Fermilab

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Memorandum

June 5, 2009

To: Bruce Chrisman

From: Nancy Grossman NG

Subject: Revised FESHM Chapter 5031 – Pressure Vessels

FESHM Chapter 5031, Pressure Vessels, was revised to allow vessels with the European Commission Pressure Equipment Directive (PED) CE-mark to be used at Fermilab. The Mechanical Safety Subcommittee re-organized the sections of the Chapter to match other 5030 ES&H Chapters. This chapter was out for labwide review and comments were addressed.

After final approval, please return this approval page to Elizabeth Bancroft at MS119 for posting on the web.

Encl.

Recommended for Approval:

Bruce Chrisman _____ 6/9/09 Date

Approved:

Piermaria Oddone _____ 6/15/09 Date

PRESSURE VESSELS

INTRODUCTION

Pressure vessels, such as cryogenic and gas storage tanks containing substances under pressure, pose a potential hazard to equipment and personnel from rupture or explosion/implosion. This chapter specifies the procedure to be followed in designing, fabricating, testing, and operating pressurized vessels in order to reduce hazards.

SCOPE

This chapter applies to any vessel used at Fermilab that falls within the scope of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section VIII, excluding those vessels falling within the scope of the following FESHM chapters:

1) FESHM 5032.2 Guidelines for the Design, Review, and Approval of Liquid Cryogenic Targets
2) FESHM 5032.3 SRF Cavities Pressure Safety
3) FESHM 5035 Mechanical Refrigeration Systems.

Scope determinations shall include consideration of all system installation details and sources of pressure.

DEFINITIONS

The Code - ASME BPVC, Section VIII, Divisions 1 and 2. The latest revision of the ASME BPVC shall be applied to a given vessel at the initiation of the vessel's design.

Pressure Vessel - Any vessel falling within the scope of the ASME BPVC. The term Pressure Vessel will be shortened to "vessel," hereafter.

Engineering Note - A written analysis demonstrating that a given vessel satisfies the requirements of this chapter.

Exceptional Vessel - A vessel without a stamp or mark certifying compliance to one of the codes allowed by this chapter and does not meet the requirements described for Experiment Vessels.

Existing Vessel - A vessel in use or previously used on the Fermilab site.

Experiment Vessel - A vessel within the scope of the code that cannot fully comply with code rules because of vessel geometry, use of special materials, or code conflict with scientific goals, but provides a level of safety equivalent or greater to that provided by

the ASME BPVC.

MAWP - Pressure vessel's Maximum Allowable Working Pressure as defined in ASME BPVC.

Qualified Person - A person who, by possession of a recognized degree or certificate of professional standing, or who, by extensive knowledge, training and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

SPECIAL RESPONSIBILITIES

The division/section head that controls the area of operation of the vessel is responsible for carrying out the requirements of this chapter. The division/section head or his/her designee shall:

1. Arrange for the review of the Engineering Note by a qualified person or committee.
2. Certify vessel compliance with this chapter by signing the Engineering Note.
3. File the original Engineering Note with the ES&H section.
4. Maintain an open, current file on all pressure vessels located in his/her areas of responsibility.

The ES&H Section shall:

1. Assign pressure vessel numbers.
2. Maintain a master file of pressure vessel Engineering Notes.
3. Audit the divisions and sections on their compliance with this chapter.

The Mechanical Safety Subcommittee (MSS) and/or Cryogenic Safety Subcommittee (CSS) shall serve the division/section heads and ES&H Section in a consulting capacity on all pressure vessel matters. This includes providing recommendations regarding the applicability of a standard, other than the Code, to a given vessel.

