

FESHM 5031.5: LOW PRESSURE VESSELS AND FLUID CONTAINMENT

Revision History

Author	Description of Change	Revision No. & Date
Michael Geynisman, Mike McGee	<ul style="list-style-type: none">• New Section 6.0 on procedure for creating an engineering note• New cover form for engineering notes• Defined appropriate governing pressure vessel code or standard• Clarified use of international standards• Inserted language allowing use of CE-marked relieving devices	April 2017
Thomas Page	Updated definitions; replaced “MAWP” with “design pressure”; editorial changes based on comments from Lab-wide review.	08-Nov-2013
Thomas Page	Added gas storage membranes to the scope. Title change. Added new FESHM template.	10-Sep-2013

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1.0 INTRODUCTION

Improper operation of closed vessels or sealed volumes pose a potential hazard to equipment and personnel from rupture or collapse. This chapter identifies common situations to be evaluated to reduce hazards.

2.0 SCOPE

This chapter applies to any closed vessel or sealed volume used at Fermilab that is not addressed in [FESHM 5031](#) or [FESHM 5033](#) and which is not covered in the exclusions listed below. The Fermilab Engineering Manual must be followed in all cases and exclusion from this chapter does not constitute exclusion from the processes defined in the Fermilab Engineering Manual.

Exclusions

This chapter does not apply to:

1. Vessels containing less than 35 cubic feet (261 gallons) of volume
2. Vessels where the product of pressure * volume is less than 515 psig-ft³
3. Open vessels
4. Industrial drums used for transport and storage of liquid products
5. Piping
6. Oil-filled electrical devices covered by NFPA or NEMA standards

3.0 DEFINITIONS

The Code – The code or standard that is accepted to govern the design and construction of the vessel. The latest revision of the code or standard shall be applied to a given vessel at the initiation of the vessel's design. While a low pressure vessel does not fall under the scopes defined by the pressure vessels codes listed in [FESHM 5031](#) due to low pressure, those codes may be used for the design, construction, inspection, testing of the low pressure vessel and its associated pressure relief system. Low pressure vessels under the scope of this chapter shall provide a level of safety and quality greater than or equivalent to that afforded by the governing Code.

Code-Referenced Standard – A standard referenced by the design code which gives additional guidance on a specific topic.

Pressure Relief – Any reclosing or non-reclosing pressure protection device designed and installed to protect low pressure vessel from overpressure.

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

Vessel – A vessel is defined as a closed vessel or sealed volume that contains a gas or fluid regardless of the material of construction.

Low Pressure Vessel - any vessel with a design pressure below the limit defined in the scope of the governing Code.

Existing Vessels - A vessel previously used on the Fermilab site. An existing vessel has an engineering note. There are no ‘grand-fathered’ vessels.

Gas Storage Membrane – A flexible, non-metallic membrane used to store or recover process gases.

Design Pressure – The most severe condition of coincident internal or external pressure and temperature (minimum or maximum) expected during service.

Accumulation - The pressure increase over the design pressure of the vessel, expressed in pressure units or as a percentage of design pressure. Maximum allowable accumulations are established by applicable codes for emergency operating and fire contingencies.

Qualified Person: A qualified person is 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.

4.0 SPECIAL RESPONSIBILITIES

The Division/Section Head

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. Maintain an open, updated file on all low pressure vessels within the scope of this chapter located in their areas of operation.
4. File the original note with the ESH&Q section.

The ESH&Q Section

The ESH&Q Section shall:

1. Assign pressure vessel numbers (no longer a requirement, as numbers are assigned through Teamcenter).
2. Maintain a master file of the engineering notes (no longer a requirement, as notes are stored in Teamcenter).
3. Issue a silver sticker to be attached to the note.
4. Audit the divisions and sections on their compliance with this chapter.

The Mechanical Safety Subcommittee

The Mechanical Safety Subcommittee shall serve the Division/Section Heads and ESH&Q Section in a consulting capacity on all low pressure vessel matters. This includes providing recommendations regarding the applicability of a standard to a given component or system. The Mechanical Safety Subcommittee may propose appropriate modifications to this chapter as necessary. Changes in policy and responsibility shall be recommended by the Laboratory FESHComm after consulting with the Division/Section Heads.

