

## FESHM 5031.4: INSPECTION AND TESTING OF RELIEF SYSTEMS

### Revision History

Author	Description of Changes	Revision Date
Roza Doubnik	<ul style="list-style-type: none"><li>• Updated definitions and added references.</li><li>• Clarified the frequency of testing and visual inspection of PRDs.</li><li>• Added RBI assessment definition to indicate test intervals.</li></ul>	December 2021
Abhishek Deshpande	Added information about paying attention to accumulation of vacuum grease on tested/inspected relief devices in Section 4.2.	September 2018
Abhishek Deshpande	<ul style="list-style-type: none"><li>• Added information about inspection and testing of vacuum vessel relief devices.</li><li>• Updated inspection details for trapped volume relief devices.</li><li>• Changed D/S/C to D/S/P.</li></ul>	July 2017
Michael White	<ul style="list-style-type: none"><li>• Updated introduction section to reference all other FESHM chapters which require relief valves;</li><li>• Revised definitions section;</li><li>• Updated responsibilities section;</li><li>• Reduced maximum testing frequency interval from six to five years for primary relief devices;</li><li>• Added reference to Fermilab Relief Device Database</li><li>• Deleted inspection form</li></ul>	October 2016
Thomas Page	Revised definition of “primary relief devices”; changed “external inspection” to “visual inspection”.	December, 2011
Thomas Page	Added chapters 5031.1 and 5031.6 to the scope of the chapter. Revised wording in Section 3.3.	January, 2011

**TABLE OF CONTENTS**

<b>1.0</b>	INTRODUCTION.....	3
<b>2.0</b>	DEFINITIONS .....	4
<b>3.0</b>	RESPONSIBILITIES .....	8
<b>3.1</b>	Division Head/Section Head/Project Manager (D/S/P) .....	8
<b>3.2</b>	The Relief Device Owner .....	8
<b>3.3</b>	The Mechanical or Cryogenic Safety Subcommittee(s).....	8
<b>3.4</b>	The ES&H Section .....	8
<b>4.0</b>	PROCEDURE .....	8
<b>4.1</b>	Visual Inspection.....	8
<b>4.2</b>	Primary Relief Devices Testing .....	8
<b>4.3</b>	Corrective Actions.....	10
<b>4.4</b>	Records.....	10
<b>4.5</b>	Existing Systems .....	11
<b>5.0</b>	FERMILAB RELIEF DEVICE DATABASE .....	11
<b>6.0</b>	REFERENCES.....	12

## 1.0 INTRODUCTION

Relief systems, at the Fermilab site in Batavia, Illinois, and all Fermilab leased spaces, must be periodically inspected, and maintained to assure proper operation. This chapter specifies an inspection and testing program for all pressure relief systems that are required per the following Fermilab ES&H Manual Chapters:

- 5031: Pressure Vessels
- 5031.1: Piping Systems
- 5031.5: Low-Pressure Vessels<sup>A</sup>
- 5031.6: Dressed Niobium SRF Cavity Safety
- 5031.7: Membrane Cryostats
- 5031.8: Boilers
- 5032.1: Liquid Nitrogen Dewar Installation & Operation Rules<sup>B</sup>
- 5033: Vacuum Vessels<sup>A</sup>
- 5033.1: Vacuum Window Safety<sup>C</sup>
- 5034.1: Retesting Procedures for D.O.T Gas Storage Cylinders Including Tube Trailers<sup>D</sup>
- 5035: Mechanical Refrigeration Systems<sup>E</sup>
- 6020.3: Storage & Use of Flammable Gases<sup>F</sup>