PROCEDURE

1. *Preparation of Engineering Note:* An Engineering Note shall be prepared by a qualified person for all pressure vessels at Fermilab within the scope of this chapter. The format of the Engineering Note is shown in TA5031 Pressure Vessel Engineering Note Form. Its purpose is to allow a reviewer to check the design, fabrication, and installation of the vessel and to inform a future user of the vessel parameters. The Engineering Note shall include design calculations for Experiment Vessels and Exceptional Vessels, a copy or photo of the U-stamp or CE-mark or the manufacturer's data reports for ASME BPVC or CE stamped

vessels. The Note shall also include precautions and operating procedures necessary for the safe use of the vessel. For vendor owned and maintained vessels which are used on the Fermilab site, no Engineering Note is required but the vessel must meet all other sections of this standard.

2. *Review of Engineering Note:* All Pressure Vessel Engineering Notes shall be reviewed by an independent, qualified person for concurrence to this chapter. The reviewer shall be from a group not reporting to the preparer of the Engineering Note or his supervisor.
3. *Amendment of Engineering Note:* Any subsequent change in usage, operating temperature, valving, etc., which could affect the safety of the vessel requires an amendment to the original Engineering Note. This amendment shall be reviewed in the same manner as the original Note.
4. *Exceptional Vessels / Director's Exception:* Exceptional vessels require the approval of the Laboratory Director or his/her designee. The need for such exceptions is to be minimized by adherence to the provisions of this chapter. Exceptions are to be identified and submitted to the Director for review as early in the design process as possible. These exceptions shall only be allowed after the Director has assured himself that sound engineering practice will be followed during design, fabrication and test of the vessel. The ES&H Section shall maintain copies of exceptions for the Director. The Director's approval is documented by his/her signature in the Engineering Note.
5. *Vessel Marking:* After signed approval of the Engineering Note, the Fermilab engineering standard conformance label shall be attached to the vessel. Each vessel shall be marked with its unique pressure vessel number.
6. *Records:* Approved engineering notes shall be filed with the ES&H office.

REQUIREMENTS FOR DESIGN, FABRICATION, INSPECTION AND TEST

Vessels within the scope of this chapter shall satisfy one of the following:

1. Include an ASME BPVC U-stamp.
2. Include a European Commission Pressure Equipment Directive (PED) CE-mark and be built per either standard EN-13445 or AD 2000.
3. Conform to another more applicable code in its entirety. Before fabrication, allowance for use of another code shall be approved and documented in a signed memo by the Division/Section Head or designee in consultation with the MSS and CSS.
4. Vessels which do not include a code stamp or mark from one of the codes allowed above shall provide a level of safety and quality greater than or equivalent to that afforded by the ASME BPVC. At a minimum, these vessels shall satisfy the "Experiment Vessel Requirements" section of this standard.

5. All other vessels shall be considered "Exceptional". They shall be approved only after the designer, reviewer, and Director (or Director's designee) are satisfied that provisions have been made providing a level of safety and quality greater than or equivalent to that afforded by the ASME BPVC.

Experiment Vessel Requirements

1. Design: Design in accordance with the ASME BPVC, but with ASME BPVC values of maximum allowable stress values reduced by a multiplicative factor of 0.8. For those materials that the Code exempts from Charpy impact tests for a design temperature of -425 degrees F, no Charpy impact tests need be done for lower design temperatures provided the maximum allowable stresses have been reduced by the multiplicative factor of 0.8.
2. Vessel Built With Non-Code Materials: When a vessel or part of a vessel uses materials not referenced in the Code (mylar, beryllium, niobium, glass, etc.) the Engineering Note must establish allowable stresses by Code rules and by supplying test data of the material or by documenting prior experiences with the material for the allowable operating temperature range of the vessel. The 0.8 multiplicative factor shall be applied to allowable stresses determined in this manner.
3. Vessels Subjected to External Pressure: Pressure vessels operating under external pressures greater than atmospheric pressure shall conform to the requirements of this chapter. Pressure vessels which are periodically subjected to internal vacuum (in operations such as pumping and backfilling) shall be designed to withstand evacuation to full vacuum and the engineering analysis for this condition shall be included in the Engineering Note.
4. Welding/Brazing:
    a. Welding and brazing shall be done using qualified weld/braze procedures and welders/brazers under the rules of the ASME BPVC, Section IX. The Weld/Braze Procedure Specification (WPS/BPS), Procedure Qualification Record (PQR), and Welder/Brazers Performance Qualification (WPQ/BPQ) shall be attached to the Engineering Note.
    b. Joint designs not explicitly forbidden by the ASME BPVC are acceptable if qualified by analysis and/or test. Joint designs and qualifications shall be presented in the Engineering Note.
5. Inspection/examination: The Engineering Note for an Experiment Vessel, shall set forth the inspection/examination requirements for that vessel, showing that the level of safety achieved is commensurate with the requirements of the ASME BPVC rules. Satisfaction of those requirements shall be documented in the Engineering Note. Inspection/examination requirements may include (but are not limited to) the following:

a. Examination of the pressure retaining parts to make certain they are free from defects and conform to the prescribed shape and thickness requirements

b. Examination of welded/brazed joints (in-process and post-process)

c. Documentation of material certification, procedures, and inspection / examination results.

6. Test: Experiment Vessels shall be pressure tested per the ASME BPVC and FESHM Chapter 5034. A vessel to be pneumatically tested shall have its Engineering Note reviewed before test by an independent, qualified person. This reviewer does not have to be the person assigned to review the engineering note. The test shall be documented in the Engineering Note before final sign off of the reviewer.

Existing Vessels

All such vessels shall comply with the requirements of this chapter and require an Engineering Note. Questionable vessels or those with incomplete histories or fabrication documents are considered Exceptional and shall have their previous service taken into account during the review process. Existing Vessels shall comply with the following requirements:

1. The Engineering Note for an existing ASME BPVC Stamped vessel need only include a completed TA5031 Form (See Technical Appendix).
2. The Engineering Note for an existing vessel built to and appropriately marked in accordance with a Standard other than the ASME BPVC, Section VIII shall include a properly completed engineering note and the determination that the Code other than ASME BPVC, Section VIII is more applicable. Fabrication and pressure test result documents shall be appended to the Engineering Note (weld procedures, inspection results, material certification) that demonstrate a level of safety equivalent to or greater than that afforded by ASME BPVC.
3. The Engineering Note for an existing vessel which is not ASME BPVC stamped nor meets standards other than ASME BPVC shall meet the requirements for Experiment Vessels of this Chapter (including fabrication, inspection, and testing requirements). Fabrication and pressure test result documents shall be appended to the Engineering Note (weld procedures, inspection results, material certification) that demonstrate a level of safety equivalent to or greater than that afforded by ASME BPVC.
4. In the event that the Engineering Note cannot be approved, operation shall be discontinued until appropriate modifications or administrative safeguards are instituted which result in the Engineering Note being approved and a Director's Exception granted if necessary.

Exceptional Vessels

The reasons for the Exception(s) shall be clearly stated and additional safety measures, test protocols, installation details, etc. implemented to address the exception(s) shall be documented in the extended Engineering Note.

Unmanned Area Vessels

If a pressure vessel cannot be made in accordance with the Experiment Vessel requirements, it may be installed in a non-manned area with suitable administrative and physical controls to restrict access when operating the vessel and restraints to minimize human risk and property damage in case of failure. A vessel of this type shall be considered an Exceptional Vessel. The vessel must be clearly and indelibly identified for use in non-manned areas only and be sufficiently secured to prevent its removal from the non-manned area. The extended Engineering Note for Exceptional Vessels shall include descriptions of the administrative controls implemented to providing a level of safety greater than or equivalent to that afforded by the ASME BPVC.

