U-1, U-1A, etc. shall be considered as sufficient review and documentation of the required calculations, examinations and other fabrication documents.

The DA shall ensure that the basic requirements listed in <u>Part 2: Section 2.2.2.1.1 Basic</u> <u>Requirements</u> are met by the standard vessel.

# 2.2.3 Excluded Vessels

Vessels where the ASME BPVC cannot be directly applied to all areas of construction (design and fabrication) are considered **Excluded Vessels**. These vessels present challenges that can be

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as unique as the engineering design and applications for which they are intended. The DA may determine that the ASME BPVC does not directly apply to a vessel for one or more of the following reasons:

- The vessel is expressly excepted or excluded from all Divisions of the ASME BPVC.
- The vessel is considered to be equipment such as a mechanical pump, compressor, or turbo machinery.
- The vessel must be fabricated from unlisted materials.
- The vessel must operate under extreme conditions outside the scope of the ASME BPVC
- The vessel has special geometry, including thin sections, weld geometries, etc.
- The vessel is considered to be instrumentation.
- The vessel is considered as internal piping
- Scientific or functional requirements of the engineering design preclude strict adherence to Code requirements. Examples of this include some experimental target vessels and some superconducting magnets.
- The vessel cannot be tested or examined using methods given in the Code.

## 2.2.3.1 Design and Fabrication

Excluded Vessels shall be designed and fabricated to meet the requirements of the most applicable ASME BPVC Section and Division to the greatest extent that is reasonably possible. For vessels designed on-site, the DA shall be responsible for the determination of the most applicable Code. For those designed off-site, the DA shall be responsible for the Code selection and shall either determine the applicable Code Section and Division or approve this selection.

For the specific Code requirements that cannot be met, Equivalent Measures shall be employed as required in <u>Part 3: Equivalent Measures</u> (paying particular attention to the definition and duties of the "Owner/User", the "Manufacturer", and the "Inspector" described therein). Design documentation, drawings, calculations, etc. shall be peer reviewed and filed in the appropriate pressure system folder.

Design and fabrication of these vessels shall also conform to the requirements given in <u>Part 2</u>: <u>Sections 2.4 Design</u>, <u>Part 2</u>: <u>Section 2.5 Reviews</u>, <u>Part 2</u>: <u>Sections 2.6 Use of Unlisted</u> <u>Components</u>, and <u>Part 2</u>: <u>Section 2.7 Materials</u> with the exception that the applicable Code is the ASME BPVC.

## 2.2.3.2 Examination

The DA shall determine the extent of examination required by Code and the engineering design and ensure that these examinations are completed by individuals qualified as given in <u>Part 1</u>:

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<u>Section 1.4.2 Examiners</u>. Examinations shall also meet the requirements of <u>Part 2: Section 2.9</u> <u>Examination</u> with the exception that the applicable Code is the ASME BPVC.

## 2.2.3.3 Testing

The DA shall ensure that the testing required by the Code is completed and documented as required in <u>Part 6: Pressure and Leak Testing</u>.

## 2.2.3.4 Welding Inspection

Welding inspections shall be completed by the Jefferson Lab QA/CI Inspector or an individual designated by the QA/CI Inspector. The DA shall determine the extent of any additional inspections and the qualifications of the inspectors. This determination shall be peer reviewed.

## 2.2.4 Repurposed and Reconditioned Vessels

Vessels may be repurposed or procured as preowned for use at Jefferson Lab. These vessels may be ASME Pressure Vessels or Excluded Vessels (e.g. superconducting magnets).

### 2.2.4.1 ASME Pressure Vessels

The DA shall ensure that vessels meet the basic requirements of the engineering design as given in <u>Part 2: Section 2.2.2.1.1 Basic Requirements</u>. The DA shall further consider the current condition of the vessel including wall thickness after possible corrosion, exposure to fluids incompatible with the current system fluid, etc. These considerations may require that the MAWP or other operating limit of the vessel be derated.

Reconditioned vessels that required repair or alteration shall have been repaired or altered by an agency possessing a valid National Board R Stamp. The Form R-1 or R-1A shall be filed with the original manufactures data report (Form U-1 or U-1A etc.). A current valid inspection shall also be filed with these forms. This inspection shall conclude that the vessel is acceptable for use in the current system.

## 2.2.4.2 Excluded Vessels

The acceptance of Excluded Vessels not originally fabricated by Jefferson Lab or authorized subcontractors of Jefferson Lab shall be performed on a case by case basis. The Pressure Systems Committee Chair shall determine the requirements for acceptance and review. Independent review such as the experimental equipment review process may be considered acceptable.

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The acceptance of Excluded Vessels fabricated by Jefferson Lab or an authorized subcontractor of Jefferson Lab shall be determined by Jefferson Lab peer review (see <u>Part 2: Section 2.5.1.2</u> <u>Peer Review</u>).

## 2.2.5 Vessel Numbering

All pressure vessels and boilers are to be numbered with a specific and unique number for each vessel. This number shall be conspicuously and durably displayed on the vessel. The numbering scheme shall be as follows:

- The Jefferson Lab Building Identification Number The System abbreviation as in PS number (see <u>Part 1: Section 1.5.2 Numbering Convention</u>) - Sequential number of vessel in system: B#-PS-ABC-XX-123-V#
- The Building number B# shall be the building in which the vessel is located or services. B# shall be 00 for portable vessels.
- For example: The helium after cooler on Compressor #1 in the CHL addition would display the following tag:

```
08-PS-CHL-XX-001-1
```

• A second vessel would then be labeled with -2 instead of -1.

The DA is responsible for the initial tagging of the vessels. Once operational, the System Owner shall be responsible for the continued integrity of this marking (i.e. readability).

This number shall also be clearly applied to the vessel in the system P&ID (see <u>Part 1: Section</u> 1.5.5 Folder Content).

## 2.2.6 Registration

The DA shall complete a pressure vessel registration form (Form PS-4) for each new pressure vessel (Excluded and ASME). This form shall be provided to the Vessel Inspection Coordinator along with a copy of the associated P&ID. This form shall also be filed in the appropriate folder in the Pressure Systems database.

The DA shall assign the appropriate in-service inspection type and frequency as given in <u>Part 9</u>: <u>Section 9.2 In-service Inspection Expectations and Procedures</u>. If other types of inspections are required, the DA or System Owner shall note this requirement.

## 2.2.7 Final System Walkthrough and System Turnover

The DA shall ensure that all vessels are considered in the performance of the walkthrough and turnover as given in <u>Part 2: Sections 10 Inspections</u> and <u>Part 2: Section 11 System Turnover</u>.

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### 2.3 Pressure Piping

Pressure piping shall be designed, fabricated, tested, and inspected, to the greatest extent possible, in compliance with the ASME B31 Code for Pressure Piping. Where full compliance is not possible, equivalent measures as defined in <u>Part 3: Equivalent Measures</u> shall be applied. The requirements for the construction of pressure piping are given in <u>Part 2: Section 2.3 Pressure Piping, Section 2.4: Design, Section 2.5 Reviews, Section 2.6, Use of Unlisted Components, Section 2.7 Materials, and Section 2.8 Fabrication by Welding, Brazing and Soldering. <u>Part 2: Sections 2.10 Inspections</u> and <u>Section 2.11 System Turnover</u> shall be completed after leak testing and prior to system operation.</u>

## 2.3.1 Applicable Codes

The DA shall be responsible for the determination of the applicable ASME B31 Piping Code(s) and/or other relevant Code(s) for each component in a pressure system. The application of multiple Piping Codes may be required depending on the complexity of the system. The applicable Code(s) for pressure piping and associated components depend upon their end use or purpose. If used to generate power, ASME B31.1 applies. If used as building services, ASME B31.9 applies. If used as part of a process, ASME B31.3 applies. If a pressure component is clearly not within the scope of these or other B31 Codes, the Code permits the DA to select any B31 Code System determined to be generally acceptable.

Every reasonable effort shall be made to design and construct pressure components in full compliance with these Codes. In cases where an ASME Piping Code cannot be directly applied or is expressly excluded (cf. ASME B31.3 300.1.3), in all aspects of design or fabrication, the DA shall employ sound engineering principles and select an ASME Piping Code that is most applicable. The selected Code is known as the **most applicable ASME Code**. All components where ASME Codes cannot be directly applied shall be considered Excluded Elements. The requirements for Excluded Elements are given in <u>Part 2: Section 2.3.2 Excluded Elements</u>.

For new construction, the **Code of Record** for a pressure component shall be that version (or Code year) of the most applicable ASME Pressure Code in effect 6 months prior to the start date of the system design (a later version may also be used, if available, at the discretion of the DA). For pressure systems that are constructed complete by subcontractors, the latest edition issued at least 6 months prior to the original contract date shall be used. For building services, the Code of Record shall be chosen as stated in applicable building codes. A Code of Record shall be determined for each component regardless of whether or not an ASME Pressure Code can be fully applied.

Below is a list of Codes which may be used in Jefferson Lab pressure system construction and installation:

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Pressure Piping:

- ASME B31 Code for Pressure Piping
  - B31.1 Power Piping: applicable to piping generally found in electric power production and district heating plants
  - B31.3 Process Piping: General piping code most applicable for piping systems at Jefferson Lab not associated with building services.
  - B31.4 2002 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
  - B31.5 Refrigeration Piping and Heat Transfer Components: Applicable to HVAC systems.
  - o B31.8 2003 Gas Transmission and Distribution Piping Systems
  - B31.9 Building Services: Applicable to piping carrying nonhazardous fluids at moderate temperatures typical in building services such as hot and cold water as well as instrument air systems.
  - o B31.11 2002 Slurry Transportation Piping Systems
  - B31.12 Hydrogen Piping and Pipelines

Pressure-Relieving Devices:

- American Petroleum Institute (API)
  - API 520:Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries applies to the sizing and selection of pressure relief devices used in refineries, chemical facilities and related industries and gives excellent guidance for selecting relief devices
  - API 521: Guide for Pressure-relieving and Depressuring Systems. This Code gives guidance for determining the causes of overpressure and mitigating measures that can be taken.

Installation:

- National Board Inspection Code (NBIC) / NB-23
  - Part 1: Installation
  - Part 2: Inspection
  - Part 4: Pressure Relief Devices

### **2.3.2 Excluded Elements**

Components where ASME Pressure Codes cannot be directly applied to all areas of construction (design and fabrication) are considered **Excluded Elements**. These components present challenges that can be as unique as the engineering design and applications for which they are intended. The DA may determine that the ASME Codes listed in <u>Part 2: Section 2.3.1 Applicable</u> <u>Codes</u> do not directly apply to a system, or component for the following reasons:

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- The component(s) is expressly excepted or excluded from all the ASME Codes listed in <u>Part 2: Section 2.3.1 Applicable Codes</u>.
- The component(s) is considered to be a mechanical pump, compressor, or turbo machinery.
- The component(s) must be fabricated from unlisted materials.
- The component(s) must operate under extreme conditions outside the scope of the ASME B31 Piping Code.
- The component(s) has special geometry, including thin sections, weld geometries, etc.
- The component(s) is considered to be instrumentation.
- The component(s) is considered as internal piping
- Scientific or functional requirements of the engineering design preclude strict adherence to Code requirements.
- The component(s) cannot be tested or examined using methods given in the ASME Codes.

In such cases, the component(s) shall be considered an Excluded Element. Excluded Elements shall be designed and fabricated to meet the requirements of the most applicable Code as much as is reasonably possible. For components designed on-site, the DA shall be responsible for the determination of the most applicable Code. For components designed off-site, the DA shall be responsible for this Code selection and shall either determine this Code or approve the selection of the most applicable Code. For the specific Code requirements that cannot be met Equivalent Measures shall be employed as required in <u>Part 3: Equivalent Measures</u>.

### 2.4 Design

The DA shall ensure that all calculations and considerations required by the applicable Code, the engineering design, and Jefferson Lab policy are performed. The DA may make use of work performed by others but shall assume responsibility for the applicability and accuracy of such work. All calculations shall be reviewed. For components where ASME Pressure Codes can be directly applied, a Technical Review (see Part 2: Section 2.5.1.1 Technical Reviews) shall be performed. For components where an ASME Pressure Code cannot be directly applied, a Peer Review (see Part 2: Section 2.5.1.2 Peer Review) shall be required. For work performed by organizations other than Jefferson Lab, the assigned DA shall ensure that all calculations and documentation required by Code and/or the engineering design are completed and reviewed. All documentation shall be filed as required in Part 1: Section 1.5 Required Documentation.

## **2.4.1 Engineering Design**

The engineering design shall be formalized in a general statement of work (SOW) or system specification for the construction of the pressure system. For simple systems, <u>Form PS-1</u> Pressure Systems Cover Sheet may suffice. The engineering design shall be as consistent as

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reasonably possible with the most applicable ASME Pressure Code(s) while maintaining the functionality, performance, and applicability required by the owner/user. The DA shall be responsible for developing the engineering design.

#### 2.5 Reviews

### 2.5.1 Description of Technical and Peer Reviews

### 2.5.1.1 Technical Review

A Technical Review is a formal review performed by any other DA. This review shall be documented on Form PS-3. The reviewer shall ensure that the required calculations or other aspects of the design have been performed according to the Code of Record. The assigned DA may perform Technical Reviews of calculations performed by other DAs or qualified individuals employed by organizations other than Jefferson Lab.

### 2.5.1.2 Peer Review

A formal review of the design, construction, or other aspect of a component performed by at least one DA not associated with the project and not a member of the same group as the system DA. Peer Reviews may also be conducted by qualified individuals (e.g. professional engineers with applicable experience) not employed by Jefferson Lab. This review shall be documented on Form PS-3.

#### 2.6 Use of Unlisted Components

Note that many common components such as Swagelok tube and piping fittings are unlisted. The ASME B31 Piping Code allows for the use of unlisted components with the consent of the owner. The assigned DA shall assume this duty of the owner. Therefore the use of unlisted components is solely at the discretion of the DA. The DA shall ensure that all required calculations are performed and properly documented; technical or peer reviews shall be performed as appropriate. No justification for the necessity for using unlisted components is required; however, the pressure design for these components shall be substantiated as required by the applicable Code. Specific guidance and a list of preapproved unlisted components are given on the Pressure Systems webpage.

Qualification of unlisted components shall be as required by the most applicable ASME Code. Note that the required use (possibly forced by the engineering design) of unlisted components does not necessary imply that their use is not fully compliant with the selected Code. Equivalent measures may not be required. Unlisted piping components shall meet the requirements listed in

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ASME B31.3 304.7.2. The choice of the qualification method shall be at the discretion of the DA.

### 2.7 Materials

The DA shall carefully consider the choice of materials for all pressure components (equipment vessels and piping). The selected materials shall be compatible with the fluid service, system fluids, and the engineering design. Where specialized materials not listed in the applicable Code(s) (i.e. unlisted materials) are required, equivalent measures given in <u>Part 3: Equivalent Measures</u> shall be applied.

The DA shall consider at least the following when selecting materials for use:

- Fluid compatibility
  - Gaseous vs liquid states
  - Corrosion, rust, scale etc.
  - Embrittlement which is often affected by pressure.
  - Flammability
  - Many non-metallic materials (e.g. PVC, CPVC, etc.) are unsuitable for gaseous service.
- Engineering design may have the greatest effect on the material choice.
  - Performance
  - Compatibility with experimental requirements
- External fields may degrade a material or apply additional loading
  - Ionizing radiation (Non-metallic materials may be especially impacted by prolonged exposure to radiation)
  - Static magnet and electrical
  - o RF fields
- Temperature extremes may reduce the allowable stress and/or force special requirements for testing.
  - Cryogenic requirements
  - High temperature ovens and bakeouts.
  - Non-metallic materials may be unsuitable for any service in extreme temperatures.
- Material form must be compatible with application. Bar may not be allowed for some components due to the grain structure for example.
  - o Plate
  - Wrought
  - Tube/pipe
  - Casting
  - Forged
  - o Bar
  - o Etc.

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- Welding/Brazing may significantly change the properties of the base metal such as annealing aluminum thereby decreasing the maximum allowable stress.
  - Base metal
  - Weld metal
  - Heat affected zone
  - Resulting weld chemistry
  - o Flux
- Material degradation from exposure to sunlight and seasonal or diurnal temperature changes may be possible.
  - Exposure times
- Cyclic loading
- Brittle fracture and toughness may be of concern especially for cryogenic systems.
- Other environmental factors
  - o Electrolysis

The above list is in no way complete. The DA shall employ sound engineering principles when making material selections.

