

FESHM 5034: PRESSURE TESTING

Revision History

Author	Description of Change	Revision Date
Michael White	<ul style="list-style-type: none">Added reminder to 7.2.e about protecting internal, external, and adjacent volumes from accidental over pressurization during pressure test	28-Jan-2021
Michael White	<ul style="list-style-type: none">Inserted required safety precaution in 7.1.c based on ASME PCC-2 pneumatic stored energy and safe distance calculationsUpdated definitions and responsibilitiesAdded requirements for preliminary leak checkingModified requirements for determination of system pressure when leak detection is allowed	01-Dec-2020
Michael White	<ul style="list-style-type: none">Added ES&H training requirements for personnel participating in pressure testingCreated process by which a Division Safety Officer may designate an alternate reviewer prior to a pressure testCreated process by which a Division Safety Officer may designate an alternate observer for a pressure testAdded reference to FESHM chapter 4240 on oxygen deficiency hazards in list of safety precautions for pressure testUpdated pressure test permit form	7-Mar-2015
Thomas Page	Five-year review of chapter 5034. Release Chapter 5034 using new FESHM template.	03-Dec-2013

TABLE OF CONTENTS

1.0	INTRODUCTION	3
2.0	SCOPE	3
3.0	DEFINITIONS	3
4.0	SPECIAL RESPONSIBILITIES	4
5.0	STANDING HYDROSTATIC TEST PERMIT	5
6.0	REQUIREMENTS	5
7.0	TECHNICAL APPENDIX TO PRESSURE TESTING	7
7.1	SAFETY PRECAUTIONS FOR PRESSURE TESTING	7
7.2	EQUIPMENT AND MATERIALS	8
7.3	PRESSURE TEST INSTRUCTIONS	8
7.4	EXHIBIT A	10
7.5	EXHIBIT B	11

1.0 INTRODUCTION

Pressure vessels and piping systems to be used at Fermilab must be pressure tested to assure safe operation. When such testing is done on site, precautions shall be taken to minimize the risk of injury to persons and equipment in the test area.

2.0 SCOPE

This chapter describes requirements for conducting and documenting pressure tests when required by the following Fermilab ES&H Manual (FESHM) Chapters: 5031 Pressure Vessels, 5031.1 Piping Systems, 5031.5 Low Pressure Vessels and Fluid Containment, and 5031.6 Dressed Niobium SRF Cavity Pressure Safety.

3.0 DEFINITIONS

Engineering Note: A written analysis demonstrating that a given vessel or system satisfies the requirements of the appropriate FESHM Chapter.

Engineering Note Peer Reviewer: The qualified person reviewing the Engineering Note and Pressure Test Permit.

Lead Engineer: The qualified person with overall responsibility for preparing the Engineering Note and Pressure Test Permit.

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.

Test Coordinator: A test coordinator is a Fermilab employee who, by extensive training and experience, has successfully demonstrated the ability to conduct pressure tests. The test coordinator may be a different person than the Lead Engineer.

Test Observer: A Trained Person designated by the Division Safety officer to witness the pressure test

Test Reviewer: A qualified person designated by the Division Safety officer to review the system undergoing pressure testing and the surrounding area prior to the Pressure Test.

Trained Person: All people participating in the test must be trained persons. A trained person is up to date on all training requirements for the following Fermilab ES&H classes:

- FN000271 Pressure Safety Orientation
- FN000213 Compressed Gas Cylinder Safety

The Code: The following industry standard Codes are referenced in this chapter.

- ASME Boiler and Pressure Vessel Code (BPV)
- ASME B31 – Pressure Piping Code

4.0 SPECIAL RESPONSIBILITIES

The Division/Section Head

The Division/Section Head who controls the area of operation of the pressure containing components is responsible for carrying out the requirements of this chapter.

The ESH&Q Section

The ESH&Q Section shall audit the Divisions and Sections on their compliance to this chapter.

The Mechanical Safety Subcommittee

The Mechanical Safety Subcommittee is available to advise and assist Division/Section personnel with pressure testing.