Overpressure Relief

1. All vessels shall be protected from overpressure by the rules described in the ASME BPVC except as described in the next item below.
2. Some vessels with internal MAWP's below 15 PSI fall within the scope of the ASME BPVC while it is not possible to procure ASME BPVC stamped relief valves with relief pressures below 15 PSI. For this class of vessels, non-Code relief devices are allowed. Operability tests demonstrating function and flow capacity of the relief device must be performed and documented in the Engineering Note.

ENGINEERING NOTE

An Engineering Note (see Technical Appendix for note format) shall be prepared by a Qualified Person for all pressure vessels within the scope of this chapter. Its purpose is to allow a reviewer to check the design and installation and to inform a future user/re-tester of the appropriate vessel parameters. At a minimum, the note shall include the following:

1. Identification and Description: Obtain a vessel identification number from the ES&H section. Describe the vessel, its purpose, site location, and how the maximum allowable working pressure (MAWP) was established. Include in the note a copy of the information on the engineering standard conformance label.
2. For an Experiment Vessel, include:
    a. Design Information: Provide all design calculations and drawings deemed

pertinent to the safety review.

b. Attach required weld documentation

c. Attach inspection and examination reports.

d. Pressure Test: Provide a copy of the pressure test report.

3. For ASME BPVC stamped vessels, include a copy or photo of the U-stamp or CE-mark or a copy of the manufacturer's data report is acceptable.

4. System Venting Verification: The principal safety backup for a vessel is its pressure relief system. Provide a schematic of the vessel system's components and appropriate calculations or test results to prove that over-pressurization beyond the limits of ASME BPVC rules will not occur under any operating condition. Prove that relief valves will not be isolated from the vessel except as allowed by ASME BPVC rules. For LN_2 Dewars follow the LN_2 Installation Rules (Chapter 5032). Vessel relief valves must meet UG-129 or R-4 in Division 2. If a standard other than the Code or Compressed Gas Association (CGA) is used, the venting calculations required by that standard shall be made. Also the stamping, documentation, and maintenance requirements of that standard must be satisfied.

5. Operating Procedures: Provide any cautions and operating procedures necessary for the safe use of the vessel.

Extended Engineering Note for Exceptional Vessels

The Note shall be prepared using the same or similar format as noted on TA5031 (Pressure Vessel Engineering Note Per Chapter 5031) Form, but in addition shall include the following information:

a. *Reason for Exception:* Division/Section head or designee shall provide a statement showing the necessity for a director's exception.

b. *Analysis/Burst Test:* For exceptions based on stresses above code allowables, the system designer shall provide a stress analysis of all exceptional parts of the vessel. Include data, formula or test results which demonstrate the anticipated safety factor. Source of information shall be referenced. Alternately, provide burst test data from samples demonstrating the anticipated safety factor. In cases where a vessel is exceptional because the relief system does not conform to the ASME BPVC, provide calculations or test results as appropriate to demonstrate the venting system capacity exceeds the maximum required flow rate.

c. *Fabrication:* The system designer shall provide a fabrication procedure, a list of planned and completed inspections and any other quality control procedures taken.

d. *Hazard Analysis:* The system designer shall provide a description of

personnel hazards associated with vessel operation and the methods used for protection. The hazard analysis shall address vessel application, operating limits and controls, possible effects in the event of vessel failure and inherent safeguards provided.

e. *Pressure Test:* A pressure test shall be performed per Chapter 5034 of the Fermilab ES&H Manual.

f. The division/section head or his designee shall provide a written record of the decisions, judgment, tests, administrative controls, and hazard analyses that were necessary to approve this type of vessel.