Materials of unknown origin shall not be used. This does not necessarily require material certifications or mill test reports (CMTR). ASTM markings (including heat#) on piping material may be acceptable when specific chemistry is not required such as having a low carbon content. The DA shall determine the extent of documentation required.

## 2.8 Fabrication by Welding, Brazing, and Soldering

## 2.8.1 General Requirements

All welding, brazing, and soldering operations affecting the pressure boundary of a component shall be performed by certified personnel using qualified procedures. Personnel and procedures shall meet the requirements of the Jefferson Lab Welding and Brazing Supplement and of the applicable ASME or NB Code of construction or post construction. Where ASME Pressure Codes do not directly apply, the DA shall determine the most applicable Code. See <u>Part 2:</u> <u>Section 2.8.5 Unlisted Materials</u> for requirements relating to unlisted materials.

Welding and brazing performed on support elements, not directly attached to a pressure boundary by weld or braze, shall be performed by certified personnel using qualified procedures. The personnel and procedures shall meet the requirements of the most applicable ASME Pressure Code or AWS Structural Welding Code and the Jefferson Lab Welding and Brazing Supplement.

Welding, brazing, and soldering operations include the following:

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- Design of welded, brazed, or soldered connections (including design drawings and analyses)
- Weld, braze, and solder operations directly affecting the pressure boundary of any pressure component.
- Welding or brazing operations performed on support elements
- Certifications of welders, brazers, and solderers
- Certifications of examiners
- Certifications of Inspectors
- Qualification of welding, brazing, and soldering procedures
- Welding/brazing documentation
- Welding, brazing, and soldering of unlisted materials

The requirements of this section are applicable to all pressure components and attachments to their pressure boundaries (see exceptions below). These requirements also apply to support elements of pressure equipment including piping hangers, rollers, springs, structural supports and attachments, etc.

### 2.8.1.1 Exceptions

The following are exempt from the requirements of this section:

- Category 0 Vacuum systems: all weld, braze, and solder joints
- Category 2 Vacuum systems: all weld, braze and solder joints on components less than 35 ft<sup>3</sup> in volume or having no cross section larger 33 in<sup>2</sup>.
- Welding, brazing, and soldering, not directly affecting a pressure boundary, for supports for small elements such as instrumentation or signage.

## 2.8.1.2 Vacuum Systems

Welding, brazing, and soldering performed on a pressure boundary of a Category 1 or 2 (see above for size exception) vacuum system component shall be performed by qualified personnel using qualified procedures. These procedures shall meet the requirements of ASME B31.3 or the most applicable AWS Code.

## 2.8.1.3 Design

The DA shall ensure that all welding, brazing, and soldering joint designs meet the requirements of the code of construction and those given in the Welding and Brazing Supplement. (Note: Joint

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designs may be other than those listed explicitly in the code of construction. See for example ASME B31.3 § 304.7.2.)

The DA shall complete the <u>Design Parameter Form</u> for welds and brazes or provide the specifications on a drawing, specification, or other document (e.g. statement of work). These specifications shall include:

- Applicable Code
- Design pressures/temperatures
- Leak/Test pressure and method
- Sensitive Leak test specification (if applicable)
- Examination requirements and methods
- Inspections required
- Other applicable NDE

#### 2.8.1.4 Examinations

Note: Welding and brazing examinations are not to be considered inspections.

Examinations of welds and brazes shall be performed as required by the most applicable ASME, NB, or AWS Code. These examinations shall be performed by personnel qualified to perform the specified examination process. Examinations shall not be performed by the welder(s), operator(s), or brazer(s) performing the actual weld or braze.

The extent of the required examinations shall be specified by the DA. The examiner shall complete a weld examination report; the DA shall ensure that this report is filed with the pressure system documentation as required in <u>Part 1: Section 1.5.5 Folder Content</u>.

### 2.8.1.5 Inspections

Inspections of welds and brazes shall be performed where required by the applicable code and the engineering design. These inspections shall be performed by a CWI as given in <u>Part 1:</u> <u>Section 1.4.3.3 Welding and Brazing Inspectors</u>. The inspector (at his or her discretion) may inspect the following:

- Welds, brazes, fitting, etc.
- Qualification records for procedures, welders, and brazers
- Quality program documentation

The inspector shall complete a weld inspection report; the DA shall ensure that this report is filed with the pressure system documentation as required in <u>Part 1: Section 1.5.5 Folder Content</u>.

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**2.8.2 Qualification of Procedures** 

### 2.8.2.1 Welding Procedures

Welding procedure specifications (WPS) used by employees of Jefferson Lab for welds directly affecting a pressure boundary, shall meet the requirements of ASME BPVC IX. These procedures shall be approved and maintained by the designated CWI. Where a welding procedure is only to be used on support elements not directly attached (by welding) to a pressure boundary, the WPS shall conform to either ASME BPVC Section IX or the most applicable AWS Code.

Welding procedures used by agencies other than Jefferson Lab shall meet the requirements of the Code of construction/post construction. Certified copies of these procedures shall be filed with the pressure system documentation as required in <u>Part 1: Section 1.5.5 Folder Content</u>.

Standard welding procedures may be used by Jefferson Lab employees provided that they are approved by the designated CWI and meet the requirements of the most applicable Code. Standard procedures may be used by other agencies provided that they are used within the limits of the most applicable Code.

Excluded Elements shall be welded using procedures that conform, as much as practicable, to the requirements of ASME BPVC Section IX. For welding to be performed by Jefferson Lab employees, these procedures shall be approved by the designated CWI. For welding performed by agencies other than Jefferson Lab, a Peer Review shall be performed to approve the procedure. Certified copies of these procedures shall be filed with the pressure system documentation as required in Part 1: Section 1.5.5 Folder Content. See Part 2: Section 2.8.5 Unlisted Materials for additional requirements and guidance.

## 2.8.2.2 Brazing Procedures

Brazing procedures specifications (BPS) used by Jefferson Lab employees shall meet the requirements of ASME BPVC IX. These procedures shall be approved and maintained by the designated CWI.

Brazing procedures used by agencies other than Jefferson Lab shall meet the requirements of the code of Construction. Certified copies of these procedures (if BPS's are required) shall be filed with the pressure system documentation as required in <u>Part 1: Section 1.5.5 Folder Content</u>.

Excluded Elements shall be brazed using procedures that conform, as much as practicable, to the requirements of ASME BPVC Section IX. For brazing to be performed by Jefferson Lab

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employees, these procedures shall be approved by the designated CWI. For brazing performed by agencies other than Jefferson Lab, a Peer Review shall be performed to approve the procedure. Certified copies of these procedures shall be filed with the pressure system documentation as required in <u>Part 1: Section 1.5.5 Folder Content</u>. See <u>Part 2: Section 2,8.5</u> <u>Unlisted Materials</u> for additional requirements and guidance.

### 2.8.2.3 Soldering Procedures

The joining of piping and tubing by soldering shall conform to ASTM B828.

### 2.8.3 Documentation

### 2.8.3.1 Design Drawings and Sketches Drawn by Jefferson Lab

Design drawings and sketches drawn by Jefferson Lab personnel shall be signed by the DA. Drawings and sketches specifying weld, braze, and solder joints shall detail the following:

- Weld symbols shall conform to AWS A2.4. Other standards may be used provided that the chosen standard is clearly indicated on the drawing or sketch.
- Code for welding and examination
- Base and filler metal specifications
- Examination requirements
- WPS (for welds to be performed by Jefferson Lab employees)

This drawing or sketch may be used as a traveler/weld map. The drawing or sketch shall be filed with the pressure system documentation as given in <u>Part 1: Section 1.5.5 Folder Content</u>.

At the discretion of the DA, a <u>Design Parameter Form</u> provided in the WBS may be used in lieu of a detailed list of specifications, requirements and/or as a traveler.

### 2.8.3.2 Design Drawings and Sketches Drawn by Agencies Other than Jefferson Lab

The DA shall determine the signature requirements and content for drawings and sketches drawn by agencies other than Jefferson Lab.

#### 2.8.3.3 Welding and Brazing Procedure and Performance Qualifications

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The DA shall determine the extent of documentation required for qualifications. The documents or reference number with alternate storage location shall be filed with the pressure system documentation as required in Part 1: Section 1.5.5 Folder Content.

### 2.8.3.4 Weld and Braze Traceability

Documentation such as weld/braze maps providing weld traceability shall detail the following:

- Unique welder or brazer identification
- Base and filler metal heat or lot numbers
- Examiner identification

### 2.8.3.5 Examinations and Inspections

Examination and inspection reports shall be filed with the pressure system documentation as required in Part 1: Section 1.5.5 Folder Content.

### 2.8.4 Soldering

In all soldering operations, the filler shall melt below 840°F. Soldering may be performed within the limits of the code of construction. Personnel shall perform soldering operations in conformance with ASTM B828 or CDA Copper Tube Handbook. Use of solder joints is prohibited under the following conditions:

- Flammable or toxic fluid service.
- Fluid service temperatures above 250°F.
- Gaseous service in piping with a cross sectional area larger than 12.6 in<sup>2</sup> (4 in ID piping)

When designing solder joints, the DA shall consider the following:

- Corrosion effects and other chemistry associated with the solder and flux.
- Effects on the base metal temper from heat affects associated with soldering operations.

Attachments of thermal-couples, instrumentation, etc. to the pressure boundary of a component may be made using low temperature soft solder at the discretion of the DA.

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### 2.8.5 Unlisted Materials

Welding or brazing with unlisted base or filler metals shall be allowed provided a WPS or BPS is developed. This procedure shall conform as much as possible to ASME BPVC Section IX. Limitations or other effects (e.g. reduced fracture toughness, reduced temper, etc.) shall be noted on the WPS or BPS as applicable. These limitations shall be considered by the engineering design. Procedures used by Jefferson Lab employees shall be approved by the designated CWI.

### 2.9 Examinations

The DA shall ensure that all examinations required by Code, Jefferson Lab policy, and the engineering design are completed. The DA shall determine the extent of the examinations required.

Examinations shall be categorized as follows:

- Welding/Brazing examinations
- Mechanical examinations

#### **2.9.1 Welding Examinations**

Welding examinations shall be completed by certified individuals as given in <u>Part 1 Section</u> <u>1.4.2.1 Welding</u> and documented as required in <u>Part 2: Section 2.8.1.4 Examinations</u>. The selection of the method chosen for welding examinations shall be at the sole discretion of the DA responsible for the system. These examinations shall meet the requirements of the most applicable ASME Code and the engineering design. The DA may seek advice and council when making this determination but, with the exception of a peer review, shall not be constrained in this decision. The DA may choose RT (radiographic testing), UT (ultrasonic testing), VT (visual testing) or any other method approved by Code.

#### **2.9.2 Mechanical Examinations**

The following additional examinations shall be performed where applicable and in accordance with the Code of Record:

- Materials, components (e.g. fittings, valves, etc.), and products to ensure that they meet specifications and the requirements of engineering design.
- Applicable procedures for assembly, glue bonding, etc.
- Assembly of threaded, bolted and other joints shall conform to Code and engineering design.
- Alignment, supports, and cold spring meet requirements of the engineering design.

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• Dimensional checks of components and materials shall meet the requirements of Code and the engineering design.

In-process mechanical examinations shall be performed and documented as applicable and in accordance with the Code of Record. A final mechanical examination shall be completed when installation is complete. This examination shall be performed by qualified individuals (see <u>Part 1:</u> <u>Section 1.4.2.2 Mechanical</u>) and documented by completing <u>Form PS-6</u>. The DA shall ensure that these examinations (in-process and final) are completed and that all documentation is filed in the appropriate pressure system folder.

### 2.10 Inspections

All new pressure systems (equipment, vessels, and piping) shall be inspected by one or more qualified pressure system construction inspectors. Except as otherwise noted, all references to "inspector(s)" without a qualifier such as "in-service" shall refer to this qualified pressure system inspector. These inspector(s) shall meet the qualifications given in <u>Part 1: Section 1.4.3</u> Inspectors. The inspector shall not be involved in any design or fabrication process associated with the pressure system. The inspector shall complete the final system walkthrough as given in <u>Part 2: Section 2.10.1 Inspections</u>, and witness the final system pressure test. Upon agreement of the inspector, the System Owner, and the system DA, the inspector may forego the witness of the final system pressure test.

### 2.10.1 Final System Walkthrough

For all new construction (equipment, vessels, and piping), an inspector or team of inspectors shall perform a final system walkthrough prior to system startup. The completed final walkthrough shall include the following:

- □ <u>Form PS-1</u> Pressure System Project Cover Sheet is complete and filed.
- □ <u>Form PS-2</u> complete and filed if applicable.
- □ Review of construction documentation including:
  - Review of pressure/leak test documentation, completed and filed (Form PS-7)
  - Technical and Peer Reviews have been performed and filed (Form PS-3).
  - Ensure that welding and brazing inspections have been performed if applicable
  - Ensure that final mechanical examination has been performed, (Form PS-6)
  - Ensure that fabrication documents (e.g. weld and non-weld examinations, and material certs) have been filed.
- □ Review of P&ID, critical elements (i.e. relief devices, vessels, relief paths etc.) match as-built condition.
- □ Conspicuous and durable Jefferson Lab specific tags are installed on pressure vessels and boilers

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- □ Form PS-4 and Form PS-5 are filed for vessels and their relief valves
- □ General physical system condition and readiness.
- □ Checks on all relief devices providing overpressure protection.
  - Through direct visual examination, relief devices (providing overpressure protection) are installed and that the relief paths are free (e.g. stop valves are locked open, test plugs removed etc.) and direction of discharge is safe.

Upon completion of a successful system walkthrough, the inspector shall issue a final inspection report (Form PS-8) stating that the pressure system is acceptable for use. The DA shall file this with the system documentation. When the system contains piping, the inspector(s) shall be aware that they are acting as the B31 "Owners Inspector."

### 2.11 System Turnover

After completion of the final system walkthrough and prior to normal operations, the DA shall turn the system over to the System Owner. The DA shall ensure that the following tasks are completed on Form PS-9:

- Operating requirements are defined and documented.
- Any special maintenance requirements are defined and documented such as
  - Replacement intervals for thin windows upon lifetime/exposure limits
  - o Replacement intervals for parts exposed to cyclic loading
  - Cathodic corrosion protection replacement
- In-Service Inspection requirements are defined and documented. See <u>Part 9: Pressure</u> <u>Equipment In-Service Inspection Program</u> for details.

Both the DA and System Owner shall sign and date the form. The DA shall forward the completed form to the Pressure Systems Committee Designee for filing and incorporation into the operating pressure systems database.

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ES&H Manual Pressure and Vacuum Systems Safety Supplement Part 3: Equivalent Measures

## Part 3: Equivalent Measures

Equivalent measures shall be used to ensure a level of safety equal to or greater than that required by ASME Pressure Codes for Excluded Elements. These measures shall be taken for each Excluded Element. Because of the unique nature of each Excluded Element, it is not possible to give detailed requirements for the nature of these *equivalent measures*. The general requirements for equivalent measures (also known as equivalency) shall be as follows:

- Documentation for Excluded Elements shall include all of the following in addition to the documentation required by <u>Part 1: Section 1.5 Required Documentation</u> of this Supplement:
  - Reason why the engineering design requires that each Excluded Element cannot fully comply with selected Code of Record.
  - Specific Code requirements that cannot be met.
  - Calculations as required by Code, sound engineering principles, and the engineering design.
  - Specifications for special examinations or inspections if applicable.
  - Specific measures taken.
- Measures taken to ensure a level of safety equal to or greater than that required by the most applicable ASME Pressure Code can include:
  - Extensive detailed analysis
  - Protective barriers
  - Secondary containment
  - Specialized testing
  - Protection of thin sections from accidental damage
  - Administration controls
- The duties of organizations defined by ASME BPVC for vessels that cannot fully meet the requirements of the ASME BPVC shall be as follows:
  - The DA and System Owner shall assume the duties of the *Owner/User*
  - The DA shall assume the responsibilities of the *Manufacturer*
  - The duties of the *Inspector* shall be assumed by the "Owners Inspector" defined in <u>Part 1: Section 1.2.3.1 Responsibilities Derived from ASME B31 Piping</u> <u>Codes.</u>
- A Peer Review of each Excluded Element shall be performed. Complete Form PS-3.

The above requirements shall also apply to any component constructed by agencies other than Jefferson Lab. This includes the requirement for a Peer Review(s).

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Part 3: Equivalent Measures

The DA is encouraged to consult other Jefferson Lab DAs for assistance, guidance and arbitration. The DA may request both formal and informal guidance from the Pressure Systems Committee.