### Notes:

- A. Relief devices on low-pressure and vacuum vessels are not required to be retested per FESHM 5031.5. However, the relief devices shall be visually inspected every five years and opened (if appropriate) every 5 years per FESHM 5031.5.
- B. Liquid nitrogen dewars may have additional components such as automatic fill line shutoff valves that require inspection and/or testing as outlined in FESHM 5032.1. Records of these tests shall be maintained in the Fermilab Relief Device Database.
- C. If the vacuum window is on a vacuum system that may experience an excursion to positive pressure under any circumstance, then a relief device shall be installed to maintain the maximum pressure below 1/4<sup>th</sup> of the pressure which would cause the failure of the vacuum window per FESHM 5033.1.
- D. Relief devices on D.O.T gas storage cylinders require D.O.T certification as outlined in FESHM 5034.1. Records of inspections and tests are required to be stored in the Fermilab Relief Device Database.
- E. Mechanical refrigeration systems are exempt from inspection and testing requirements per FESHM 5035 (due to the safety and environmental hazards associated with the release of the refrigerant). Details of the relief devices are still required to be stored in the Fermilab Relief Device Database.
- F. See FESHM 6020.3 for detailed requirements regarding relief devices discharging into a common vent header and requirements for venting relief devices outdoors.

## 2.0 DEFINITIONS

Design Pressure: A relief device is always set to open at or below the design pressure of the protected system. The qualified person designing the protected system is responsible for verifying that all components have a maximum allowable working pressure (MAWP) greater than or equal to the design pressure across the entire range of expected operating temperatures.

Engineering Note: a formal analysis of any relief devices required by one of the FESHM chapters listed in Section 1.0 for a protected system. The engineering note shall undergo a formal peer review and approval. The relief device specifications for a protected system covered by an engineering note cannot be changed without revising the Engineering Note and undergoing another peer review and approval.

Engineering Document: in some cases, a formal engineering note is not required by FESHM. An engineering document is then created by a qualified person to capture the relief device's required capacity calculations, specified relief device capacities, and other key relief device specifications. A single engineering document may cover a group of relief devices.

External Pressure Source: the qualified person designing the protected system is responsible for identifying all credible sources of pressure external to the volume which the relief device protects. Common examples of external pressure sources at Fermilab include compressors, pumps, gas storage tanks, dewars, gas cylinders, tube trailer fill connections, and cryogenic liquid fill lines.

Pressure Vessel Primary Relief Device: a relief device that protects a system including a pressure vessel from pressures exceeding the vessels design pressure due to upset conditions including, but not limited to equipment failure, control failure, operator error, sustained heat loads, self-limiting heat loads, and external sources of pressure. The relief device shall be stamped or certified as required by the governing code.

Potentially Degrading Fluid System: protected systems that may be susceptible to corrosion, fouling, scaling, or any other processes leading to a degradation in the performance of the relief system over time. Examples of potentially degrading working fluids include steam, hot water, and industrial cooling water pumped from ponds. The required inspection and testing intervals shall be determined by a qualified person and shall be recorded in an engineering note or engineering document. The required inspection and testing intervals shall not exceed those for Stable Fluid Systems.

Process Piping Primary Relief Device: a process piping primary relief device protects a volume of piping from pressures exceeding piping design pressure due to upset conditions including, but not limited to equipment failure, control failure, operator error, sustained heat loads and external sources of pressure. Process Piping Primary Relief Devices also serve as trapped volume relief devices.

Protected System: piping, pressure vessels, or systems of piping and vessels for which a relief system is required.

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."

Pressure Relief Device: a general term for a device designed to prevent pressure or vacuum from exceeding a predetermined value by the transfer of fluid during an emergency or abnormal condition [6]. A relief device is always set to open at or below the design pressure of the protected system.

Reclosing Relief Device: a pressure relief device designed to actuate and reclose after operating.

Pressure Relief Valve (PRV): a pressure relief device designed to actuate on inlet static pressure and reclose after normal conditions have been restored. It may be one of the following types and have one or more of the following design features:

balanced direct spring-loaded PRV: a direct spring-loaded pressure relief valve that incorporates means of minimizing the effect of back pressure on the operational characteristics (opening pressure, closing pressure, and relieving capacity).

conventional direct spring-loaded PRV: a direct spring-loaded pressure relief valve whose operational characteristics are directly affected by changes in the backpressure.

direct spring-loaded PRV: a pressure relief valve in which the disk is held closed by a spring.  
full-bore PRV: a pressure relief valve in which the bore area is equal to the flow area at the inlet to the valve, and there are no protrusions in the bore.