Engineering Note Reviewer

- Review of the Engineering Note and Pressure Test Permit
- Once FESHM requirements are satisfied, provide recommendation to DSO and Lead Engineer to proceed with the Pressure Test
- Review of the completed Pressure Test Permit

Lead Engineer

- Preparation of the Engineering Note and Pressure Test Permit
- Designation of a Test Coordinator if test coordination responsibilities are delegated

Test Coordinator

- Responsible for the test setup, conducting the pressure test, and recording the results
- The test coordinator may be assisted by one or more trained persons.

Division Safety Officer/Test Reviewer/Test Observer

- Reviewing the system undergoing pressure testing and the surrounding area prior to the Pressure Test. Designation of a Test Reviewer if delegated.
- Providing approval to commence with pressure testing
- Witnessing the pressure test. Designation of a Test Observer if delegated.

5.0 STANDING HYDROSTATIC TEST PERMIT

A standing permit may be used for routine hydrostatic tests which are performed for maintenance, repair or production of components or systems if the following conditions are met: 1) a written test procedure and hazard analysis for the routine test is submitted and approved by safety, 2) the testing is performed as described in the procedure.

6.0 REQUIREMENTS

1. The Lead Engineer responsible for the design, procurement or operation of the vessel or system shall prepare an Engineering Note when required by FESHM Chapter 5031, Chapter 5031.1, 5031.5, or 5031.6. The Engineering Note shall be reviewed as required in the applicable FESHM chapter by an independent Engineering Note Peer Reviewer, but not signed off, prior to conducting the pressure test.
2. The Lead Engineer shall prepare a "Pressure Testing Permit" and obtain all required signatures prior to conducting the test (see "Exhibit B").
3. The Division Safety Officer shall review the system under test and the surrounding area to assure all appropriate safety precautions have been taken, prior to the commencement of the test. The Division Safety Officer may designate another reviewer provided that:
 - The designee is a qualified person who is independent of the group or project for which the pressure test is performed
 - The Division Safety Officer provides a written statement for the test coordinator to append to the "Pressure Testing Permit" regarding who has been designated to review the pressure test
 - The designated reviewer provides a written approval to commence with pressure testing for the test coordinator to append to the "Pressure Testing Permit"
4. Pressure testing shall be performed per the ASME BPV Code, Section VIII, Division 1, UG-99 or UG-100 for pressure vessels or per the ASME B31 Code series for piping systems. It is the responsibility of the design engineer to use hydrostatic or pneumatic pressure test values consistent with the latest revision of the applicable Code and Division.
5. All pressure tests shall be directed by Lead Engineer or designated Test Coordinator and observed by the Division Safety Officer. The Division Safety Officer may designate another observer provided that:
 - The Division Safety Officer provides a written statement for the test coordinator to append to the "Pressure Testing Permit" regarding who has been designated to observe the pressure test
 - The designated observer is a "trained person"
 - The designated observer signs the completed "Pressure Testing Permit"
6. A report shall be prepared for all pressure tests by the Lead Engineer or designated Test Coordinator. The report shall include the time, date, location, an equipment layout drawing, test

data, conditions, personnel present and pressure readings. The layout shall show all system components and their pressure ratings. See attached "Exhibit A" for suggested set up for pressure testing, and also "Exhibit B" for test report format.

7. The completed report shall be filed with the Engineering Note.
8. A technical appendix which provides a detailed discussion of required documentation, safety precautions, equipment and materials, and test procedures is attached

7.0 TECHNICAL APPENDIX TO PRESSURE TESTING

Requirements for hydrostatic and pneumatic pressure testing are as follows:

7.1 SAFETY PRECAUTIONS FOR PRESSURE TESTING

- a) Hydrostatic testing is considerably safer than pneumatic testing and should be used whenever possible.
- b) If a pneumatic test will use a working fluid other than air, then the oxygen deficiency hazards of the pressure test on the surrounding enclosure(s) shall be analyzed. If the pressure test has the potential to create an oxygen deficient atmosphere as defined by FESHM 4240, then an ODH analysis must be written and approved prior to the start of the pressure test. The pressure test procedure shall follow all requirements specified by the ODH analysis. Requirements may include limits on the number of gas cylinders or dewars allowed in the enclosure, temporary reclassification and posting of ODH areas, enclosure evacuation and/or barricading, oxygen monitors, ODH fan flow verification, or other safety measures to protect workers from oxygen deficiency hazards.
- c) Air or gas is hazardous when used as a testing medium. It is therefore required that the vessel and piping be tested in such a manner as to ensure personnel safety from a release of the total internal energy of the vessel and piping. See also ASME PCC-2, Article 501, Mandatory Appendix 501-II, "Stored Energy Calculations for Pneumatic Pressure Test," and Mandatory Appendix 501-III, "Safe Distance Calculations for Pneumatic Pressure Test." Liquid test media may also present hazards due to the stored energy in the compressed liquid and strain energy stored in the vessel material. Reference: ASME BPV Code, Section VIII, Division 2, 8.1.2
- d) Testing should be done in an area set aside for the test with unnecessary persons kept away. This is especially important in pneumatic testing. All pressurized components shall be secured to prevent them from becoming missiles or whipping assemblies. Signs, lights, fences and barriers should be employed as needed to limit unauthorized access.
- e) The vessel or system support shall be evaluated to ensure that buckling will not occur during the hydrostatic test. The floor loading conditions also should be evaluated so as to safely transfer the vessel or system's weight and contents to the floor slab and the supporting grade.
- f) Prior to testing, the Division Safety Officer or designee shall inspect the system to assure it conforms to the system layout drawing and that all appropriate safety precautions have been taken.
- g) A minimum of two trained people shall be present for the entire pressure test. The test coordinator can be counted as one of the trained people. The Division Safety Officer or

designee does not count towards the minimum of two trained people since they are present solely as an observer.

7.2 EQUIPMENT AND MATERIALS

- a) The pressure test medium shall be inert. For hydrostatic testing, a nonhazardous liquid such as water shall be used at temperatures below 90°F and over 50°F to aid in avoiding condensation on the tank during the test. For pneumatic testing, an inert gas such as nitrogen or clean air (less than 50% RH) shall be used.
- b) Pressure test gauges should be of good quality and have a full-scale range of 1.5 to 4.0 times the intended maximum test pressure. The gauge shall be connected directly to the vessel or system and shall be visible to the operator throughout the duration of the test. Calibration of gauges should be kept up to date and recalibrated at any time there is reason to believe that they are in error. Reference: ASME BPV Code, Section VIII, Division 1, UG-102. It is recommended that pressure test gauges be used exclusively for pressure testing to avoid damage and contamination and should be placed in a secured storage area when not in use.
- c) For hydrostatic tests, vents shall be provided at high points to purge gas pockets during filling. A drain line with a valve capable of withstanding the test pressure shall be in place prior to filling the system. The manually operated valve shall be secured to a fitting at the lowest point of the system (flanged or threaded) and the drain line is to be connected to the outlet side of the valve. Reference: ASME BPV Code, Section VIII, Division 1, UG-99.
- d) For pneumatic and hydrostatic-pneumatic tests, the pressure source shall have a relief valve of proper capacity and a set cracking pressure not higher than the test pressure plus the lesser of 50 psi or 10% of the test pressure. Reference: ASME B31.3 Code, Para. 345.5.2. Relief sizing calculations for the test setup shall be provided as part of the pressure test permit. See FESHM 5031.3 for requirements on relief devices mounted downstream of pressure regulators. The relief valve shall be tested for proper operation prior to conducting the test.
- e) Consideration shall be given to the potential for leakage from the volume at test pressure into internal, external, or adjacent volumes rated for lower design pressures. These volumes rated for lower design pressures shall be protected by open vents or trapped volume relief devices during the pressure test to prevent accidental over pressurization. Typical examples at Fermilab include installing a relief device on external vacuum jackets, on the opposite flow path of a heat exchanger, and using block-and-bleed valve configurations on piping systems
- f) The gaskets, O-rings, plugs, etc. may be reused if inspected and found to be acceptable by the Lead Engineer or designated Test Coordinator.