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### Part 4: Overpressure Protection

### 4.1 General Requirements

This section describes the requirements for overpressure protection for pressure systems and components. In this section, the term "relief device" shall apply only to those relief devices providing overpressure protection. The requirements of this section do not apply to devices serving other functions. The system design must account for all reasonable sources of overpressure and mitigate them through the use of relief devices, system design, or other suitable method. Excellent guidance for this is given in API 520 and API 521. The DA is strongly encouraged to consult these references when designing system overpressure protection.

For systems and components with design pressures (or MAWP) higher than 15 psi, the DA shall determine by calculation and analysis all credible causes of overpressure (see <u>Part 4: Section 4.2</u> <u>Potential Causes of Overpressure</u>) by performing the following:

- Analysis of possible failure modes and their effects
  - This can be a simple analysis or a more formalized analysis such as a Failure Mode, Effects, and Criticality Analysis (FMECA) or Fault Tree Analysis. The DA shall determine the extent of analysis required.
- Calculations determining the justification for the relief capacity required for each failure mode
  - The capacity shall be adequate to ensure the accumulated pressure during a relief event does not exceed that which is allowable by the applicable code(s).
- Consider discharge effects (if applicable) such as
  - Reaction forces from relief loads
  - Venting to safe locations
  - Environmental factors and fluid properties (e.g. relief of toxic fluids at ground level)

For Excluded Elements and Vessels, with design pressures (MAWP) higher than 15 psi, overpressure protection requirements shall be as given in ASME BPVC VIII D1.

The overpressure protection analysis shall undergo a Technical Review as described in <u>Part 2:</u> <u>Section 5 Reviews</u>. It shall also be maintained in the appropriate folder in the Pressure Systems database.

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**Part 4: Overpressure Protection** 

Relief devices protecting vacuum components from pressurization above 15 psi (Category 2 and 3) shall meet the requirements of <u>Part 7: Section 7.5.1 Pressure Relief</u> and this section.

## 4.2 Potential Causes of Overpressure

This section describes some of the principle causes of overpressure in pressure systems (piping and vessels). Overpressure results from a disruption or unbalance of the flow of fluid or energy that causes the buildup of fluid, energy, or both in all or part of a system. Below is a partial list of potential causes of overpressure.

- Operator Error: Operator error is the most common cause of system overpressure
- Closed outlets on vessels
- Inadvertently closed or opened block valves
- Check valve leakage:
- Utility failure: power or water failure
- Electrical or mechanical failure
- Loss of cooling or heating
- Heat exchanger tube failure
- Transient pressure surges: surges such as water hammer and pressure waves resulting from fast acting valves.
- Combustion or explosion of system fluid
- External fire
- Loss of insulting vacuum on vessels or piping containing cryogenic fluids
- Blocked or partially obstructed vent lines

### 4.3 Relief Devices Exposed to Weather

For relief devices installed in exterior environments, the following shall be considered:

- It is recommended that all relief devices installed outdoors be equipped with bug screens.
- The exhaust of relief devices shall be protected from rain, snow, and ice
- Relief devices exposed to rain or snow should be made from materials compatible with water exposure

## 4.4 **Pressure Relieving Requirements**

The DA shall determine the largest credible relief capacity required and size relief devices appropriately. The maximum allowable accumulation for a pressure component shall be determined by the most applicable Code. For Excluded Elements and Vessels, with design

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Part 4: Overpressure Protection

pressures (MAWP) higher than 15 psi, overpressure protection requirements shall be as given in ASME BPVC VIII D1. Relief devices shall be sized such that the total capacity of all relief devices is sufficient for the calculated mass flow. The relief path shall also be analyzed for adequate capacity and pressure drop.

### 4.4.1 Overpressure from Exposure to a Prolonged External Fire

Exposure of a pressure component to external fire can result in extremely large relief loads. It is further expected that prolonged exposure to a fire will result in vessel or piping failure regardless of any reasonable protective measure. Excellent guidance for exposure of pressure equipment to liquid hydrocarbon pool fires is given in API 521. This type of fire represents the highest credible heat flux for fires of any type (with the exception of metallic combustion). Sizing of reliefs for this type of fire shall be considered acceptable practice for any fire exposure. The Jefferson Lab Fire Protection Engineer shall provide guidance for any design where the hydrocarbon pool fire is considered inappropriate or excessive.

Fire mitigation may also be provided by preventative measures. These measures may include the following:

- Adequate drainage, dikes, etc. to prevent hydrocarbon fuels from pooling near or under vessels and piping
- Removal of brush from areas near vessels and piping
- Elimination or limitation of flammable material near vessels or piping
- Installation of fire suppression systems
- Insulation and fireproofing installed on vessels and piping

Such measures may obviate sizing of reliefs for fire conditions.

It is Jefferson Lab policy that piping of size NPS 6 or less need not be protected from overpressure due to fire if the system fluid is not Category M.

## 4.4.2 Overpressure Due to the Loss of Insulating Vacuum

## 4.4.2.1 Cryogenic Vacuum Insulation

It is common practice to insulate piping and vessels containing cryogenic fluids with a combination of vacuum and single and multi-layer insulation (MLI or super-insulation). This is achieved by separating an inner fluid space and a surrounding vacuum insulation space by an inner pressure boundary. Loss of vacuum in the insulation space, due to a failure of a component, operator error, etc., will subject the inner pressure boundary to a high temperature gradient between the fluid space and the vacuum space. This high temperature gradient can cause rapid

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boil-off of the cryogenic fluid resulting in a rapid pressure rise in the inner fluid space. Failure of the vacuum space shall be considered for piping and vessels containing cryogenic fluids insulated in this manner.

The DA shall ensure that adequate relief capacity is installed on the system to prevent components from overpressure beyond Code limits (see ASME BPVC UG-125 (c)(3)). Determination of the adequacy of this relief depends on many factors (see references below):

- Fluid properties and chemistry
  - o Boiling temperature and pressure
  - Heat transfer within the fluid and thermal conductivity
  - Latent heat
  - Densities etc.
- Geometry of piping and or vessels
- Insulation
  - Type of insulation
  - Thickness of insulation
- Temperature gradient across insulation and internal pressure boundary

The determination of the heat transfer rate is critical to calculating the required relief capacity. Heat transfer rates between 25 and 40 kW/m<sup>2</sup> have been used for bare metal surfaces. Rates for insulated surfaces range from 1 to 7 kW/m<sup>2</sup>. The DA shall employ sound engineering judgement to determine an appropriate heat transfer model. The DA is encouraged to collaborate with other DAs experienced on this subject.

The insulating vacuum space must also be relieved. This may be accomplished by commercial or Jefferson Lab fabricated devices. Guidance for the relief capacity required for insulating vacuum spaces is given in the Compressed Gas Association CGA S-1.3.

### 4.4.2.2 High Temperature Vacuum Insulation

Loss of insulating vacuum on high temperature surfaces (e.g. vacuum induction furnaces) may result in irreversible catastrophic system failure. Due to the unique nature of these systems, they shall only be operated under an OSP/TOSP by personnel trained explicitly on the individual system.

### 4.4.2.3 References

Barron: Cryogenic Heat Transfer (1999)

Collier: Convective Boiling and Condensation (1972) Harrison: Loss of vacuum experiment on superfluid helium vessel. (2001)

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Johnson: Thermal performance of cryogenic insulation (2007) Lehman: Safety Aspects for the LHE Cryostats and LHE Transport Containers (1978) Lienhard and Lienhard: A Heat Transfer Textbook. Weisend: Cryogenic Engineering (1998) Wiseman: Loss of cavity vacuum experiment at CEBAF. (1991)

### 4.5 **Overpressure Protection by Relief Device**

Relief devices generally have two forms: reclosing (such as a spring loaded safety relief valve) and non-reclosing (e.g. rupture disk). Requirements for relief devices depend on the date of installation of the device and the set pressure of the device.

### 4.5.1 Relief Devices with a Set Pressure at or above 15 psi

Relief devices installed (either for new construction or replacement of an existing valve) on or after 1 March 2008 with a set pressure at or above 15 psi shall comply with the following:

- All relief devices providing overpressure protection shall comply with the most applicable section of the ASME BPVC unless approved otherwise by the Pressure Systems Committee Chair. For systems where no section of the ASME BPVC is applicable, relief devices shall comply with ASME BPVC VIII D1.
- Relief devices providing overpressure protection for pressure vessels (ASME or otherwise), Category M fluid systems (regardless of application), and piping larger than 6 NPS shall be registered as described in <u>Part 4: Section 4.7 Relief Device Registration</u>.

Relief devices that were installed or in the process of being installed on unaltered systems prior to 1 March 2008 with a set pressure at or above 15 psi shall comply with the following:

- All devices providing overpressure protection for ASME Section I and IV pressure vessels and on all vessels servicing Building Heating Water, Building Chilled Water, Compressed Air, and Instrument (Control) Air comply with the appropriate section of the ASME BPVC edition in effect at the time of vessel installation or edition in effect at the time of the device replacement.
- All devices providing overpressure protection for ASME Section VIII vessels, not considered boilers, are either CE/PED or ASME stamped and installed in accordance with the ASME BPVC code edition in effect at the time of vessel installation. If an existing relief device is replaced, the replacement shall comply with the edition of the ASME BPVC VIII in effect at the time of vessel installation or the edition in effect at the time of device replacement.
- All devices providing overpressure protection for pressure system piping are of reputable manufacture and are either ASME stamped, CE/PED certified, or non-

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certified. If an existing relief device is replaced, the replacement shall comply with the edition of the ASME BPVC VIII in effect at the time of device replacement.

• All devices providing overpressure protection for Excluded Vessels are of reputable manufacture and are either ASME stamped, CE/PED certified, or non-certified. If an existing relief device is replaced, the replacement shall comply with the edition of the ASME BPVC VIII in effect at the time of device replacement.

## 4.5.2 Relief Devices with a Set Pressure below 15 psi

Relief devices with a set pressure below 15 psi are not required to comply with the full requirements of the ASME BPVC. These devices may be procured or manufactured whole or in part on or off site. Relief devices, with set pressures less than 30 psi, protecting vacuum jackets for cryogenic piping less than or equal to 6 NPS are also not required to comply with the full requirements of the ASME BPVC.

## 4.5.2.1 **Procured Relief Devices**

Devices shall be procured from reputable manufacturers. The capacity of the device shall be determined by either the manufacturer or the DA through suitable calculations and/or testing. The set pressure of any reclosing device shall be verified by test (see <u>Part 9: Section 9.3</u> <u>Procedures for Operational Inspection and Testing of Relief Devices</u>). Devices protecting insulating vacuum spaces from pressurization from condensed and frozen gasses (i.e. CVI vacuum pump outs etc.) are exempt from this requirement if the DA is assured of their effectiveness.

## 4.5.2.2 Jefferson Lab Fabricated Relief Devices

Design and fabrication of these devices shall comply with the requirements of this Supplement. The capacity of the relief device shall be determined by calculations and/or suitable tests that comply with ASME BPVC VIII D1 UG-131, Appendix 11, ASME PTC 25, API 520, API 521, or other applicable method. The set point of any reclosing device shall be determined by pressure test (see <u>Part 9: Section 9.3 Procedures for Operational Inspection and Testing of Relief Devices</u>).

## 4.5.2.3 Parallel Plate Relief Valves

Unless measured by suitable technique, the maximum coefficient of discharge (as defined in ASME BPVC VIII D1 UG-131) shall be no greater than  $K_d = 0.62$  for parallel plate relief values.

## 4.6 Installation

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Relief devices shall be installed by qualified and experienced technicians. Block or stop valves may be installed upstream of a relief device provided the requirements of ASME BPVC VIII D1 Appendix M (or equivalent) are met. Such requirements include operating procedures and the installation locks or anti-tampering devices on the valves. In all cases, direction of discharge shall be considered in regards to safety to personnel and equipment.

### 4.7 Relief Device Registration

A Pressure Relief Device Data Sheet (<u>Form PS-5</u>) shall be completed by the DA, and sent to the Vessel Inspection Coordinator, for any relief device providing overpressure protection for any of the following components or systems

- Pressure vessels (ASME Boilers, ASME Pressure Vessels, and Excluded Vessels)
- All Category M fluid components
- Piping larger than NPS 6, installed on or after 1 March 2008.

Exceptions to this requirement are:

- Relief devices with set points less than 15 psi.
- Relief devices on any system where all of the following criteria are met
  - The maximum system pressure cannot exceed 15 psid (pounds per square inch differential) at any time including all credible failure modes
  - The system fluids are nonflammable, nontoxic, and not harmful to human tissue (as described in ASME B31.3 Para 300.2)
  - The system design temperature is greater than -20F and less than 366F

The forms for all relief devices installed on a pressure system shall be maintained in the "Overpressure Protection" folder in the system documentation folder.

## 4.8 Overpressure Protection by System Design

Overpressure protection by system design (see ASME BPVC VIII D1 UG-140) is recommended in situations where release of the system fluid may be hazardous to humans or the environment, where there are no credible sources of overpressure, or when traditional relief devices are not effective. If the system fluid is water with a maximum design temperature less than 130 °F and the system does not include a pressure vessel, there are no further requirements and a report is not necessary. In cases where overpressure protection by system design is chosen by the DA for new pressure equipment with a design initiated on or after January 4, 2016, the following requirements shall be met.

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A formal report shall be written addressing the following:



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- The reason for using overprotection by system design.
- A detailed failure analysis (such as Failure Modes Effects and Criticality Analysis (FMECA) or Fault Tree Analysis) shall be performed by a multi-disciplinary team, to determine all credible failure modes.
- A detailed analysis to determine the maximum credible pressure that must be contained by the system shall be documented in the report.
- The requirements for periodic inspections and testing of controls (both hardware and soft or firm ware), procedures, and instrumentation used for overpressure protection

<u>Form PS-2</u> shall be completed by the DA, submitted for approval by the Pressure Systems Committee Chair as provided by <u>Part 4: Section 4.8.2 Approvals</u> below and filed in the Overpressure Protection folder for the pressure system.

#### **4.8.1 ASME Pressure Vessels**

For all new ASME Pressure Vessels, the manufacturer data report (Form U-1 or U-1A for Div 1 vessels) shall indicate that overpressure protection is by system design. Existing pressure vessels may be used in systems where overpressure protection is by design provided written approval from the Pressure System Committee Chair is obtained. All other requirements of the code of construction shall be met (i.e. ASME BPVC VIII D1 UG-140). This documentation shall be maintained in the Overpressure Protection folder for the pressure system.

### 4.8.2 Approvals

All systems, unless excepted below, where overpressure protection is by system design shall require formal written approval of the Pressure Systems Committee Chair prior to operation. Form PS-2 shall be reviewed and signed by the Pressure Systems Committee Chair. The following systems are excepted from this approval requirement:

- ASME B31.3 Category D Service Piping
- ASME B31.5 Piping
- ASME B31.9 Piping

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### Part 5: Repair and Alteration

### 5.1 General

Repairs and alterations of all pressure systems and components, regardless of initial fabrication or design date, shall be performed by qualified personnel under the direction of the DA assigned to the specific task. Repairs and alterations shall be performed in compliance with the requirements of this section. Jefferson Lab shall not assume the duties of the fabricator or inspector for repairs or alterations of the pressure boundary on an ASME Pressure Vessel. All personnel directly involved in the repair or alteration of a pressure system onsite shall meet the requirements given in <u>Part 1: Section 1.4.5 Pressure System and Test Technicians</u>.

Below is a list of the Codes possibly applicable to Jefferson Lab pressure system repair and alteration. Included are brief descriptions of where these Codes may be applicable.

- ASME Boiler and Pressure Vessel Code
  - Section II: Specifications for materials including tables of allowable stresses.
  - Section V: Requirements and methods for non-destructive testing
  - Section VIII: Rules for construction of pressure vessels. This Section is split into 3 divisions. Division 1 is the standard set of rules. Division 2 is alternative rules where more detailed analysis is required but, lower factors of safety are required. Division 3 consists of rules for high pressure vessels.
  - Section IX: Welding and Brazing Qualifications
- National Board Inspection Code (NBIC) / NB-23
  - Part 1: Installation
  - Part 2: Inspection
  - Part 3: Repair and Alteration
  - Part 4: Pressure Relief Devices
- ASME B31 Code for Pressure Piping
  - B31.1 Power Piping: applicable to piping generally found in electric power production and district heating plants
  - B31.3 Process Piping: General piping code most applicable for piping systems at Jefferson Lab not associated with building services.
  - B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids
  - B31.5 Refrigeration Piping and Heat Transfer Components: Applicable to HVAC systems.
  - o B31.8 Gas Transmission and Distribution Piping Systems

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- B31.9 Building Services: Applicable to piping carrying nonhazardous fluids at moderate temperatures typical in building services such as hot and cold water as well as instrument air systems.
- B31.11 Slurry Transportation Piping Systems
- B31.12 Hydrogen Piping and Pipelines
- B31E Standard for the Seismic Design and Retrofit of Above-Ground Piping Systems
- ASME PCC-2 Repair of Pressure Equipment and Piping

Pressure-Relieving Devices:

- American Petroleum Institute (API)
  - API 520:Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries applies to the sizing and selection of pressure relief devices used in refineries and related and gives excellent guidance for selecting relief devices
  - API 521: Guide for Pressure-relieving and Depressuring Systems. This Code gives guidance for determining the causes of overpressure and mitigating measures that can be taken.