TECHNICAL APPENDIX FORM (TA5031) FOR PRESSURE VESSELS
PRESSURE VESSEL ENGINEERING NOTE PER CHAPTER 5031

Prepared by: _____
Preparation date: _____

1. Description and Identification
Fill in the label information below:

THIS VESSEL CONFORMS TO FERMILAB ES&H MANUAL CHAPTER 5031

Vessel Title _____

Vessel Number _____ ←**Obtain from Division/Section Safety Officer**

Vessel Drawing No. _____

Maximum Allowable Working Pressure (MAWP)

Internal Pressure _____

External Pressure _____

Working Temperature Range _____ °F _____ °F

Contents _____

Designer / Manufacturer _____

Test Pressure (if tested at Fermilab) Acceptance Date _____ ← **Document per Chapter 5034 of the Fermilab ES&H Manual**

_____ PSIG, Hydraulic ____ Pneumatic ____

Accepted as conforming to standard by

_____ ←**Actual signature required**

Of Division / Section _____ Date: _____

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by: _____
(Print Name)

Signature: _____ Date: _____

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

Signature: _____ Date: _____

Amendment No.:	Reviewed by:	Date:
_____	_____	_____
_____	_____	_____

Lab Property Number(s):_____
Lab Location Code:_____ (obtain from safety officer)
Purpose of Vessel(s):_____
_____
Vessel Capacity/Size:_____ Diameter:_____ Length:_____
Normal Operating Pressure (OP)_____
MAWP-OP =_____PSI

List the numbers of all pertinent drawings and the location of the originals.

Drawing #	Location of Original
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

2. Design Verification

Is this vessel designed and built to meet the ASME BPVC or "Experiment Vessel" requirements?
Yes___ __ No_____.

If "No" state the standard that was used _____.
Demonstrate that design calculations of that standard have been made and that other requirements of that standard have been satisfied.
Skip to part 3 "system venting verification."

Does the vessel(s) have a U stamp? Yes_____ No__ ___. If "Yes", complete section 2A; if "No", complete section 2B.

A. Staple photo of U stamp plate below.
Copy "U" label details to the side

Copy data here:
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Provide ASME design calculations in an appendix. On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. (Only for non-coded vessels)