7.3 PRESSURE TEST INSTRUCTIONS

- a) A preliminary leak check may be performed prior to a hydrostatic test and shall be performed prior to or at the beginning of a pneumatic test procedure. The pressure shall be gradually increased until a gage pressure that is the lesser of one-half the test pressure or 170 kPa (25

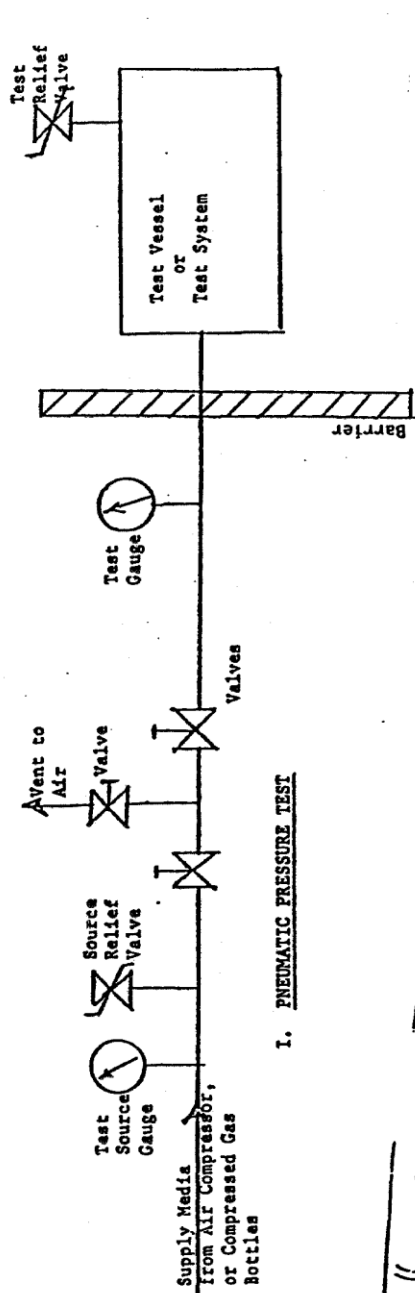
psi) is attained. Reference: ASME B31.3 Para. 341.2.1(c) and Para. 345.5.5. Preliminary leak checking shall be performed by Trained Person(s) under the direction of the Lead Engineer.

- a) All seams, connections of fittings, manways, plugs, couplings and welds made to the outside surface shall be visually examined in hydrostatic tests and soap-bubble checked in pneumatic tests after the maximum test pressure specified by the Code has been reduced to the design pressure. Helium leak checking may alternatively be used in lieu of soap-bubble checking in pneumatic tests.
- b) If a leak is detected at any pressure level reading during the test, the pressure shall be immediately reduced to less than 90% of that pressure level reading while locating the leak. The pressure level shall be less than or equal to the design pressure while examining for leakage.
- c) If a leak is detected, the vessel or system shall be depressurized before attempting any repairs or adjustments.
- d) If the pressure during the pressure test exceeds the test pressure listed on the signed pressure test permit (see Exhibit B) such that visible permanent distortion is encountered, or if visible permanent distortion in excess of the expected design amount is encountered without exceeding the maximum test pressure, an engineering review shall be required to determine the disposition of the vessel or system (e.g. repair, de-rate or scrap).
- e) If the pressure during the pressure test exceeds the test pressure listed on the signed pressure test permit (see Exhibit B) but the vessel or system shows no measurable permanent deformation, the maximum allowable working pressure of that vessel or system need not be reduced. When this situation occurs, an engineering review shall be required before the vessel or system is accepted. This engineering review shall include a revised engineering note and a signed review of that note by a second Engineering Note Peer Reviewer.
- f) After inspection, the vessel or system shall be relieved of its pressure gradually through a valve at the test stand.
- g) For hydrostatic tests, the vents at the top of the vessel or system shall be opened after pressurization, the liquid media drained and the system dried to preclude excessive corrosion.