#### **5.1.1 Definition of Repair**

A repair of an existing pressure system shall be defined as any work performed on an existing system that is not considered maintenance (see <u>Part 8: Section 8.2 Maintenance</u>) and does not change the fluid service or any aspect of the original design specifications. A repair of any pressure system component installed on an existing system shall either return this component to its original specifications or replace it with a new component with equivalent specifications.

Repairs or replacement of components not larger than NPS 5 (DIN 125) that do not require welding, brazing, or other hot work may be considered routine in nature and are considered in Part 8: Section 8.2 Maintenance.

### 5.1.2 Definition of Alteration

An alteration of an existing pressure system shall be defined as any work performed on an existing system that may change any aspect of the design specification or fluid service; this includes changes to the structural supports for piping or vessels and extension of piping.

### 5.2 Repair or Alteration of Pressure Vessels

Repairs or alterations to Excluded Vessels (i.e. those without an ASME stamp) shall be performed in accordance with <u>Part 5: Section 5.4 Repair and Alteration Procedures</u>.

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Repairs or alterations to ASME Pressure Vessels, excluding those not affecting the pressure resisting components (i.e. the pressure boundary), shall be performed by an organization that is authorized to use the National Board R stamp. These repairs or alterations to pressure vessels shall be coordinated by the Facilities Management and Logistics Department.

### **5.3** Repair or Alteration of Relief Devices

Repairs or alterations to "ASME", "V", "UV", "HV", "UV3", "TV", or NBIC "VR" stamped pressure relief devices shall be performed by an organization that is authorized to use the National Board "VR" stamp. All other relief devices with set pressures greater than 15 psi requiring repair shall be replaced with Code compliant devices.

### 5.4 Repair and Alteration Procedures

Repairs and alterations to pressure systems must be completed under the direction of the DA and be properly documented as described in <u>Part 1: Section 1.5 Required Documentation</u>.

Repairs to piping components and Excluded Vessels installed on a pressure system shall comply with the original construction Code, NBIC (Part 3), ASME PCC-2, or other suitable post construction code. Where the original Code is unknown and the DA chooses not to use NBIC or PCC-2, the most applicable ASME Pressure Code in effect at the time of repair shall be used. Where ASME Pressure Codes do not apply, sound engineering principles and equivalent measures as described in <u>Part 3: Equivalent Measures</u> shall be used.

All alterations to pressure systems shall be completed under the direction of an assigned DA. Where an ASME Pressure Code applies, all design and fabrication of the alteration and tie in to the existing system, shall be performed to the Code edition (year) in effect at the time of the alteration. Applicable Codes may be construction codes (e.g. ASME B31.3, ASME B31.9, ASME B31.12, etc.) or post construction codes such as ASME PCC-2 or NBIC Part 3. Where Codes do not apply, sound engineering principles and equivalent measures as described in <u>Part 3</u>: <u>Equivalent Measures</u> shall be used. When performing any alteration the DA shall at least consider the following:

- Changes to design temperature and the effect on materials.
- Changes to design pressure may have multiple affects. Relief device set points and capacities may be affected. Relief paths may not be adequate for new requirements. While the original wall thicknesses may be adequate, corrosion effects may require reduced operating pressures.
- Tie-ins to existing systems:
  - The DA shall fully understand the upstream operating conditions
    - Design pressure/temperatures
    - Fluid service

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- Relief capacities
- Method of tie-in and reaction loads
- The DA shall ensure that adequate relief capacity is installed on the system
- Flow paths and changes to relief paths as these may affect pressures and reaction loads.
- Changes in fluid service as these may affect live loads, pressures, operating temperatures, relief capacities, corrosion allowance, etc.
- Seismic, wind, and other loads as given in ASCE 7

Repairs and alterations do not require a system wide pressure test or inspection. The extent of the test and inspection requirements shall be determined by the DA.

### **5.4.1 Repairs to Energized Systems**

Repairs to any pressure component or branch (i.e. pressure boundary) of a system that is energized shall be categorized as follows:

Case 1: Repairs to a component or branch that has been isolated by valve lineup or system configuration (e.g. blank flanges, etc.) and locally deenergized; meaning part of the system unaffected by the repair remains energized.

Case 2: Repairs to components that are fully or partially energized.

The component or branch of the system to be repaired shall be isolated, as given in Case 1 above, provided that this does not cause an unacceptable service interruption or create an unsafe condition.

Repairs to components not retaining pressure (e.g. piping supports, hanger, etc.) on energized systems may be performed when the system integrity, personnel and equipment safety is assured through appropriate procedures and review, as determined by the DA.

Repairs shall be affected as follows:

Case 1:

- An OSP or TOSP detailing the system configuration and preparation prior to and following the repair as well as the repair procedure itself shall be written by or approved by the DA in addition to normal procedural signoffs
- If the system fluid is flammable, Category M as defined by ASME B31.3, or considered hazardous by the ES&H manual then the isolated component or branch of the system shall be purged by an inert fluid prior to any repair. The procedure for purging shall be included in the OSP or TOSP.

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Case 2:

• An OSP or TOSP detailing the system configuration and preparation prior to and following the repair as well as the repair procedure itself shall be written by or approved by the DA in addition to normal procedural signoffs.

#### 5.4.2 Repairs to Deenergized Systems

Standard work planning tools (i.e. THA, Atlis, TOSP, AHA, etc.) shall be written to ensure personnel and equipment safety. These documents shall describe any required system configuration and preparation prior to and following the repair as well as the repair procedure itself (if required).

If the system fluid is flammable, Category M as defined by ASME B31.3, or considered hazardous by the ES&H manual then the system must be purged by an inert fluid prior to any repair.

### **5.4.3** Alterations to Energized Systems

Alterations to any pressure component or branch (i.e. pressure boundary) of a system that is energized shall be categorized as follows:

Case 1: Alterations to a component or branch that has been isolated by valve lineup or system configuration (e.g. blank flanges, etc.) and locally deenergized; meaning part of the system unaffected by the alteration remains energized.

Case 2: Alterations to components that are fully or partially energized.

The component or branch of the system to be altered shall be isolated, as given in Case 1 above, provided that this does not cause an unacceptable service interruption or create an unsafe condition.

Alterations to components not retaining pressure (e.g. piping supports, hanger, etc.) on energized systems may be performed when the system integrity, personnel and equipment safety is assured through appropriate procedures and review, as determined by the DA.

Alterations shall be affected as follows:

Case 1:

- An OSP or TOSP detailing the system configuration and preparation prior to and following the alteration as well as the alteration procedure itself shall be written by or approved by the DA in addition to normal procedural signoffs.
- If the system fluid is flammable, Category M as defined by ASME B31.3, or considered

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hazardous by the ES&H manual then the isolated component or branch of the system shall be purged by an inert fluid prior to any alteration. The procedure for purging shall be included in the OSP or TOSP.

Case 2:

- An OSP or TOSP detailing the system configuration and preparation prior to and following the alteration as well as the alteration procedure itself shall be written by or approved by the DA in addition to normal procedural signoffs.
- The DA shall provide detailed procedures in the OSP or TOSP to ensure personnel and equipment safety.
- Alterations to systems where the system fluid is Category M shall require written approval from the Jefferson Lab Director
- Hot Tapping:
  - Hot tapping on systems where the system fluid is water shall require only the approvals included in the signoff of the associated OSP or TOSP.
  - Hot tapping on systems where the applicable Code and fluid Category is B31.3 Category D (other than water), B31.5, or B31.9 and the piping is not larger than NPS 6 (DN 150) shall require only the approvals included in the signoff of the associated OSP or TOSP.
  - All other hot tapping operations shall require written approval from the Jefferson Lab Director in addition to the approvals included in the signoff of the associated OSP or TOSP.

#### **5.4.4** Alterations to Deenergized Systems

Standard work planning tools (i.e. THA, Atlis, TOSP, AHA, etc.) shall be written to ensure personnel and equipment safety. These documents shall describe any required system configuration and preparation prior to and following the alteration as well as the alteration procedure itself (if required).

If the system fluid is flammable, Category M as defined by ASME B31.3, or considered hazardous by the ES&H Manual, then the system must be purged by an inert fluid prior to any alteration of any pressure retaining components.

### 5.5 Design Calculations

The DA shall determine the nature and extent of the calculations required for all pressure system repairs and alterations. These calculations shall be reviewed as required:

• A Technical Review shall be performed where the design of the repair or alteration meets ASME Pressure Codes, or NBIC.

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• A Peer Review shall be performed where the design of the original or modified system component(s) cannot meet national consensus codes.

The extent of the calculations required shall depend on the nature of the repair or alteration. Calculations are required for all repairs and alterations requiring welding or brazing. Where piping repairs or repairs to Excluded Vessels are affected, calculations showing that the repair returns the component to original design requirements (or exceeds them) are required. Calculations for alterations and tie-ins to existing piping shall be the same as those for new construction (see <u>Part 2: Section 2.4 Design</u>). The DA shall determine the nature and extent of the calculations required.

### 5.6 Repairs and Alterations Requiring Welding, Brazing or Hot Work

Repairs and alterations requiring welding or brazing shall meet the additional requirements given in the Jefferson Lab Welding and Brazing Supplement (WBS). If the system fluid is flammable, Category M as defined by ASME B31.3 or considered hazardous by the ES&H Manual, the system shall be purged with an inert fluid and the purged condition shall be verified by acceptable detection methods prior to any hot work performed on the system.

Exception: "Hot Tapping" of pressure systems shall comply with <u>Part 5 Section 5.4.3 Alterations</u> to <u>Energized Systems</u>.

## 5.7 Examinations and Testing

Repairs and alterations requiring welding or brazing shall meet the requirements for examination given in the applicable Code of construction or post construction. With the exception of Category M and High Pressure Piping (as defined in ASME B31.3), the DA responsible for the repair or alteration shall ensure that one or more of the following tests or examinations are performed. In the following list, where exclusive use of a certain method is prohibited, at least one other test or examination method shall be used.

- Hydrostatic Pressure Test:
  - Test shall be as described in ASME B31 (relevant Section), ASME PCC-2, or NBIC Part 3
- Pneumatic Pressure Test:
  - Test shall be as described in ASME B31 (relevant Section), ASME PCC-2, or NBIC Part 3. Plastic and other piping subject to brittle failure such as PVC, CPVC, and PVDF shall not be pneumatically tested. See <u>Part 6: Section 6.1</u> <u>Pressure and Leak Testing</u>.
- Initial Service Leak Test:
  - o If the fluid service is Category D or Normal (as described in ASME B31.3) and

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not flammable, toxic, or harmful to humans or the environment or otherwise considered hazardous by ES&H Manual, then an initial service leak test may be performed. The exclusive use of this test is prohibited unless explicitly allowed by the original code of construction.

- Vacuum Test:
  - A sensitive vacuum leak test may be performed. Exclusive use of this test is prohibited on all systems with a design pressure greater than 15 psi.
- Nondestructive examination:
  - Nondestructive examinations in compliance with ASME BPVC Section V may be performed. These examinations may be performed instead of or in addition to the pressure tests described above. Exclusive use of the visual examination (VT) is prohibited on all components larger than NPS 5 (DIN 125).

## 5.7.1 Category M Fluid Systems

The required examinations and testing shall be as given in the most recent edition of ASME B31.3.

## 5.7.2 High Pressure Piping (ASME B31.3 Chapter IX)

The required examinations and testing shall be as given in the most recent edition of ASME B31.3.

#### 5.8 Inspections

Repairs and alterations requiring welding or brazing shall meet the requirements for inspection as given in the Welding and Brazing Supplement.

#### 5.9 Documentation

Documentation for each pressure system repair and/or alteration shall be as described in <u>Part 1:</u> <u>Section 1.5.5 Folder Content</u>.

### 5.10 Revision Summary

Revision 1.1 - 01/10/19 - Updated Section 5.1 to comply with January 2019 DOE revisions to 10 CFR 851. Remove years associated with standards.

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### Part 6: Pressure and Leak Testing

### 6.1 Pressure and Leak Testing

The primary reason for pressure testing is to confirm the integrity of a pressure system. Hydrostatic pressure testing can also provide local relief of mechanical stresses. Pressure testing of new systems or new components poses a potential hazard to both equipment and personnel due to the stored energy of the pressurized fluid. For this reason, only trained and qualified personnel may supervise a pressure test. Pressure or leak tests may require internal pressure, external (i.e. vacuum) pressure or both. This section describes the requirements for pressure and leak testing.

All pressure systems considered new construction shall be tested as required by the Code of Record. This test shall be witnessed by the inspector. Upon agreement of the inspector, the System Owner, and the system DA, the inspector may forego the witness of the final system pressure test. Documentation of this test (Form PS-7) is required and shall be filed in the appropriate file in the Pressure System database.

All personnel directly involved in pressure testing shall meet the requirements of <u>Part 1: Section</u> <u>1.4.5 Pressure System and Testing Technicians</u>. For pressure systems tested on-site by subcontractors, the DA/SOTR is responsible for ensuring that the contract includes requirements for personnel to be appropriately trained and qualified to perform the work as well as trained in the hazards of pressure if exposed. Training and qualification through the subcontractor is acceptable.

## 6.1.1 Applicable Codes and Standards

The following Codes and Standards may be applicable to any given pressure or leak test.

- ASME B31 Piping Codes
- ASME BPVC
- ASME PCC2
- NBIC (NB-23)

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#### Part 6: Pressure and Leak Testing

#### 6.1.2 General

ASME and National Board Codes require pressure/leak testing for new construction, alterations and repairs. The requirements of the most applicable Code of construction or post construction shall be met. Due to the potential significant hazards associated with pressure testing, the DA or pressure test engineer shall determine the stored energy of components to be tested. The stored energy shall be calculated by any method determined suitable by the DA or pressure test engineer such as those given in <u>Part 6: Section 6.1.4 Stored Energy</u>.

Procedures for leak/pressure testing shall follow ASME B31.3 ¶ 345, ASME BPVC D1 UG-99 through UG-102 or other more applicable Code Section. In general, there are three basic types of pressure tests

- Hydrostatic where the test fluid is liquid
- Pneumatic where the test fluid is a gas
- Hydro-pneumatic where the test fluid is a combination of gas and liquid

Pneumatic and hydro-pneumatic testing shall not be performed on piping systems, vessels, or any other components subject to brittle fracture such as glass, PVC, CPVC, cast iron, etc. Pneumatic pressure testing of special use components (e.g. target cells) fabricated from such material is allowed under an OSP or TOSP.

Although the stored energy of pneumatic tests is typically much larger, they may be more appropriate in certain conditions. Where a hydrostatic or hydro-pneumatic test may damage lining or insulation, overstress the system or supports due to test fluid weight, or contaminate the process, a pneumatic test may be more suitable. This may also be true if the test temperature of a hydrostatic or hydro-pneumatic test could lead to brittle fracture.

Leak testing vacuum equipment or pressure components evacuated for leak testing with both a cross sectional area larger than 33 in<sup>2</sup> and a volume greater than 35 ft<sup>3</sup> shall follow the process steps given in <u>Part 6: Section 6.1.3 Process Steps</u>. When a sensitive leak test is performed, it shall be considered a pneumatic test and the process steps of <u>Part 6: Section 6.1.3 Process Steps</u> shall be followed.

### 6.1.3 Process Steps

The following process steps shall be used to perform leak/pressure tests

- 1. Determine the scope and nature of the pressure test. Ensure that both Code and Jefferson Lab requirements will be met.
- 2. Determine the stored energy of the test.