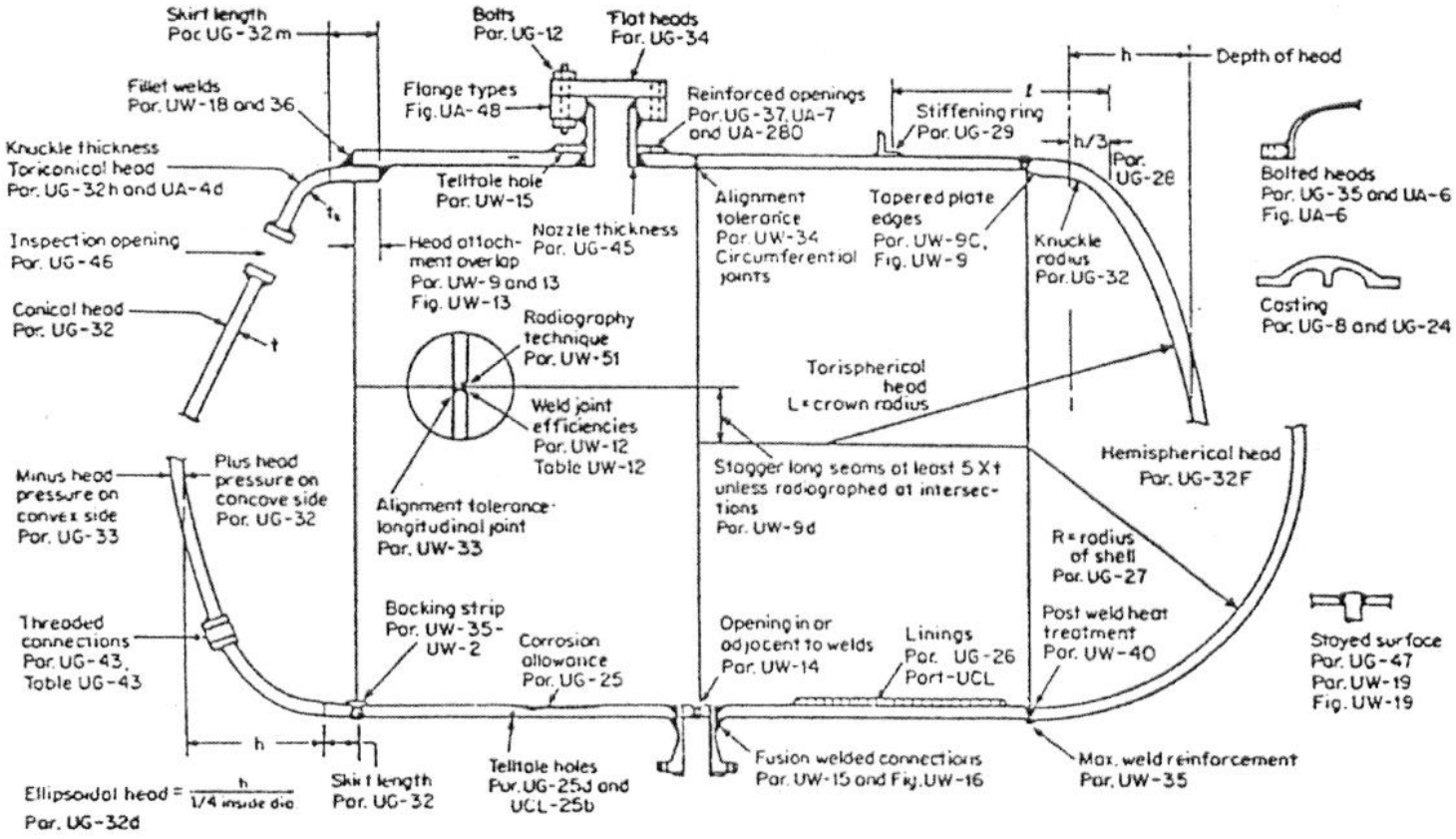

Figure 1. ASME Code: Applicable Sections

2B.

Summary of ASME Code

Item	Reference ASME Code Section	CALCULATION RESULT (Required thickness or stress level vs. actual thickness calculated stress level)
_____	_____	_____ vs _____
_____	_____	_____ vs _____
_____	_____	_____ vs _____
_____	_____	_____ vs _____
_____	_____	_____ vs _____

3. System Venting Verification Provide the vent system schematic.

Does the venting system follow the Code UG-125 through UG-137?
Yes___ No___

Does the venting system also follow the Compressed Gas Association Standards S-1.1 and S-1.3?
Yes _____ No_____

A "no" response to both of the two proceeding questions requires a justification and statement regarding what standards were applied to verify system venting is adequate.

List of reliefs and settings:

Manufacturer	Model #	Set Pressure	Flow Rate	Size

4. Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?
Yes_____ No_____ (If "Yes", it must be appended)

5. Welding Information

Has the vessel been fabricated in a non-code shop? Yes_____ No_____
If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.

6. Existing and Unmanned Area Vessels

Is this vessel or any part thereof in the above categories?
Yes_____ No_____

If "Yes", follow the requirements for an Extended Engineering Note for Existing and Unmanned Area Vessels.

7. Exceptional Vessels

Is this vessel or any part thereof in the above category?
Yes_____ No_____

If "Yes", follow the requirements for an Extended Engineering Note for Exceptional Vessels.

THIS VESSEL CONFORMS TO FERMILAB ES&H MANUAL CHAPTER 5031

Vessel Title _____

Vessel Number _____

Vessel Drawing No. _____

Maximum Allowable Working Pressure (MAWP)

Internal Pressure _____

External Pressure _____

Working Temperature Range _____ °F _____ °F

Contents _____

Designer / Manufacturer _____

Test Pressure (if tested at Fermilab) Acceptance Date _____

_____ PSIG, Hydraulic _____ Pneumatic _____

Accepted as conforming to standard by

_____

Of Division / Section _____

NOTE: Any subsequent changes in content, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review and test.

Figure 2. Sample of sticker to be completed and be placed on vessel.