5.0 POLICY AND REQUIREMENTS

Any closed vessel or sealed volume within the scope of this chapter shall be considered a low-pressure vessel. There are no ‘grand-fathered’ low-pressure vessels. All existing and new low pressure vessels must conform to the requirements of this FESHM chapter. Gas storage membranes have special requirements which are defined in Section 7 of this chapter.

1. *Design*: The design pressure of the vessel shall be established per the governing Code.
2. *Pressurization*: If the vessel can be pressurized beyond its rating, either intentionally or inadvertently, pressure relief devices shall be included in the design. Consideration shall be given for relief of over-pressure from all possible sources, including release of gases or fluids (by design or by accidental rupture of internal components), heat, fire, connected sources (such as compressors or compressed gas cylinders through valves or regulators), etc. A relief device must remain connected to the vessel while the vessel is in service.
 - 2.1. A relief device(s) must be sized such that the vessel pressure does not exceed its design pressure and Code allowed accumulation and has a flow capacity in excess of the largest overpressure scenario. The source(s) for the allowed accumulation must be documented (reference applicable code, vendor documents or calculations).
 - 2.2. Relief devices are not required to be Code-stamped or marked on low pressure vessels with a design pressure below that defined in the scope of the governing Code.
 - 2.3. All relief devices shall be certified by the manufacturer for relieving pressure. A test report and an analysis predicting the flow shall be included in the Engineering Note.

- 2.4. Calculations of relief valve sizing shall be included in the Engineering Note.
- 2.5. A list of all potential means of pressurization shall be compiled.
- 2.6. Additional standards are often referenced by the design codes. Code-referenced standards often have more detailed and/or specialized guidance on a specific topic. Engineering judgement is required in selecting the most appropriate Code-referenced standards given the range of operating conditions and credible failure scenarios for the low pressure vessel. The following Code-referenced standards are recommended for the sizing, selection, and installation of pressure relief systems.

ASME BPVC VIII Div. 1 Appendix M and ASME BPVC VIII Div. 2 Annex 9-A.9

Standard Organization	Standard Title
American Petroleum Institute (API)	Recommended Practice 520, Sizing, Selection, and Installation of Pressure-Relieving Systems, Part I Sizing and Selection
American Petroleum Institute (API)	Recommended Practice 520, Sizing, Selection, and Installation of Pressure-Relieving Systems, Part II Installation
American Petroleum Institute (API)	Recommended Practice 521, Guide for Pressure-Relieving and Depressuring Systems
American Petroleum Institute (API)	Standard 2000, Venting Atmospheric and Low-Pressure Storage Tanks (Nonrefrigerated and Refrigerated)
Compressed Gas Association (CGA)	S-1.1, Pressure Relief Device Standards Part 1 Cylinders for Compressed Gases
Compressed Gas Association (CGA)	S-1.2, Pressure Relief Device Standards Part 2 Cargo and Portable Tanks
Compressed Gas Association (CGA)	S-1.3, Pressure Relief Device Standards Part 3 Compressed Gas Storage Containers

EN13445-1 Paragraph 1

Standard Organization	Standard Title
EN	764-7 Pressure Equipment – Part 7: Safety systems for unfired pressure equipment
EN	13648-1 Cryogenic Vessels – Part 1: Safety valves for protection against excessive pressure
EN	13648-2 Cryogenic Vessels – Part 2: Bursting disc safety devices for cryogenic service
EN	13648-3 Cryogenic Vessels – Part 3: Determination of required discharge – Capacity and Sizing
EN ISO	4126 Safety devices for protection against excessive pressure