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- 3. An OSP or TOSP shall be prepared if any of the following conditions exist.
  - $\circ$  The mechanical stored energy of the test is greater than 73756 ft-lb (100 kJ)
  - Any component to be tested was exposed to a Category "M" fluid as described in ASME B31.3 and has not been fully cleaned and released
  - The test fluid is not inert (i.e. water, nitrogen, helium, etc.)
  - The test fluid is air and the test pressure is greater than 250 psi
  - The test must be performed on a radioactively contaminated system
- 4. The OSP or TOSP, if required, must describe the following in detail
  - Roles and Responsibilities
  - Rational for selection of test type
  - Stored energy of test
  - Qualifications of personnel performing the test
  - Protection for personnel performing the test
  - Protection for personnel near or potentially exposed to the test area
  - Protection for equipment
  - Description of system and extent of tested components
  - Test rig or pressure manifold
  - o Schematic of the test instrumentation, relief valves, and tested system
  - Possible ODH hazards
  - Detailed procedure for performing the test competent

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- Inspection prior to, during, and after test
- Recovery procedures if applicable
- 5. A pressure test form (Form PS-7) shall be completed by the test engineer, test technician, and Owner's Inspector if applicable.
- 6. The DA shall ensure that the pressure test form is filed in the Pressure Systems database.

### 6.1.4 Stored Energy

The stored mechanical energy of the test volume may be calculated using several methods. These methods include the following:

- Ideal Gas Laws
- Brode equation for stored energy of a gaseous volume
- Baker equation for stored energy of a gaseous volume (given below)
- Aslonov-Golinsky equation for stored energy of a gaseous volume
- Enthalpy tables
- Equation for stored energy of liquid

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The DA shall determine the method most appropriate for determining the stored energy of the test volume. The DA or test technician performing the calculation is cautioned to ensure consistency with units. If the system fluid is reactive, flammable, or explosive, the chemical potential energy must also be determined. The stored energy of a pressurized fluid that is flammable or explosive is thus the sum of the chemical as well as mechanical stored energies.

### 6.1.4.1 Stored Energy Calculation of a Gas

The stored mechanical energy of a gas may be calculated using the following expression

$$E = \frac{\frac{P_{\text{test}}V}{k-1}}{k-1} \left[ 1 - \left( \frac{\frac{P_{\text{atm}}}{P_{\text{test}}}}{k-1} \right)^{-(k-1)/k} \right]$$

Where:

E = stored energy of test V = test volume  $P_{atm}$  = absolute atmospheric pressure of test (14.7 psia in US cust. units)  $P_{test}$  = absolute pressure of test K = Ratio fo specific heats

Note: any system of units may be used (e.g. ASME PCC-2 Article 5.1) provided that they are consistent.

### 6.1.4.2 Equivalent Mass in TNT

The stored mechanical energy may be converted to an equivalent mass of TNT. The following equation may be used to convert the stored energy of a system to pounds of TNT:

$$TNT = \frac{E}{1488617}$$

Where:

E = stored energy of test (ft-lbf) TNT = equivalent amount of TNT (lb)

Note: alternate units may be used (e.g. ASME PCC-2 Article 5.1) provided that they are consistent.

### 6.1.4.3 Stored Energy of a Liquid

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The stored mechanical energy of a liquid that does not boil at ambient pressure and temperature may be calculated using the following equation:

$$E = \frac{V}{y} \left[ \frac{yP}{1+yP} - ln(1+yP) \right]$$

Where:

E = stored energy of test V = test volume P = test pressure

Y = compressibility of fluid

The compressibility of water at 10,000 psi is  $2.7 \times 10^{-6} psi^{-1}$ . Similar fluids have compressibilities of the same order of magnitude. Thus, in many cases of moderate pressure, a good approximation of the stored energy is:

$$E = \frac{VyP^2}{2}$$

This expression should only be used for conditions where  $\gamma P \ll 1$ . Note that it is readily apparent that the stored energy of a typical compressed liquid volume is much less than the equivalent volume and pressure of a typical gas.

#### 6.1.4.4 Stored Energy of a Vacuum

The stored energy within a vacuum vessel may be approximated with the following equation using US customary units:

$$E = 144 \operatorname{in}^2/\operatorname{ft}^2(P_{atm})(V)$$

Where

E =stored energy of test (ft-lbf)

 $P_{atm}$  = absolute atmospheric pressure of test (14.7 psia in US customary units)

V = test volume (in cubic feet)

Note: alternate units may be used (e.g. ASME PCC-2 Article 5.1) provided that they are consistent.

#### **6.1.5 Safe Distance Calculations for Pneumatic Test**

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The minimum safe distance between personnel and the equipment being tested shall be the greater of 3 ft. and R which is determined by the following equation:

$$R = R_s(TNT)^{1/3}$$

Where:

 $R_s$  = scaled consequence factor 50  $ft/lb^{1/3}$ TNT = stored energy in lb of TNT R = required minimum distance for personnel

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### Part 7: Vacuum Systems

### 7.1 Introduction

All vacuum systems and components are considered pressure systems and components. Users, fabricators, and designers of vacuum systems shall be aware of the potential hazards vacuum systems pose especially when performing operations such as backfilling or when working near a vacuum chamber with a thin section or window. Such hazards include rupture from overpressure during a backfill operation, buckling collapse, or implosion do to failure of a component such as a thin window.

Vacuum systems with a design initiated on or after January 4, 2016 shall meet the requirements of <u>Part 7: Vacuum Systems</u> of this Supplement. For vacuum systems under construction prior to the above start date, the assigned DA or Vacuum Engineer/Technician shall choose to either follow <u>Part 7: Vacuum Systems</u> of this Supplement or continue following Revision 3.3 of ES&H Manual Chapter 6151 Pressure and Vacuum Safety Program and its Technical Appendices. If Revision 3.3 is followed and the vacuum system is a Category 3 system as defined below, the DA must still complete Form PS-1, Form PS-4 and Form PS-5 of this Supplement; create and file a P&ID; and complete the steps defined in <u>Part 2: Section 2.10 Inspections</u> and <u>Part 2: Section 2.11 System Turnover</u>.

A qualified Vacuum Technician or Responsible Vacuum Engineer shall determine the proper category for a proposed vacuum system design, repair, or alteration.

### 7.2 Vacuum System Categories

A vacuum system shall be classified into one of the following categories:

### 7.2.1 Category 0

A vacuum system that is not connected to any credible pressure source exceeding 15 psig may be considered a Category 0 system if all of the following conditions are met.

- Total system volume is less than 35 ft<sup>3</sup> or the largest internal cross sectional area does not exceed 33 in<sup>2</sup> regardless of length.
- The pressure source relieving the vacuum cannot exceed 15 psig in any failure mode. A regulator attached to a building nitrogen supply at 60 psig, for example, does not meet

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this requirement.

- The system is not an insulating vacuum for cryogenic components; examples of this include cryostats, cryogenic transfer line vacuums, and storage vessels for LHe or LN2.
- The system has no component or section with an unreinforced wall thickness less than 0.02 inches more than 6 inches in diameter.

### 7.2.2 Category 1

Vacuum systems not used to insulate cryogenic surfaces in which the differential operating pressure can never exceed 15 psi but have a volume larger than 35 ft<sup>3</sup> and a cross sectional area larger than 33 in<sup>2</sup>. Examples of Category 1 vacuum systems include HMS and HRS vacuum systems, injector chambers and dog-leg chambers.

### 7.2.3 Category 2

Vacuum systems attached to or containing a credible pressure source that can exceed 15 psig and are protected from pressurization exceeding 15 psig through engineering controls (e.g. pressure relief devices). Insulating vacuums for cryogenic systems shall be considered Category 2 vacuum systems. Examples of Category 2 vacuum systems include cryostats, cryogenic transfer lines, cold boxes, and target scattering chambers.

### 7.2.4 Category 3

Vacuum systems attached to or containing a credible pressure source that can cause the vacuum system pressure to exceed 15 psig and where this system cannot be protected from pressurization exceeding 15 psig shall be considered a pressure system with a design pressure (or MAWP) exceeding 15 psig and subject to the full rigor of <u>ES&H Manual Chapter 6151 Pressure and Vacuum Systems Safety Program</u> and this Supplement.

Note: Thin windows installed on Category 3 systems shall be designed in accordance with the applicable ASME Code and shall not be designed following the rules give in <u>Part 7: Section 7.7</u> Requirements for Components with Thin Windows.

### 7.3 Requirements for Category 0 Vacuum Systems

Vacuum systems meeting the criteria for Category 0 shall be designed by a qualified vacuum technician. The vacuum technician shall assume responsibility for the safe construction, alteration, or repair of the system following sound engineering principles. No further requirements (including the generation of a PS number and folder structure) apply.

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### 7.4 Requirements for Category 1 Vacuum Systems

Vacuum systems meeting the criteria for Category 1 shall be designed by a qualified Responsible Vacuum Engineer experienced in the design of vacuum systems and vessels. The design, fabrication, testing, repair, and alteration of Category 1 systems shall comply with all the requirements of this section. A PS number and folder structure are not required.

### 7.4.1 Design

Vacuum systems in Category 1 are not required to meet the full rigor of the ASME Codes. These systems shall be designed to ensure that the system maintains suitable safeguards against buckling collapse. This can be verified using applicable paragraphs from ASME BPVC Section VIII Div 1 or Div 2. Alternatively, vacuum system design may be verified using other peer approved methods. A buckling analysis with a minimum factor of safety of 2 shall be performed by a Responsible Vacuum Engineer and reviewed by another Responsible Vacuum Engineer or DA.

### 7.4.2 Fabrication, Repair and Alteration

All welding and brazing performed on Category 1 vacuum components shall meet the requirements of the Welding and Brazing Supplement. Welded and brazed joints shall be designed using sound engineering principles supported by detailed calculations, testing, and/or service experience. These designs shall be technically reviewed. The welding/brazing procedures for these joints shall fully comply with ASME IX or AWS. All welders/brazers performing these procedures shall be qualified to them in compliance with the applicable Code. Materials of unknown origin shall not be used in structurally relevant application on these components. The Responsible Vacuum Engineer shall determine the method and extent of examinations and inspections to be performed.

All other fabrication of the system may be overseen by a qualified vacuum technician.

### 7.4.3 Testing

In addition to any leak testing to demonstrate performance, Category 1 systems shall require an evacuation test (i.e. negative pressure test) which shall be supervised and witnessed by the Responsible Vacuum Engineer. For ordinary vacuum systems, the test pressure shall be full atmospheric pressure differential. For vacuum systems not intended to be pumped out to the full atmospheric pressure differential, the test pressure shall be 110% of the maximum allowable external differential pressure, but not more than full atmospheric pressure. The process steps for completing this test shall be as given in <u>Part 6: Section 6.1.3 Process Steps</u> with the exception that Steps 5 and 6 may be omitted.

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For a vacuum system within a pressure vessel, the test differential pressure shall be 110% of the maximum allowed working pressure differential. Thin windows and other delicate equipment may be removed while testing the vacuum system.

### 7.4.4 Documentation

Documentation for Category 1 systems (design calculations, material certifications, etc.) shall be maintained by the Responsible Vacuum Engineer. A Vacuum System folder within the Pressure Systems webpage is available for documentation storage.

### 7.5 Requirements for Category 2 Vacuum Systems

Category 2 systems with a volume less than 35 ft<sup>3</sup> or having no cross section larger 33 in<sup>2</sup> are only required to meet the requirements of <u>Part 7: Section 7.5.1 Pressure Relief</u> and shall be designed by a Responsible Vacuum Engineer. All other fabrication, repair, or alterations of the system may be overseen by a qualified vacuum technician.

All other Category 2 systems shall meet the full requirements of this section. A PS number and folder structure are not required.

### 7.5.1 Pressure Relief

For Category 2 systems, the Responsible Vacuum Engineer shall ensure, using sound engineering practices, that there is adequate pressure relief (relief capacity) for the entire system and that the maximum system pressure does not exceed 15 psid. Coded relief devices are not required. Non-coded relief devices shall be qualified through operability tests demonstrating function and flow capacity or calculations showing adequate flow capacity. Flow capacities provided for devices produced by a reputable manufacturer shall be acceptable. A properly designed and relieved purge system may be used provided that the users of such a system are fully trained. A Responsible Vacuum Engineer shall ensure that the purge system is designed to provide adequate capacity using sound engineering principles. It is recommended that relief capacities be determined using methods similar to those given in API 520 and 521.

A properly designed purging system may be used on any Category 2 system provided all of the following conditions are met:

- The purge system shall be flow limited. This limit shall be determined by calculations, flow testing, or manufacturer rating.
- A relief device, that is located between the backfill pressure source and the vacuum volume, having equal or greater capacity than the flow limit determined above, shall be

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installed in such a manner that the pressure in the vacuum system being purged cannot exceed 15 psig under any normal or credible fault condition.

### 7.5.2 Fabrication, Repair and Alteration

All welding and brazing performed on Category 2 vacuum components shall meet the requirements of the Welding and Brazing Supplement (WBS). Welded and brazed joints shall be designed using sound engineering principles supported by detailed calculations, testing, and/or service experience. These designs shall be technically reviewed. The welding/brazing procedures for these joints shall fully comply with ASME IX or AWS. All welders/brazers performing these procedures shall be qualified to them in compliance with the applicable Code. Materials of unknown origin shall not be used in structurally relevant application on these components. The Responsible Vacuum Engineer shall determine the method and extent of examinations and inspections to be performed.

All other fabrication of the system may be overseen by a qualified vacuum technician.

### 7.5.3 Testing

In addition to any leak testing to demonstrate performance, Category 2 systems shall require an evacuation test (i.e. negative pressure test) which shall be supervised and witnessed by a Responsible Vacuum Engineer. For ordinary vacuum systems, the test pressure shall be full atmospheric pressure differential. For vacuum systems not intended to be pumped out to the full atmospheric pressure differential, the test pressure shall be 110% of the maximum allowable external differential pressure, but not more than full atmospheric pressure. The process steps for completing this test shall be as given in <u>Part 6: Section 6.1.3 Process Steps</u>, with the exception that Steps 5 and 6 may be omitted.

For a vacuum system within a pressure vessel, the test differential pressure shall be 110% of the maximum allowed working pressure differential. Thin windows and other delicate equipment may be removed while testing the vacuum system.

### 7.5.4 Documentation

Documentation for Category 2 systems (design calculations, material certifications, relief device calibration data, etc.) shall be maintained by the Responsible Vacuum Engineer. A Vacuum System folder within the Pressure Systems webpage is available for documentation storage at the discretion of the Responsible Vacuum Engineer.

### 7.6 Requirements for Category 3 Vacuum Systems

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Category 3 vacuum systems are considered pressure systems with a design pressure (or MAWP) exceeding 15 psi. The DA shall ensure that all work on Category 3 vacuum systems including system design, fabrication, testing, alteration, and repair meets the requirements of the <u>ES&H</u> <u>Manual Chapter 6151 Pressure and Vacuum Systems Safety Program</u> and all sections of this Supplement. A PS number and folder structure in the Pressure Systems database **are required** for Category 3 vacuum systems. The System Owner of a Category 3 vacuum system must follow the operation, maintenance and in-service inspection requirements described in <u>Parts 8:</u> <u>Operation and Maintenance</u> and <u>Part 9: Pressure Equipment in-Service Inspection Program</u> of this Supplement.

#### 7.7 Requirements for Components with Thin Windows

Thin windows are common at Jefferson Lab. These components are often installed on spectrometer vacuum systems, scattering chambers, beam dumps, and detectors. They are required to reduce background interactions and multiple scattering of the main electron beam and of recoil particles impinging on detectors. These components are crucial to the mission at Jefferson Lab. This section details the requirements for thin window design for Category 1 and 2 vacuum system components with sections where the wall thickness is less than 0.02 inches larger than 33 in<sup>2</sup> in area or when installed in critical applications. Windows installed on Category 3 vacuum systems are subject to the ASME codes or equivalent measures. The rules defined below are not equivalent measures to the codes and therefore shall not be used for Category 3 systems.

### 7.7.1 Qualifications of the Category 1, or 2 Window Designer

Category 1 and 2: The safety of the window design shall be assured by a Jefferson Lab DA experienced in thin window design.