full-lift PRV: a pressure relief valve in which the actual discharge area is the bore area.

internal spring PRV: a direct spring-loaded pressure relief valve whose spring and all or part of the operating mechanism is exposed to the system pressure when the valve is in the closed position.

low-lift PRV: a pressure relief valve in which the actual discharge area is the curtain area. Also called a restricted-lift PRV.

pilot operated PRV: a pressure relief valve in which the disk is held closed by system pressure, and the holding pressure is controlled by a pilot valve actuated by system pressure.

power actuated PRV: a pressure relief valve actuated by an externally powered control device.

reduced-bore PRV: a pressure relief valve in which the flow path area below the seat is less than the flow area at the inlet to the valve.

relief valve: a spring-loaded pressure relief valve actuated by the static pressure upstream of the valve. The valve opens normally in proportion to the pressure increase over the opening pressure. A relief valve is used primarily with incompressible fluids.

safety relief valve: a pressure relief valve characterized by rapid opening (popping) or by gradual opening that is proportional to the increase in pressure. It can be used for compressible or incompressible fluids.

safety valve: a pressure relief valve characterized by rapid opening (popping) and normally used to relieve compressible fluids

temperature and pressure relief valve: a pressure relief valve that may be actuated by pressure at the valve inlet or by the temperature at the valve inlet.

Non-reclosing Relief Device: a pressure relief device designed to actuate and remain open after operation. A manual resetting means may be provided. A non-reclosing device may be one of the following types and have one or more of the following design features:

breaking pin device: a device designed to function by the breakage of a load-carrying section of a pin that supports a pressure-containing member.

buckling pin device: a device designed to function by the buckling of an axially loaded compressive pin that supports a pressure-containing member.

direct spring-loaded device: a device actuated by static differential pressure or static inlet pressure in which the disk is held closed by a spring. Upon actuation, the disk is held open by a latching mechanism.

full-bore device: a device in which the flow path area below the seat is equal to the flow path area of the inlet to the device.

full-lift device: a device in which the actual discharge area is independent of the lift of the disk.

low-lift device: a device in which the actual discharge area is dependent on the lift of the disk.  
pin device: a device actuated by static differential pressure or static inlet pressure and designed to function by the activation of a load-bearing section of a pin that supports a pressure-containing member. A pin is the load-bearing element of a pin device. A pin device housing is a structure that encloses the pressure-containing members [6].

Relief Device Owner: a qualified person responsible for inspecting and testing the relief device.

Pressure Relief Systems: the fluid flow path and its associated equipment for relieving excessive pressure from the pressurized equipment to the final point of discharge. The associated equipment typically includes one or more pressure relief devices, piping, and piping components, and may include a muffler, liquid separator, scrubber, thermal oxidizer, flare, and/or other equipment necessary to safely discharge the effluent [6].

Risk Assessment or Risk-based Inspection (RBI): a method that can be used to determine inspection intervals and the type and extent of future inspections/examinations. An RBI assessment determines risk by combining the probability and the consequence of equipment failure [3].

Self-limiting Heat Loads: A heat load applied to a protected system that can be blocked in by valves, flanges, or other closures to create a trapped volume. Self-limiting sources of heat on a trapped volume include but are not limited to heat transfer from ambient air, fire, and sudden loss of insulating vacuum [5].

Stable Fluid Systems: protected systems that utilize a clean inert internal working fluid and are subjected to external conditions which are also not corrosive to the materials of construction. Examples of inert working fluids commonly encountered at Fermilab include nitrogen, argon, and helium. No performance degradation of the relief system is expected over time.

Sustained Heat Loads: a heat load applied to a protected system that may require a relief device to operate for an extended period to prevent over pressurization. Sustained sources of heat on a protected system include but are not limited to heaters, power supplies, and heat exchangers.

Testing of a Re-closing Relief Device: verifying that the set pressure satisfies the requirements of ASME Section VIII Division 1 paragraph UG-154 and UG-155 or ASME Section VIII Division 2 Part 9 as well as ASME Section XIII 9 for code stamped relief valves or other Codes/Standards as required by the systems Engineering Note or Document. The relief device may be tested in place provided the test pressure does not exceed the maximum allowable working pressure of the protected system; otherwise, the relief device must be removed for testing.