3. *Vacuum*: If it is possible to draw a vacuum on a low pressure vessel, then the vessel shall be designed for the vacuum. A vacuum relief device shall be included in the design if it is possible to exceed the vacuum pressure rating of the vessel and consideration shall be given for relief of vacuum from all possible sources, including pump-down or draining of liquids, etc. Vacuum relief may be provided by:
 - 3.1. Vent – Provide an appropriately sized vent to cause the vessel to be open to atmosphere.
 - 3.2. Vacuum Relief Device – Provide an appropriately sized vacuum relief device. This requires that the vacuum level permissible in the vessel be determined; that the vacuum relief device shall be set so that vacuum does not exceed the permissible level; and that the relief device be sized such that the capacity of the relief device exceeds the capacity of the evacuation source. A list of all potential means of evacuation shall be compiled.
4. Relief devices used on low-pressure vessels are not required to be retested as required by FESHM 5031.4. However, the relief devices shall be visually inspected every three years and opened (if appropriate) every 5 years.
5. Prior to putting the low-pressure vessel in service, all relief devices shall be installed and the documentation requirements satisfied.
6. Vessels within the scope of this chapter shall be either pneumatically or hydrostatically pressure tested as required per the governing Code. Pressure tests performed at Fermilab shall also follow the rules of FESHM Chapter 5034. In cases where a hydrostatic test is impractical the low pressure vessel shall be pneumatically tested at least at 110% of the design pressure, with the test temperature adjusted for differences in allowable stress between the test temperature and design temperature. The test pressure shall be selected to satisfy both the governing Code and FESHM 5034 Section 6.0, Subpart 4.

6.0 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 TA5031.5 Low 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 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. If it is possible to draw a vacuum on a low pressure vessel, then the engineering note shall discuss the design for vacuum and vacuum relieving conditions (if needed) per guidelines of FESHM Chapter 5033.
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. A new TA5031.5 form with the signatures required to approve the amendment shall be created.
4. *Exceptional Vessels / Director's Exception:* Exceptional vessels require the approval of the Laboratory Director or his/her designee as well as the Chief Safety Officer 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 been assured that sound engineering practice will be followed during design, fabrication and test of the vessel. The Director's and Chief Safety Officer'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 (silver sticker) shall be attached to the vessel. Each vessel shall be marked with its unique pressure vessel number which is the Engineering Note item number assigned by Teamcenter.

When making an amendment to an existing Engineering Note, a new silver sticker shall be created and signed by the appropriate individuals if the changes to the vessel affect any of the operating parameters listed on the silver sticker: Vessel Number, MAWP, temperature range or contents. If the changes do not affect the listed parameters, then a new silver sticker is not required. In both cases, the amendment shall be reviewed as required in (3) above.

When replacing a silver sticker due to damage or other reasons (painting vessel, etc.), the new silver sticker does not require an actual signature by the Division/Section Head. Writing "Signature on file" or similar on the new silver sticker is acceptable.

6. *Records:* Approved engineering notes shall be filed in Teamcenter.
 - a. A New Item shall be created in Teamcenter with the type chosen as Engineering Note
 - i. The New Item Name shall use the Pressure Vessel prefix followed by a meaningful Name which briefly describes the contents of the note
 - ii. A full Description shall be entered for the New Item
 - b. If applicable the Division Legacy Number shall be entered
 - c. The appropriate Engineering Note category of Pressure Vessel shall be chosen
 - d. The Revision Author, Revision Comments, Lab Location Code, Exceptional Status, and Division\Section shall be entered
 - e. The Engineering Note and supporting files shall be added as Data Sets. All documentation required for independent review of the Engineering Note must be included.
 - f. Approval
 - i. The Teamcenter Workflow may be used to electronically obtain the required approvals and release the Engineering Note.

- ii. Approvals may also be obtained by physical signature, scanned, and included with the Engineering Note. A Teamcenter Workflow must still be completed so that the Engineering Note is released. This workflow need not involve the required approvers in the case of physical signature.
- g. Amendments to existing Engineering Notes shall be entered as a Revision to the original Item in Teamcenter.

7.0 GAS STORAGE MEMBRANE REQUIREMENTS

All flexible, non-metallic gas storage membrane (gas storage membrane) systems built and/or operated at Fermilab shall be in accordance with this chapter. Gas storage membrane requirements defined in this Section supersede the requirements defined in Sections 5 above unless otherwise noted.