### 7.7.2 Design Requirements for Category 1, or 2 Vacuum Windows

#### 7.7.2.1 General

The design of any thin vacuum window shall consider the following:

- Material compatibility
- Life cycle and fatigue.
- Effects from radiation or corrosion
- Possible accidental damage from puncture etc.
- Magnitude of deformation
- Crack and tear propagation

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Design calculations (see <u>Part 7: Section 7.7.2.2 Stress and Deformation Calculations</u>) or proof test (see <u>Part 7: Section 7.2.3 Proof Test</u>) shall be performed to ensure that the stresses in the thin window are acceptable

### 7.7.2.2 Stress and Deformation Calculations

The stress in the window shall be determined after all fabrication steps have been completed (i.e. hydro-forming). The calculated stress in the window shall be less than the allowable stress. The allowable stress in tension for any thin vacuum window shall be the lesser of:

- $S_a = 0.5 S_{ut}$  (allowable stress is  $\frac{1}{2}$  ultimate tensile)
- $S_a = 0.9 S_v$  (allowable stress is 9/10 yield)

### 7.7.2.3 Proof Test

Alternatively, a proof test may be performed. The design pressure (or MAWP) of the window shall be given by:

$$P_{design \leq \frac{P_{test}}{2}} = \frac{S_{list}}{S_{test}}$$

Where:

 $P_{design}$  = design pressure  $P_{test}$  = the test pressure  $S_{list}$  = the specified minimum ultimate tensile strength  $S_{test}$  = the ultimate tensile strength of the material used in the test

If it is known that only material from one batch, heat or lot is to be used, then the stress ratio in the above equation may be assumed to be 1. If the window material is not listed and its properties are not known, a sample from each batch, heat or lot shall be proof tested using the above equation where the stress ratio is assumed to be 1. A different maximum design pressure shall be determined for each material heat, batch, or lot.

### 7.7.3 Documentation

Documentation for thin windows (design calculations, material certifications, test data, etc.) shall be maintained by the Responsible Vacuum Engineer. A Vacuum System folder within the Pressure Systems webpage is available for documentation storage.

### 7.7.4 Formed Windows

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Windows that are shaped by hydro-forming or some other process can often be safely made from much thinner material than a corresponding flat window of the same diameter. Typically, a thin flat disc of Aluminum is hydro-formed into a predetermined spherical shape. A typical hydro-forming pressure is two to three times the usual operating pressure (14.7 psi). This pressure is necessary to yield the material into the desired shape and has the benefit of an inherent overpressure test. Many hydro-formed windows exist at Jefferson Lab - typically made from Al 2024 Alclad which is available in a half soft state and has a large elongation and a moderately high yield and ultimate strength. It is recommended that only 30% of the available elongation be used so that adequate reserve remains in the window to provide safety against foreign object penetration. The thin window stock or precut blanks shall be carefully inspected prior to use to ensure that there are no defects, deep scratches or wrinkles that could easily compromise the strength of these thin materials.

### 7.7.4.1 Formed In Situ Windows

Windows that are formed in situ are simply thin pre-tested materials that are highly deformed during the initial evacuation. Examples of thin windows of this type are the spectrometer entrance and exit windows that are made from Mylar-Kevlar-Mylar laminates and the Aluminum (5054) or Kapton scattering chamber windows. These windows shall be tested to determine that, after the initial deformation, an adequate safety margin exists. Alternatively an Elastic-Plastic analysis may be performed, instead of a test, using an accurate model of the material. Once these windows are tested, replacement windows may be made from the same heat, batch, or lot of material used to make the test window. All new material stocks without a certified material test report (CMTR) shall be tested to verify that the material meets all design requirements. A proof test, as described in <u>Part 7: Section 7.7.2.3 Proof Test</u>, meets this requirement. Experience at Jefferson Lab shows that laminated window materials can vary substantially with each batch while metal window materials have always been consistent within the normal range of material specifications.

### 7.7.5 Testing

With the exception of formed in situ windows, each thin window shall be tested either during a forming process or during a dedicated pressure test. The test pressure shall be greater than 110% of the design pressure (or MAWP). Windows made from material where tear propagation may be a factor should be puncture tested to determine the extent of this affect.

Materials, supplied in lots, batches or heats, to be used for formed windows shall be tested to verify the ultimate strength; a CMTR supplied by the material manufacturer is acceptable. These windows are often formed with pressures exceeding the required test pressure. If such is the case, this forming may be substituted for the final pressure test of the window.

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#### 7.7.6 Additional Considerations

Reasonable efforts to protect thin windows from accidental damage shall be performed. Such efforts include both engineering and administrative controls. Examples include covers for thin windows that are temporarily installed on scattering chamber windows and removed just prior to the start of a run period. Some thin windows installed on vessels with a high stored energy and having large aperture may require remotely operated covers that are moved into position prior to personnel access into a given area where the thin window resides. Examples of this type of control include the HMS exit vacuum window. Proper PPE such as safety glasses and hearing protection may be required when working near thin windows covering large volumes.

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### Part 8: Operation and Maintenance

### 8.1 Operation

The requirements of this section apply to all pressure systems regardless of design or fabrication date. The System Owner is responsible for the safe operation of the pressure system.

In the event that ownership of a system is reassigned, the new System Owner is responsible for communicating this change to the Pressure Systems Committee Designee.

Reasonable steps shall be taken to ensure that the system is operated by qualified personnel with adequate training. Operators of pressure systems shall meet the qualifications given in <u>Part 1</u>: <u>Section 1.4.4 Operators and Users</u>. Operators of pressure systems shall have specific system training as determined by the System Owner. This training shall include understanding of the operational characteristics of the system, operating strategies, inherent hazards associated with the system and requirements for addressing all credible failure scenarios, and emergency procedures.

The System Owner shall develop to the extent deemed necessary operating procedures required for the safe and reliable operation of the system. These procedures shall be maintained by the System Owner. These may be filed in the Operations folder for the pressure system in the Pressure Systems database.

In all cases, operation of the system shall conform to the engineering design limits. System Owners and/or Operators shall regularly check the pressure system considering the following items:

- Check pressure relief valves, gages, rupture disks, vessels, piping and other system components (compressors, pumps, etc.) for leaks, degradation, corrosion and blockage.
- Verify valve positions are correct prior to operation and after any system changes.
- Monitor and maintain pressure systems within operational parameters with installed instrumentation

If a system is taken out of operation permanently, the System Owner is responsible for communicating this change to the Pressure Systems Committee Designee.

If a pressure vessel or boiler is removed from service, the System Owner must notify the Vessel Inspection Coordinator of a change in status. The pressure equipment database shall be updated



to reflect this change. Before a vessel is placed back into service, it must be re-inspected as described in <u>Part 9: Section 9.2 In-service Inspection Expectations and Procedures</u>.

The System Owner shall notify the Vessel Inspection Coordinator regarding a change in status of a relief device protecting a pressure vessel/boiler or a Category M system or piping larger than 6 NPS. The master list shall be updated, by the Vessel Inspection Coordinator or Pressure Systems Committee Designee, as required.

#### 8.2 Maintenance

The requirements of this section apply to all pressure systems regardless of design or fabrication date. Work on Category M, or other hazardous (as determined by the ESH manual) systems where the system pressure boundary is breached shall be considered a repair. Work on flammable fluid systems where the pressure boundary is breached or hot work is performed near the pressure boundary and the fluid system cannot be inerted shall be considered a repair. Work which requires hot work (welding, grinding, cutting and/or brazing operations) on the pressure boundary shall be considered a repair. Machining operations not considered hot work on components not larger that NPS 5 (DIN 125) may be considered maintenance provided that the original system design specification is maintained.

Examples of maintenance activities include:

- Painting and corrosion control
- Oil changes
- Wear pad replacement
- Valve seal replacement
- Filter cartridge replacement

The System Owner shall be responsible for maintaining the integrity and placement of vessel identification markings.

#### 8.2.1 General

Pressure systems and components shall be maintained in compliance with schedules and requirements given by equipment manufacturers, the system DA, the System Owner, and other applicable Jefferson Lab policies. The required maintenance of a pressure system shall be determined as follows:

- DA responsible for the system construction shall determine any special maintenance requirements (on Form PS-9) such as:
  - o Replacement intervals for thin windows upon lifetime/exposure limits

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- Replacement intervals for parts exposed to cyclic loading
- Cathodic corrosion protection replacement
- The System Owner shall be responsible for developing routine maintenance requirements such as:
  - o Maintaining paint and basic corrosion control measures
  - Keeping relief device discharge paths unobstructed (i.e. removing wasp nests etc.)
  - Basic equipment maintenance required by manufacturers
  - Support hanger spring replacement.
  - Support roller lubrication and replacement

In all cases, the System Owner is responsible for the long term maintenance and safe operation of the system. In the event that ownership of a system is reassigned, the new Owner is responsible for communicating this change to the Pressure Systems Committee Designee. All personnel performing maintenance on a pressure system shall be qualified as determined by their supervisor.

Maintenance work shall be completed by competent technical staff under the direction of the System Owner. It is recommended that documentation be filed in a readily accessible manner such as an electronic logbook or the Pressure System project folder within the Pressure Systems database. It shall be the responsibility of the System Owner to maintain this documentation.

Maintenance work requiring the system or part of the system to be deenergized (e.g. valve seal replacement, pump bearing replacement, filter cartridge replacement, etc.) shall be performed under the direct supervision of personnel trained in the safe operation of the system. The deenergized state of the system shall be determined by suitable method prior to performing the maintenance work. Proper lock, tag, and try procedures shall be used where appropriate.

### **8.2.2 Energizing the System after Maintenance Work**

Caution shall be exercised when energizing a system following maintenance work. The system shall be energized by personnel trained in the safe operation of the system. The integrity of all disassembled components shall be considered untested until an informal in-service leak test is performed. Personnel not directly involved in the in-service leak test shall maintain a safe distance during the test. Personnel performing the test shall stand at a safe distance (keeping arms and legs away from hazardous locations) and inspect for leaks only after the system pressure is stabilized.

### 8.2.3 Pressure Relief Valve Preventive Maintenance

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Pressure relief valves are mechanical devices that require periodic preventive maintenance even though external inspection and test results indicate acceptable performance. There may be wear on internal parts, galling between sliding surfaces or internal corrosion, and fouling which will not be evident from an external inspection or test. Periodic re-establishment of seating surfaces and the replacement of soft goods such as o-rings and diaphragms are also well advised preventive maintenance activities that can prevent future problems. If the valve is serviced, a complete disassembly, internal inspection, and repair as necessary, such that the valve's condition and performance are restored to a like new condition, should be done by an organization accredited by the National Board.

Service records with test results and findings should be maintained for all overpressure protection devices. A service interval of no more than three in-service inspection intervals or ten years, whichever is less, is recommended to maintain device condition. Results of the internal inspection and maintenance findings can then be used to establish future service intervals.

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### Part 9: Pressure Equipment In-Service Inspection Program

### Part 9: Pressure Equipment In-Service Inspection Program

### 9.1 In-Service Inspections of Pressure Equipment

This part specifies the requirements for in-service inspection of pressure equipment located both on site or owned by Jefferson Lab on leased properties. The Inspection Category defined in <u>Part 9: Section 9.1.2 In-Service Inspection Categories</u> as well as any special requirements designated by the DA, System Owner or inspector shall determine the extent of required inspections.

### 9.1.1 Types of In-Service Inspection

Typically, the inspector shall perform a visual inspection of vessels, piping, and ancillary equipment as required by the Inspection Category. The DA, System Owner or inspector shall use sound engineering principles to determine if further inspection, testing and examination techniques are required.

### 9.1.2 In-Service Inspection Categories

The Pressure Equipment In-service Inspection Program consists of four Inspection Categories.

- IC4 (Inspection Category 4): ASME boilers and relief devices protecting them.
- IC3: ASME Pressure Vessels and Category M systems and relief devices protecting them.
- IC2: Relief devices providing overpressure protection on Excluded Vessels or piping larger than 6 NPS.
- IC1: All other pressure equipment (e.g. piping, turbo and reciprocating machinery, Excluded Vessels, vacuum equipment such as insulating jackets, etc.).

### 9.1.3 Responsibilities

### 9.1.3.1 System Owner

- Shall ensure that all required inspections are completed.
- Shall ensure their systems have a valid Pressure System number/title and an identified Inspection Category.
- Shall ensure that their ASME vessels and the associated relief devices are identified in the Vessel Inspection Coordinators database.



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- Maintains responsibility for their pressure equipment and must cooperate with the Vessel Inspection Coordinator to ensure accurate and complete information is included in the inspection program database.
- Shall ensure in-service inspections of IC2 and IC1 equipment are completed and documented.
- Shall ensure operational inspections and testing of IC4, IC3 and IC2 relief devices are completed and documented.
- May specify additional inspection requirements using sound engineering principles to ensure safety and performance criteria.

### 9.1.3.2 Vessel Inspection Coordinator

• Shall coordinate and document the inspector/inspections for IC4 and IC3 pressure equipment.

### 9.1.3.3 Design Authority

- Shall specify the Inspection Category, Type of Inspection required and Inspection Interval for new equipment (new systems and alterations) on Form PS-9 as required by Part 2: Section 2.11 System Turnover.
- May specify additional inspection requirements using sound engineering principles to ensure safety and performance criteria.

# 9.1.3.4 In-Service Inspector (See <u>Part 1: Section 1.4.3.2 In-</u> <u>Service Inspectors</u> for descriptions and qualifications of different inspectors)

- Conducts the inspection of all identified in-service pressure equipment.
- Completes and signs the required inspection forms (Form PS-10, Form PS-11 and/or Form PS-12).
- Provides additional testing means and methods as required for vessel inspections.
- Reviews inspection results with the designated Vessel Inspection Coordinator and/or the System Owner as appropriate.
- May specify additional inspection requirements after inspection of a component or system using sound engineering principles to ensure safety and performance criteria.

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#### 9.1.4 Intervals for In-Service Inspection

The DA and/or System Owner shall determine the required in-service inspection interval for IC4, IC3, and IC2 pressure equipment by consulting Table 1 and considering the following:

- Fatigue, vibration, and pressure pulsing
- System fluid
- Component materials
- Environment in which the component is installed
- The potential for rust, scale, or build-up
- Other relevant factors determined by the System Owner/user or DA

The inspection interval shall not be greater than that given in Table 1 unless a suitable record of acceptable inspections for similar service has been established. EXCEPTION: In-service Inspection Intervals for ASME boilers and Category M fluid equipment shall be no longer than as stated in Table 1. The interval for Operational Inspection and Testing of Category IC4, IC3 and IC2 relief devices shall be no longer than as stated in Table 1: Maximum initial inspection intervals for pressure equipment.

Note that this section may be used as guidance for System Owners and DAs when determining a suitable inspection frequency for IC1 pressure equipment. While these specific intervals are not required, it is a requirement that an interval be defined for IC1 pressure equipment.

	Maximum Test and/or Inspection Interval
<b>Component and Fluid Service</b>	(years)
Vessel: Gas (non-corrosive)	5
Vessel: Gas (corrosive)	2
Vessels and piping: Category M	1
fluid	
Vessel: Liquid (corrosive)	1
Vessel: Liquid (non-corrosive)	5
Dewar Vessel	2
Rupture Disk	Inspect/Replace every 5
Vessel: Boiler	2
IC4 Relief Device	2
Relief Device: Gas (non-corrosive)	5
Relief Device: Gas (corrosive)	2
Relief Device: Category M fluid	1
Relief Device: Liquid (corrosive)	2
Relief Device: Liquid (non-	5
corrosive)	

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	Maximum Test and/or Inspection Interval
<b>Component and Fluid Service</b>	(years)
Relief Device on Dewar Vessel	5

Table 1: Maximum initial inspection intervals for pressure equipment

#### 9.2 In-Service Inspection Expectations and Procedures

The extent of the in-service inspection required for a given component or subsystem is dependent on the most applicable Inspection Category (IC#) and additional requirements specified by the DA and System Owner. The requirements for inspector qualification are also dependent on the type of equipment to be inspected. See <u>Part 1: Section 1.4.3.2 In-Service Inspectors</u> for in-service inspector qualifications.

### 9.2.1 In-Service Inspection of IC4 Equipment

The Vessel Inspection Coordinator shall be responsible for coordinating the in-service inspection of all IC4 equipment. External and internal inspections of boilers and hot water heaters shall be performed as required in the Commonwealth of Virginia Department of Labor & Industry, Division of Boiler and Pressure Vessel Safety, Boiler & Pressure Vessel Rules & Regulations. The inspector for IC4 boilers shall be qualified as given in <u>Part 1: Section 1.4.3.2 In-Service</u> Inspectors. The Vessel Inspection Coordinator shall supply the inspector with the following:

- Vessel Inspection Form PS-11, Form U-1 or other applicable ASME data report (if available)
- P&ID or relevant section of the P&ID clearly indicating relief devices
- (Upon request) Relevant relief device inspection and test reports in Form PS-5 or Form PS-12.