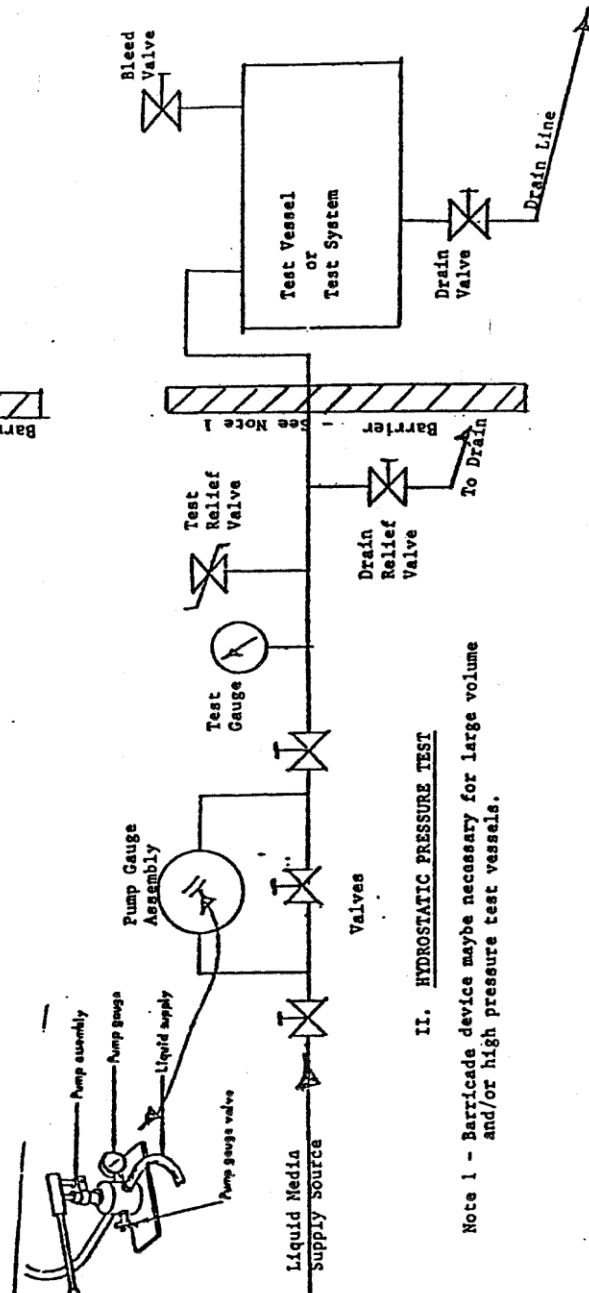
7.4 EXHIBIT A

EXHIBIT A

SCHMATIC SETUP FOR PRESSURE TEST EQUIPMENT



I. PNEUMATIC PRESSURE TEST



II. HYDROSTATIC PRESSURE TEST

Note 1 - Barricade device maybe necessary for large volume and/or high pressure test vessels.

7.5 EXHIBIT B**Pressure Testing Permit***

Date: _____

Type of Test: Hydrostatic Pneumatic

Test Pressure _____ psig Maximum Allowable Working Pressure _____ psig

Items to be Tested (Append additional pages as necessary)

Location of Test _____ Date and Time _____

Hazards Involved (use Hazard Analysis form FESHM 2060 if more space is required)

Safety Precautions Taken (Append additional pages as necessary)

Special Conditions or Requirements (Append additional pages as necessary)

Signatures Required Prior to Pressure Test

Engineering Note Peer Reviewer/ID# _____
Div/Dept/Date _____Division Safety Officer (DSO) or Designee/ID# _____
Div/Dept/Date _____

Pressure Test Results (Append additional pages as necessary)

Signatures Required After Pressure Test (both parties must be present for test)

Test Coordinator/ID# _____
Div/Dept/Date _____DSO or Designated Observer/ID# _____
Div/Dept/Date _____