1. *Design:* Gas storage membranes shall be designed with the following constraints:
 - a. Membranes are not to be pressurized above what is required to inflate the membrane and/or not above the manufacturer's pressure rating.
 - b. Membranes shall include a system to prevent overfilling. This could include level sensors, limit switches, lever activated valve, etc.
 - c. Fluid compatibility with the membrane materials shall be confirmed and documented in the Engineering Note.
 - d. It is recommended that membranes be sized larger than the volume of gas being collected when possible.
 - e. Mechanical protection shall be considered in the design of the system. This includes but is not limited to: placement of the membrane, enclosures, fencing, netting, etc.
2. *Fabrication:* All gas storage membrane systems shall be fabricated in accordance to all applicable FESHM Chapters, governing Codes and manufacturer's instructions.
3. *Installation:* All gas storage membrane system installations shall include all of the required features described in this Chapter and also meet the manufacturer's requirements and recommendations. Installations shall be reviewed by the assigned qualified reviewer(s) and a walk through of the final installation is required by the reviewer(s).
4. *Inspection:* The gas storage membrane initial installation shall be inspected by the designer, reviewer and a Division Safety Officer. Other subject matter experts may be included during the initial inspection process if necessary. In addition, gas storage membrane systems shall be inspected on a regular basis to ensure the gas membrane is in good working order and the level sensors and mechanical protection is still adequate. The frequency of inspections shall be monthly

at a minimum but can be more frequent if required by the system designer or manufacturer. Inspection details and frequency shall be outlined in the Operating Procedure for the gas storage membrane.

5. *Test*: The gas membrane system shall be fully tested after installation is complete and prior to operation. Testing shall include verification that all level / volume controls operate properly. The test permit in Chapter 5034 shall be used for documenting this test. Attached piping systems shall be tested independently, in accordance with the appropriate FESHM Chapter or Code, so there is no risk of over-pressurizing the membrane.
7. *Component Identification*: Active components on gas storage membrane systems shall be labeled as required by the appropriate governing code. In addition, it is recommended that components on all systems that require Engineering Notes be labeled to correspond to an up-to-date piping and instrument diagram. Labels should be permanent, securely attached and easy to read. Each component label should list a unique component number for that system. Guidance may be obtained from ANSI A13.1 "Scheme for Identification of Piping Systems".

8.0 DOCUMENTATION

Documentation shall include the items listed below.

1. Engineering Note: An Engineering Note shall be prepared by a qualified person for all items under the scope of this chapter. Its purpose is to allow a reviewer to check the design and installation and to inform a future user of the system's parameters. The Note shall include a description, design details and calculations, determination of design pressure, fluid contents, site location, precautions, diagrams, documents, installation details and operating procedures necessary for the safe use of the vessel. The Engineering Note shall also include relief valve size, capacity, manufacturer and model number, the relief device sizing calculations, and the documented list of all of the potential means of pressurization or potential means of evacuation. For gas storage membranes, the worst case failure scenario of the attached system shall be documented in the Engineering Note.
2. Component Identification: Attach the Process and Instrumentation Diagram (P&ID) and the associated component and instrumentation list.
3. What-if Analysis: A What-if Analysis shall be completed for all gas storage membrane systems. The system designer shall provide a description of personnel hazards associated with system operation and the methods used for protection. The What-if Analysis shall address application, operating limits and controls, possible effects in the event of failure and inherent safeguards provided.
4. Failure Mode Effects Analysis (FMEA): A failure mode effects analysis (FMEA) shall be completed for all gas storage membrane systems. Refer to FESHM Chapter 5032 for details of completing an FMEA.

7. Review: All required Engineering Notes and documentation shall be reviewed by an independent, qualified reviewer, other than the person who prepared it, for concurrence to this chapter. The reviewer shall be from a group not reporting to the preparer of the Engineering Note or his supervisor. For gas storage membranes, the review of the Engineering Note shall include review of the actual gas membrane installation to ensure conformance of the installation to this chapter.
8. Modifications and Amendments: 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.
9. Labeling: After the low-pressure vessel number has been assigned, the low-pressure vessel shall be labeled with this number.
10. Test: The pressure test report shall be appended to the Engineering Note.