The inspector shall complete NBIC Form NB-6 or its equivalent (Form PS-11) for each boiler. This documentation shall be reviewed by the Vessel Inspection Coordinator. Upon review of the inspection report, the Vessel Inspection Coordinator shall perform one of the following:

- Approve the boiler for continued operation.
- Conditionally approve the boiler for continued operation allowing the System Owner a reasonable period of time to address minor issues.
- Condemn the boiler, notify the System Owner, and issue a CATS. See <u>Part 9: Section</u> <u>9.2.5.1 Category IC4 and IC3 Condemned Vessels</u>.

The System Owner shall ensure that relief devices in this category are inspected and tested at an interval no longer than that given in <u>Part 9: Section 9.1.4 Intervals for In-Service Inspection</u> using the procedural guidance provided in <u>Part 9: Section 9.3 In-Service Inspection of IC3</u>

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<u>Equipment</u>. Note that new devices may be installed in lieu of testing. New devices shall be registered <u>per Part 4: Section 4.7 Relief Device Registration</u> and filed in the system folder.

### 9.2.2 In-Service Inspection of IC3 Equipment

The Vessel Inspection Coordinator shall be responsible for coordinating the in-service inspection of all IC3 equipment. Inspectors of IC3 vessels and associated relief devices shall be Jefferson Lab employees or employees of agencies other than Jefferson Lab experienced in pressure vessel inspection. Inspectors shall be qualified as given in <u>Part 1: Section 1.4.3.2.2 Pressure Vessels</u>.

The System Owner or designee shall orient the inspector(s) with regard to the location of the vessel/system, the fluid service, operational history, and method of overpressure protection if necessary. Note that relief devices may not be required on pressure vessels that are protected from overpressure by system design. In such cases, the requirements of <u>Part 4</u>: Section 4.8 <u>Overpressure Protection by System Design</u> shall be met. Where relief devices are required for overpressure protection they must comply with the requirements of <u>Part 4</u>: Section 4.5 <u>Overpressure Protection by Relief Device</u>. If requested by the inspector, the System Owner shall provide relevant relief device inspection/test reports. The System Owner shall ensure that relief devices in this category are inspected and tested at an interval no longer than that given in <u>Part 9</u>: <u>Section 9.1.4 Intervals for In-Service Inspection</u> using the procedures given in <u>Part 9</u>: <u>Section 9.3</u> In <u>Service Inspection of IC2 Components</u>. Note that new devices may be installed in lieu of testing. New devices shall be registered per <u>Part 4</u>: <u>Section 4.7 Relief Device Registration</u>.

#### 9.2.2.1 **Procedures for Vessel Inspection**

Inspections of vessels in this category shall be performed by following a specified procedure. For inspectors employed by agencies other than Jefferson Lab, the inspection procedure shall be approved by the Vessel Inspection Coordinator. Jefferson Lab employee inspectors shall use an approved vessel inspection procedure (accessed through the Pressure Systems webpage in the DA Toolbox "In-service Inspection" tab) or an equivalent.

### 9.2.2.2 Completion of Inspection

The inspector shall complete Form PS-11 for each vessel of this type. This documentation shall be reviewed by the System Owner and, if necessary, the Vessel Inspection Coordinator. Upon review of the inspection report, the inspector (if a Jefferson Lab employee) shall perform one of the following steps below. If an outside inspector is used, the Vessel Inspection Coordinator shall perform one of these stated actions:

• Approve the vessel for continued operation.

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- Conditionally approve the vessel for continued operation allowing the System Owner a reasonable period of time to address minor issues.
- Condemn the vessel, notify the System Owner, and issue a CATS. See <u>Part 9: Section</u> 9.2.5.1 Category IC4 and IC3 Condemned Vessels.

The completed Form PS-11 shall be forwarded to the Vessel Inspection Coordinator.

### 9.2.2.3 In-Service Inspection of IC3 Category M Systems and Components

The System Owner or designee shall orient the inspector(s) with regard to the location of the system, the fluid service, operational history, and method of overpressure protection. Note that relief devices may not be required on pressure vessels that are protected from overpressure by system design. In such cases, the requirements of <u>Part 4: Section 4.8 Overpressure Protection by System Design</u> shall be met. Where relief devices are required for overpressure protection they must comply with the requirements of <u>Part 4: Section 4.5 Overpressure Protection by Relief Device</u>. The System Owner shall provide relevant relief device inspection/test reports upon request of the inspector. The System Owner shall ensure that relief devices in this category are inspected and tested at an interval no longer than that given in <u>Part 9: Section 9.1.4 Intervals for In-Service Inspection</u> using the procedures given in <u>Part 9: Section 9.3 In-Service Inspection of IC2 Components</u>. Note that new devices may be installed in lieu of testing. New devices shall be registered per <u>Part 4: Section 4.7 Relief Device Registration</u>.

IC3 Category M systems (piping and relief devices) shall be inspected at least annually by an inspector qualified as given in <u>Part 1: Section 1.4.3.2.3 Relief Devices</u> and/or <u>Part 1: Section 1.4.3.2.4 Piping</u>. The inspector shall complete the Pressure Equipment Inspection Form (Form <u>PS-10</u>), review the Relief Device Operational Inspection and Test Data Sheet (Form <u>PS-12</u>), provide these forms to the System Owner and the Pressure Systems Committee Designee.

### 9.2.3 In-Service Inspection of IC2 Components

The System Owner shall ensure that relief devices in this category are inspected and tested at an interval no longer than that given in <u>Part 9: Section 9.1.4 Intervals for In-Service Inspection</u> using the procedures given in <u>Part 9: Section 9.3 In-Service Inspection of IC2 Components</u>. Note that new devices may be installed in lieu of testing. New devices shall be registered per <u>Part 4:</u> <u>Section 4.7 Relief Device Registration</u>.

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#### 9.2.3.1 Exceptions

The following safety relief devices are exempt from the inspection requirements given in this section. The System Owner shall be responsible for the initial and continued safety of the relief devices exempt from the specific requirements of this section.

- Relief devices with set points less than 15 PSIG **OR**
- Relief devices on any system where all of the following criteria are met
  - The maximum system pressure cannot exceed 15 psid (pounds per square inch differential) at any time including all credible failure modes
  - The system fluids are nonflammable, nontoxic, and not harmful to human tissue (as described in ASME B31.3 Para 300.2)
  - The system design temperature is greater than -20F and less than 366F

### 9.2.3.2 Inspector Qualifications

Inspection of relief devices shall be performed by or under the supervision of Jefferson Lab employees qualified as given in <u>Part 1: Section 1.4.3.2.3 Relief Devices</u> or by employees of other agencies holding a National Board VR certificate.

### **9.2.4 In-Service Inspection of IC1 Components**

Inspection of IC1 equipment shall be as required by the system DA as indicated on Form PS-9, Pressure System Turnover. If there are no specific inspection requirements defined, inspections shall be defined by the System Owner. The vessel inspection procedures (accessed through the Pressure Systems webpage in the DA Toolbox "In-service Inspection" tab) or their equivalent shall be used for Excluded Vessels. The necessity of using an in-service inspector shall be determined by the System Owner based on the complexity and risk factor associated with the system but in all cases, the System Owner shall ensure that these inspections are performed by competent individuals and documented on Form PS-10 or Form PS-12. This form(s) shall be filed in the appropriate Pressure Systems Folder.

### 9.2.5 Disposition of Pressure Equipment and Registration Requirements

### 9.2.5.1 Category IC4 and IC3 Condemned Vessels

Condemned vessels shall be immediately removed from service after the Vessel Inspection Coordinator has notified the System Owner. A tag identifying the vessel as "CONDEMNED" shall be affixed to the vessel by the System Owner. The vessel shall not be returned to service

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until inspection deficiencies are corrected and the vessel is re-inspected and deemed acceptable for use. Form PS-11 must be updated and submitted to the Vessel Inspection Coordinator.

### 9.2.5.2 Category IC4, IC3 and IC2 Defective Relief Devices

If an IC4, IC3 or IC2 relief device is determined to be defective, it shall be replaced immediately or the system shall be deenergized unless there is a relief device, or combination of devices, of adequate capacity, installed in a parallel configuration to relieve any credible overpressure condition. The location of these devices shall comply with the requirements given in ASME BPVC D1 Appendix M. In such cases, a CATS item shall be generated and a suitable replacement shall be installed as soon as reasonably possible.

### 9.2.5.2.1 Relief Devices Removed from Service and Replaced

The System Owner shall notify the Vessel Inspection Coordinator regarding a change in status of an IC4, IC3 and IC2 relief device. New relief devices must be registered by completing Form <u>PS-5</u>. The inspection database shall be updated by the Vessel Inspection Coordinator as required.

#### 9.2.5.2.2 Relief Devices Returned to Service

Any IC4, IC3 or IC2 relief device returned to service shall pass both the visual inspection and set pressure test (as given in <u>Part 9: Section 9.3 Procedures for Operational Inspection and Testing of Relief Devices</u>) in addition to any testing required by the engineering design prior to returning it to service. Results of the inspection and testing shall be documented on the inspection form (Form PS-12), filed and submitted to the Vessel Inspection Coordinator.

#### 9.3 Procedures for Operational Inspection and Testing of Relief Devices

#### 9.3.1 General

Inspections and tests shall be performed by qualified in-service inspectors. In all cases, the inspector shall complete a Relief Device Operational Inspection & Test Data Sheet (Form PS-12) for each device inspected and tested.

There are two basic types of inspections and tests.

*On-stream inspections and tests*: These inspections and tests occur while the valve is installed. A test may be as simple as lifting the actuator of a valve or involve closing block valves and checking the opening pressure. This type of test should only be

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performed on systems known to be free of corrosion, scale, buildup, or other substances that would impede the valve operation.

*Shop inspections and tests*: These inspections and tests occur in a shop environment with the relief device removed from service. This allows inspection of internal components of the device not accessible when it is installed.

#### 9.3.2 Procedures

Prior to testing and inspection of pressure relief devices, basic precautions shall be observed and P&IDs shall be made available to the inspector. Personnel performing the tests and inspections (in-service inspectors) shall be familiar with the system on which the relief devices are installed. The System Owner shall brief the in-service inspector and a procedure for safely inspecting and or testing the relief device(s) shall be agreed upon. Approved procedures (accessed through the Pressure Systems webpage in the "In-service Inspection" tab) or their equivalent shall be used. If the valve opening pressure is to be tested (either on-stream or in a shop), then, if possible, the system shall be deenergized prior to any work. On energized systems, blocking valves shall be closed and locked using proper lock, tag, and try procedures. A procedure (OSP/TOSP if appropriate) shall be developed and shall include the procedural information from the Pressure Systems webpage or Document Control or the equivalent.

In all cases <u>Form PS-12</u> must be completed and filed with the system documentation; for IC4, 3 and 2 devices, a copy shall be forwarded to the Vessel Inpection Coordinator.

Any relief device failing one or more steps of a test or inspection shall be considered defective. All defective devices shall be clearly labeled as such and either sent for repair to an ASME valve shop in possession of a valid VR stamp or disposed of. At no point are Jefferson Lab personnel to attempt a repair of a safety relief device. Any device retained by Jefferson Lab for instructional purposes shall have installed a fixture (welded nut and bolt or removed/galled pipe threads etc.) that prevents the relief device from installation.

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### Part 10: Mandatory Forms

These forms are standardized forms that shall be used when applicable for pressure system documentation. These forms are available on the Pressure Systems webpage.

#### **Pressure Systems Forms:**

• Form PS-1 Pressure System Project Cover Sheet (Applicable for each pressure system.)

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- Form PS-2 Overpressure by System Design Approval (Applicable if pressure relief devices are not in the design, see <u>Part 4: Section 4.8 Overpressure Protection by System Design</u> for exclusions.)
   pdf | docx
- Form PS-3 Technical/Peer Review Record (Applicable for each pressure system. For pressure systems built on-site by subcontractors, the DA/SOTR may use an alternate.)
   pdf | docx
- Form PS-4 Pressure Vessel Registration (Applicable for each ASME Boiler, ASME Pressure Vessel or Excluded Vessel.)
   <u>pdf</u> | docx
- Form PS-5 Pressure Relief Device Data Sheet (Applicable for each relief device protecting an ASME Boiler, ASME Pressure Vessel, Excluded Vessel, Category M pressure system or piping larger than NPS 6.)
   <u>pdf</u> <u>docx</u>
- Form PS-6 Final Mechanical Examination (Applicable for each pressure system. For pressure systems built on-site by subcontractors, the DA/SOTR may use an alternate.)
   <u>pdf</u> | docx
- Form PS-7 Pressure/Leak Test Record (Applicable for each pressure system unless additional NDE is performed in lieu of a leak/pressure test. For pressure systems built onsite by subcontractors, the DA/SOTR may use an alternate.)

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- Form PS-8 Final System Walkthrough and Documentation Review (Applicable for each pressure system.)
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- Form PS-9 Pressure System Turnover (Applicable for each pressure system.) <u>pdf</u>|<u>docx</u>
- Form PS-10 Pressure System Equipment In-Service Inspection Data Sheet (Applicable for IC3 Category M Pressure Systems and IC1 pressure equipment.) <u>pdf | docx</u>
- Form PS-11 Vessel In-Service Inspection (controlled by Ron Bartek) (Applicable for each IC4 and IC3 ASME Boiler or ASME Pressure Vessel and their relief devices.)
- Form PS-12 Pressure Relief Device Testing and Inspection Data Sheet (Applicable for IC2 relief devices protecting Excluded Vessels and piping larger than NPS 6; and IC3 relief devices on Cat M systems.)

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PRESSURE SYSTEM PROJECT COVER SH			EET		FORM PS-	-1		
GENERAI								
Pressure S	Pressure System Number:							
Pressure S	Pressure System Name:							
P&ID Nun	P&ID Number:							
Overall Ins	stallation/As	sembly Drav	wing Numbe	er:				
Design Au	thority:							
System Ov	vner:							
APPLICA	BLE CODES	S (Add Code	e Edition to a	all that apply	/)			
ASME BPVC VIII Div1	ASME BPVC VIII Div2	ASME B31.1	ASME B31.3	ASME B31.5	ASME B31.9	ASME B31.12	Other (Specify)	
Are there p YES	oressure com NC	ponents wit	h no directly	applicable	Codes?			
(If YES the	en these com	ponents req	uire a Peer F	Review)				
Briefly des	cribe and lis	t ASME Co	de and Editi	on most app	licable:			
SYSTEM	PARAMETI	ERS						
Fluid:		Fluid Serv	ice:	Design Ter	mperature:	Design Pre	ssure:	
Desaganes	Vagal Nu	mahang (A	SME and					
Excluded):	Bldg#-PS#-	-Seq#	SIVIE alla	a   Stored Energy:				
Brief Desc	Brief Description of System and Fabrication Pl			 Plan (attach more sheets as needed):				
	-							

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OVERPRESSURE BY SYSTEM DESIGN APPROVAL	FORM PS-2				
GENERAL					
Pressure System Number:					
Pressure System Name:					
Design Authority:					
OVERPRESSURE BY SYSTEM DESIGN REPORT CONTAINS: (	check if complete)				
Reason for using overprotection by design					
Detailed failure analysis by multidisciplinary team					
Detailed analysis to determine maximum credible pressure					
Requirements for periodic inspections and testing of controls, procedures and instrumentation					
APPROVAL:					
Comments:					
Pressure Systems Committee Chair signature:	Date:				
(Not required for ASME B31.3 Category D Service Piping, ASME B31.5 Piping, ASME B31.9 Piping)					
Design Authority signature:	Date:				

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TECHNICAL/PEER RE	EVIEW	RECORD	FORM P	S-3					
Pressure System Numbe	er								
Component(s) (if applic	able)								
Design Authority (DA)									
DA Group/Division									
Note: Excluded Elements require a Peer Review. Peer Review must be completed by one or more DAs not associated with the project. Technical Review is applicable to code compliant components and can be performed by any DA.									
Type of Review (check)	) _	Technical Review	Peer I	Review					
Description:									
Scope of Review:									
Applicable Code(s):									
The undersigned have r	eviewed	I the calculations and/or design	gn specificati	ons listed above and					
verify accuracy and c	ompliar	ce with JLAB requirement	s, national	consensus codes, or					
Reviewer Name	Signat	Ire D	)ate	Group/Division					
	Signat								
Comments:									