Three-way Selector Valve: a valve commonly used on pressurized equipment which allows pressure relief devices to be safely removed for testing without shutting down the equipment (as one port of the three-way selector valve always remains connected to the process stream). Three-way selector valves used for relief valves shall be configuration lock controlled. Any problems identified with the three-way selector valve shall be noted in the relief device inspection or testing report.

Trapped Volume Relief Device: a relief device required solely to protect a potentially blocked-in portion of a piping system from being pressurized above the design pressure by the expansion of a fluid due to heat absorption from self-limiting heat loads. In [1] Trapped Volume Relief Devices refer to Piping Pressure Relief Devices (PRDs).

Visual Inspection: the verification, to the extent possible without the disassembly of the relief system, that:

- a. The relief devices are the same as those described in Engineering Note/Document, e.g., that their marked set pressure(s) are suitable for the service, etc.
- b. The outlet/discharge piping of the relief devices has remained unrestricted [1].
- c. The inlet and outlet/discharge piping of the relief system has not been changed in a way that would reduce the relief capacity given in the Engineering Note or Engineering Document.
- d. The relief devices have not been subjected to severe corrosion, cracking, tampering, or any other mechanical damage.

- e. No gross leaks are evident.

## 3.0 RESPONSIBILITIES

### 3.1 Division Head/Section Head/Project Manager (D/S/P)

The D/S/P who controls the area of operation of the protected system is responsible for the appointment of Relief Device Owners who will carry out the requirements of this chapter.

### 3.2 The Relief Device Owner

The Relief Device Owner is responsible for ensuring that the Fermilab Relief Device Database is updated whenever a relief device is changed, added, inspected, tested, or removed from service D/S/P shall assist ES&H if necessary, to develop and executing a plan to bring relief devices in their areas of operation into compliance with this chapter.

### 3.3 The Mechanical or Cryogenic Safety Subcommittee(s)

The Mechanical or Cryogenic Safety Subcommittee(s) will serve in a consulting capacity to ES&H and D/S/P in all matters concerning the inspection and testing of relief systems.

### 3.4 The ES&H Section

The ES&H Section is responsible for the administration, training, and enforcement of the Fermilab Relief Device Database described in Section 5.0.

- Administration includes organizing any efforts to troubleshoot or upgrade the database.
- Training includes teaching relief valve owners to use the database and answering questions regarding the database.
- Enforcement includes monitoring the number of relief devices due for inspection or testing.

Procedures for relief devices that are out of compliance are outlined in Section 4.0. ES&H will work with groups responsible for maintaining relief devices to develop a plan to reach compliance with this chapter and monitor progress.

## 4.0 PROCEDURE

### 4.1 Visual Inspection

A visual inspection of each relief system must be made before the initial operation of the protected system. The inspection must be repeated at regular intervals. The maximum interval between inspections shall not exceed five years [1] for stable fluid systems. Potentially degrading fluid systems shall have an inspection interval determined by a qualified person. Trapped volume reliefs or piping PRDs do not need to be removed from service to be inspected. Piping PRDs that pass visual inspection may remain installed indefinitely. Such piping PRDs that do not pass visual inspection shall be replaced. Piping PRDs that carry a UV or UD stamp may be repaired and recertified.

### 4.2 Primary Relief Devices Testing

- a. Re-closing primary relief devices must be tested prior to their installation. Additional testing shall be repeated at regular intervals.



Unless documented experience and/or an RBI assessment indicates otherwise, the following testing and inspection intervals for pressure-relieving devices shall not exceed **five years** for typical process services, unless for clean (**non-fouling**), **noncorrosive services and environment** for which the interval can be increased up to **ten years [4]**. The systems with testing interval of ten years shall be visually inspected every five years.

(Relief valve installed indoors on the cryogenic system during non-relieving operation never see the temperature below the dew point is non-fouling and non-corrosive. But if PRD could see temperatures below the dew point, then there could be condensation or ice formation and potentially a corrosive and fouling environment).