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PRESSURE VESSEL REGISTRATION				FORM PS-4	
Pressure System Number:			Date:		
Pressure System Name:					
Pressure Vessel Number:			P&ID Num	ber:	
Pressure Vessel Description:					
MAWP/Design Pressure:		Desig	n Temperatu	re:	
Operating Pressure:		Opera	ting Tempera	ature:	
Code:		Code	Year:		
System Fluid:		Fluid	Category:		
Fluid State:					
VESSEL DATA					
ASME Stamp Type U StampUM Stamp Other (specify)	ASME Stamp TypeVessel Type:U StampUM StampOther (specify)Air TankWater TankNon-Flam Gas TankFlam Gas TankOther (specify)				
Vessel Manufacturer					
National Board Number					
Serial Number					
Year Built:					
Inspection Interval:					
In Service Date	Ez	xpiratic	on Date:		
VESSEL LOCATION:					
Building Number	R	oom Ni	umber:		
Specific Location in Bldg:					
APPROVAL (name and signature)				-	
Design Authority:				Date:	
Store completed form in Pressure System with a copy of the associated P&ID	File and ser	nd copy	to Vessel In	spection Coordinator along	

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PRESSURE RELIEF DEVICE DATA SHEET			FORM PS-5		
Pressure System Number:		Date:			
Pressure System Name:					
Pressure Vessel Number (if Applicable):					
Device installed directly on vessel?:YesNo		Code:			
System Fluid:		Code Year:			
Fluid State:		Fluid Categ	ory:		
RELIEF DEVICE DATA					
Device Type Safety Relief Valve Rupture Disk Other (specify)	C.	ertification T ASME Other (spec	ype: CE/PED bify)		
Manufacturer	Ra	Rated Flow Capacity:			
Part Number	С	onverted Flow	w Capacity:		
Serial Number					
Set Pressure					
Inspection/Test Interval:					
In Service Date E	xpiratio	on Date:			
INITIAL TEST/INSPECTION DATA					
General condition of device acceptable:		_	YES NO	1	
Helium (vacuum) leak test required:			YES NO	Į.	
Leak test passed:		_	YES NO	i .	
Pop test (valve only) pressure: Test pressure withi rated pressure	n 5% o	r 3psi of _	YES NO		
APPROVAL (name and signature)					
Installer:			Date:		
Design Authority:			Date:		
Store completed form in Pressure System File and se	end copy	y to Vessel In	spection Coordinator		

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ME	CHANICAL EXAMINATION	FORM PS-6							
Pres	Pressure System Number:								
Pres	Pressure System Name:								
Des	Design Authority:								
CH	ECK IF COMPLETE, N/A IF NOT APPLICABLE:								
	Materials, components and products meet specifications and the requirements of engineering design								
	Applicable procedures for assembly, glue bonding, etc.								
	Assembly of threaded, bolted and other joints conforms to Code and engineering design								
	Alignment, supports and/or cold spring meet engineering design								
	Dimensional checks of components and materials meet Code and	engineering design							
Cor	nments:								
Exa	xaminer name and signature: Date:								
Exa	Examiner name and signature: Date:								

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PRESSURE/LEAK TEST RECORD					FOI	FORM PS-7				
TEST DESCRIPTION AND REQUIREMENTS										
Pressure System Number Drawing Number				mber(s)				PAGE 1	OF	
Proje	ct Name:									
Syste	m or component des	scription	(attach des	scrip	tion if neede	d):				
Test ł	ooundaries (attach sl	ketch if	needed):							
Desig	n temperature:				Design pres	ssui	re (MAWP):			
Test r	nethod:Hydrost	atic	Pneumat	ic	Relief Valv	e S	etting:			
Test f	luid:				Applicable	coc	le:			
Requi	ired test pressure:				Test temper	ratu	ire:			
Test p	pressure as % of MA	WP:			Ambient ter	mp	erature:			
Eleva	tion difference betw	veen hig	hest point a	ind g	gauge:					
Requi	ired gauge pressure:									
Test o	late:		Start time:		Actual gauge pressure:					
Requi	ired Duration:		Finish time	e:						
SAFE	ETY									
Test v	volume:				Stored energy of test:					
SOP/	OSP/TOSP Number	(if requ	ired):							
TEST	EQUIPMENT									
Type/	'Number: H	Range:		Cal	date:	Са	I due date:			
T - 1	Detection M (1 1	17:	.1 TT 1	a - 1	test D	.1.1 1	a 4as4 T	T. 1 1	- 4	\
Leak	ner (attach procedure	visua e)	u <u>H</u> e l	еак	iest <u>Bu</u>	וטטו	ie test	ie leal	k test (re	verse)
Detec	tor Calibration (if a	pplicabl	e):							
TEST	ACCEPTANCE (n	ame and	d signature)	)						
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Pressure test result:PassFail	
Test Engineer:	Date :
Technician:	Date :
Witness:	Date :

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FIN	AL SYSTEM WAL	KTHROUGH AND	DOCUMENTA	TION REVIE	W ]	FORM PS	5-8				
Pres	sure System Numbe	r:									
Pres	sure System Name:										
Desi	gn Authority:										
CHE	ECK IF COMPLETE	E, N/A IF NOT APP	LICABLE:								
	Form PS-1 Pressure	e System Project Co	ver Sheet is com	plete and filed.							
	Form PS-2 complet	e and filed if applica	able.								
	Review of construc	tion documentation	including:								
	<ul> <li>Review of pressure/leak test documentation, completed and filed (Form PS-7)</li> </ul>										
	<ul><li>Tech</li><li>Ensu</li></ul>	nnical and Peer Revi are that welding an	ews have been pe d brazing inspec	erformed and factors have be	filed ( en pe	Form PS- rformed a	3). and				
	filed o Ensu (For	re that mechanical	examinations 1	have been per	forme	ed and fi	led				
	o Ensu	re that applicable fa	brication docum	ents have been	ı filed	•					
	Review of P&ID critical elements (i.e. relief devices, vessels, relief paths, etc.).										
	Conspicuous and duboilers	urable Jefferson Lab	o specific tags are	e installed on p	pressu	re vessels	s and				
	Forms PS-4 and PS	-5 are filed for vess	els and their relie	ef valves							
	General physical sy	stem condition and	readiness.								
	Checks on all relief	devices providing of	overpressure prot	ection.							
	Through direct visu protection) are insta test plugs removed	al examination, reli- alled and that the rel	ef devices (provid ief paths are free f discharge is saf	ding overpress e (e.g. stop valv	ure ves are	e locked o	open,				
Com	iments:	etc.) and direction of	i discharge is sai								
Owr	er's Inspector name	and signature:			]	Date:					
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PRESSURE SY	YSTEM TU	RNOVER			FORM PS
Pressure System	n Number:				
Pressure System	n Name:				
<b>OPERATING</b>	REQUIREN	MENTS:			
MAINTENIAN		DEMENITS			
MAINIENAN	CE KEQUI	KENIEN IS.			
IN-SERVICE I	NSPECTIO	N REOUIR	<b>FMFNTS</b>		
				Component	Component
	Piping	Vessels	Relief Valves	1	1
ISI Category					
UT, RT, etc)					
ISI Frequency					
Special ISI Rec	uirements:				
System Owner	name and s	ignature:			Date:
Design Author	ity name an	d signature			Date
÷	-	č			

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PRESSURE EQUIPMENT IN-SERVICE INSPECTION DA	ATA SHEET		FORM PS-10
Pressure System Number:	Date:		
Pressure System Name:	1		
Building Number:			
Specific Location:	Code:		
System Fluid:	Code Year:		
Fluid State:	Fluid Categor	ry:	
PRESSURE EQUIPMENT INSPECTION DATA			
Condition of exterior is free of corrosion, cracks, dents, bulges. If insulation is present, condition of insulation is inta	gouges,	_YES	NO
No evidence of leakage:	YES	NO	
Structural attachments and supports are free of cracks and dis	YES	NO	
Connections (nozzles, bolts, nuts., accessible flange faces) from corrosion, cracks, distortion or defects:	are free	YES	NO
Weld joints and adjacent heat affected zones are free from other defects:	cracks or	_YES	NO
Operation of control devices (temperature sensors, pressuretc.) is demonstrated through proper operation of system, control others on system or through calibration:	re gages, mparison	_YES	NO
Findings and general condition:			
APPROVAL (name and signature)			
Pressure Equipment Acceptable for continued use:		YES	S NO
Inspector:		Date:	
System Owner:		Date:	

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#### **Part 10: Mandatory Forms**

Form PS-11 Vessel In-Service Inspection - Maintained by Vessel Inspection Coordinator

NSPECT.		DATE OF BUILD				OUE		T	CE CATEGORY			JAA ACS	PONSIBLE DESIGN				
UMBER		DATE OF INSP	CIUM			DATE			CF CATEGORT.				UTHOR/TY:				
							SECTIO	NA-/	SME PRESSU	RE VESSEL							
TATUS: OUT OF SE	RVICE				PASSED				FA	ALED			COND	IMNED			SIT SECTOR
RM DOING INSPECTION:										FIRM ADDRES	s.						
SPECTOR'S NAME:																	
ESSEL MANUFACTURER:		CERTIFIED IN C	MUNE CO	389.						VESSELSERIAL	NUMBE	8				YEAR BUILT:	
SHE STAMP TYPE:			U		UM		THER			NATIONAL BOA	NUN GRU	ANCR:					
esser type:		AIR TANK				WATER TA	NK			NON-FLAM. GA	IS TANK		FLAM. GAS TANK			OTHER	
ESSEL LIST:		STORAGE				PROCESS				HEAT EXCHANG	SER		OTHER				
ULDING NUMBER:				ROOM/R	t			sei	CIRCLOCATION	IN BLDG.:							
SUPMENT VESSEL IS PART O	F (IF APPLICA	aur):			_	· · · ·					_	· · ·					
RVICE DESCRIPTION FOR VE	35R:																
SPECTION TYPE REQUIRED:		INT	TRNAL			000	RNAL			PE	essure	GAGE		OTHER			
	DATES	2 195		S YRS		2 YRS		ач	8	2 YRS		S YRS		2 YRS		SYRS	
REQUERCY REQUIRED.	CHAT	30 YRS		OTHER		10 YRS		от	er.	30 YRS		OTHER		10 YRS		OTHER	
DOITIONAL INSPECTION REQ	URDMENT:	NONE															
essel maximum allowab Korking pressure:	u			MACRIMU TEMPER/	MALLON ITURE:	WABLE WO	BONG			VESSELACTL PS	ial max Ressure	WORKING		VESSEL / TEMPER	ACTUAL MTURE	WORKING	
NOTION OF VESSEL:		CHECK FOR SI	GNS OF C	CORROSE	ON, ERO	SION, BULG	ING, WAR	PING, C	VACIONS, OR SI	VILAR CONDITIONS					_		
		IS CONDITION CERTIFICATE O	OF THE	VESSEL S E ISSUED	UCH THE	AT EITHER A	VIRGINIA	CERTIFI	CATE AND A NA	TIONAL BOARD		YES		NO		IF NO, EXPLA COMMENTS	IN WHY IN
EGALSE OF OPERATING PRES EQUIRED TO PROTECT VESSI	ISURISISA 9 17	AFETY RELIEF C	NINGE		۲	ES		IF 1	ES, OUTUNE TH	PE & DETAILS BELO	w		NO			IF NO, EXPLA COMMENTS	IN WHY IN
THE SAFETY RELIEF DEVICE	CONNECTED	DIRECTLY ON T	NE VESS	817	۲	ES							NO		]	IF NO, EXPLA	IN WHY IN
MMENTS:						_	_	_									
SALENTI REVEWED AND APPR	NE REAL	AR PRESSURE ST	ITEM DES	ISNAUTHO	NO ICE I	YES		286	DESIGN AUTHORS	TY APPROVING						DATE	
VEETY RELIEF DEVICE		RELIEF VALVE		10		R	UPTURE D	68			Τ		OTHER				
	ASME		α/	PED		ASME			CE/RED		+	DETAILS O	N "OTHER"		-		
IRTINICATION TYPE: 01	HER					OTHER:					+						
ANUFACTURER:			MODEL NUMBE	R:					QUANTITY:			928		MISC.	INFO.		
COIGN PRESSURE SET			ACTUAL	SET PRES	SURE:			06	SIGN CARAGITY:					ACTUAL	n:		
ONDITION OF SAFETY RELIEF	DEVICE:	CHECK FOR SI	SNS OF C	CORROS	ON MIS	ING LD. TA	e, wrein	LE TAG.	SAFETY SEAL M	ISSING, IMPAIRED	OPERAD	ON					
		PER VISUAL IN CERTIFICATE (	PSECTO	N IS CON	DITION	OF THE REU	EF DEVICE	SUCHT	THAT EITHER A V	RGINIA CERTIRICA	TE AND	ANATIONAL	GRAD	YES		N	
ABOVE CONDITION ANSWE	R IS NO, NOT	CERTIFICATE O	INT:	EISSUED													
								10000	N.C. COMMON								
FOLIREMENTS TO BRING VE	SSEL/RELIEF C	SEVICE UP TO I	ASSED (	CONDITIO	N:		1	SECTIO	NC-COMME	NTS							

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### Part 10: Mandatory Forms

		PAGE 2 0
EFFERSON LAB ASME PRESSURE VESSEL REPORT OF INSPECTION FORM (NOTE: Shaded/Italicized areas to be filled in Authority: Unshaded/non-Italicized areas to be filled in by Inspector)	by JLAB Design Authority OR 2nd	JLAB Design
SECTION D - VESSEL DETAILS		
ISSE DITAUS		
SECTION E - PROCESS INFORMATION		
SYSTEM FLOW DIAGRAM		
ME OF AAB PERSON TO WHOM REPORT WAS DIPLAINED:		
LE OF JUD PERSON TO WHOM REPORT WAS DEPLATED:		
CEPTED YES NO FIND, DEPLAIN WHY:		
EREBY CERTIFY THIS IS A TRUE REPORT OF MY INSPECTION: [FIRST NAME]	DATE:	
SCANTURE:	CERTIFICATION #	

Normal The Solid And Processives Input Income Theor Real Land Normal Television, 201 Normal Television, 201

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RELIEF DEVICE OPERATIONAL INSPECTION	& TEST	Г DATA S	HEET	FOR Page	M PS-12 1 of 2	
Pressure System Number:		Date:				
Pressure System Name:						
Vessel Number (if Applicable):						
Device installed directly on vessel?:YesNo		Code:				
System Fluid:		Code Ye	ar:			
Fluid State:		Fluid Ca	tegory:			
RELIEF DEVICE DATA						
Device Type Safety Relief Valve Rupture Disk Other (specify)	C 	ertification ASME Other (s ated Flow	n Type: CE/PED pecify) Capacity:	)		
Part Number	onverted I	Flow Capacity:				
Serial Number	et Pressure	2: 1 J				
Inspection/Test Interval:						
In Service Date I	Expiratio	on Date:				
INSPECTION RESULTS						
Correct device is installed and manufacturer's mark	ings are	legible:	yes	no	na	
Field conditions reflect P&ID:			yes	no	na	
Tamper resistant devices are intact:			yes	no	<u> </u>	
No flow restrictions are present (gags, blinds, clopping or other obstruction):	osed val	ves, bent	yes	no	na	
No unacceptable leaks including those to relief path			yes	no	<u> </u>	
Discharge and relief piping directed to a safe location	on:		yes	no	na	
If equipped with upstream and downstream block handles are secured in open position:	x valves	, locking	yes	no	na	
Piping is properly supported and in good condition ( forces of discharge, look for sign of fatigue, cracks,	Consider etc.):	r reaction	yes	no	na	
Valve body drains are open:			yes	no	na	

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Lift lever (if equipped) is positioned and functioning properly:	yes	na na			
A functioning gage is installed between relief valve and rupture disk combinations:	no na na				
Non-reclosing relief is properly oriented (Check flow on rupture disks):	no na				
RELIEF DEVICE OPERATIONAL INSPECTION & TEST DATA SHEET					
TEST DATA		·			
On-stream Test required:	yes	no			
Lift Lever Test allowable: Operating Pressure Operating Temperature	yes	no			
Lift Lever Test acceptable:	yes	no			
On-stream Pressure Test required: Detailed Instructions onlySOP/TOSP (#)	yes	no			
On-stream Test passed: (Within 5% or 3psi of rated pressure)	yes	no			
Valves are remarked with new test date:	yes	no			
Shop Test required:        Detailed Instructions only      SOP/TOSP (#)	yes	no			
Test 1: opening pressureclosing pressureTest 2: opening pressureclosing pressureTest 3: opening pressureclosing pressure					
Shop Test passed: (Within 5% or 3psi of rated pressure)	yes	no			
Valves are remarked with new test date:	no				
COMMENTS:		I			
Findings and general condition:					
APPROVAL (name and signature)					
Relief Device Acceptable for continued use:	<u> </u>	no			
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Inspector:	Date:
System Owner:	Date:

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