Potentially degrading fluid systems shall have a testing interval determined by a qualified person per the owner/user's QA system [4], as recorded in Engineering Notes/Documents.

Before re-installing tested/inspected relief valves, all surfaces shall be checked for accumulation of greases, oils, rags, etc. Any unwanted substances shall be removed immediately and shall be noted in the testing/inspection notes for the relief device in the Fermilab Relief Device Database.

In the case of new and previously unused relief devices, certification of the set pressure by the manufacturer will be considered to constitute a test. In this case, the test date will be the date on which the relief device was last tested, and the requirement for further testing before installation will be waived. The manufacturer's test certificate shall be uploaded to the Fermilab Relief Device Database.

- b. Non-re-closing (burst disk), trapped volume, and parallel plate primary relief devices (used on vacuum vessels and insulating vacuum spaces) need not be tested but shall be visually inspected every **five years [1]** and recorded for future reference. Trapped volume relief device inspections should be tracked in the Fermilab Relief Device Database for new systems. Trapped Volume relief devices [1] shall be visually inspected every 5 years.

For breaking/buckling pin devices, they shall be inspected annually for seal integrity, corrosion, and freedom of piston movement. The device need not be actuated during this inspection.

- c. Inspections, tests, or examinations for pressure-relieving devices that cannot be completed by their due date may be deferred, subject to the requirements in the following sub-sections [4].

A simplified short-term deferral may be utilized provided all the following conditions are met:

- a) The current due date for the inspection, testing, or examination has not been previously deferred.
- b) The newly proposed due date would not increase the current inspection/servicing interval or due date by more than 10 % or six months, whichever is less.
- c) A review of current operating conditions, as well as an assessment of pressure vessel and/or pressure-relieving device history, has been completed.
- d) The deferral request has been approved via a formal peer review and approval process and an appropriate operations management representative(s).
- e) Updates to the pressure-relieving device records including the above-required deferral documentation are complete before the pressure-relieving device is operated beyond its original due date.

Deferral requests not meeting the conditions of a simplified short-term deferral shall fully comply with the below requirements:

- a) A documented risk assessment or an update to an existing RBI assessment shall be performed to determine if the proposed deferral date would increase risk above acceptable risk threshold levels.
  - fitness-for-service analysis;
  - documented consequences of relief device failure;
  - applicable damage mechanism susceptibilities and rates of degradation;
  - calculated remaining life;
  - historical conditions/findings from inspections, tests, and examinations and their technical significance;
  - extent and/or probability of detection (i.e., effectiveness) of previous inspections, tests, or examinations, as well as the amount of time that has elapsed since they were last performed;
  - considerations for any previous changes to inspection or test intervals (e.g. reductions in interval due to deteriorating conditions);
  - disposition(s) of any previous requests for deferral on the same pressure vessel or pressure-relieving device;
  - historical conditions/findings for pressure vessels or pressure-relieving devices in similar service if available.
- b) Determine if the deferral requires the implementation of, or modification to, existing integrity operating windows or operating process control limits.
- c) Review the current inspection plan to determine if modifications are needed to support the deferral.
- d) Obtain the consent and approval of appropriate pressure vessel personnel, including the inspector representing or employed by the owner-user and appropriate operations management representative(s).
- e) Updates to the pressure vessel or pressure-relieving device records with deferral documentation are complete before it is operated beyond the original due date.

### 4.3 Corrective Actions

Immediate corrective actions must be taken if an inspection indicates that a relief device may not operate per design. The actions must ensure that the failure of the relief device to operate per design will not result in a safety hazard.

### 4.4 Records

A record of inspections and tests of each primary relief system and each primary relief device shall be maintained by the Relief Device Owner for the protected system. These records shall contain vessel/system identification numbers (from the associated P&ID), relief device specifications, and any other documents which are necessary to record the results of inspections, repairs, alterations, or re-ratings of the relief systems and/or devices. All records shall be entered into the Fermilab Relief Device Database.

## 4.5 Existing Systems

If an existing primary relief system is found to not comply with this chapter, immediate corrective actions must be taken to ensure safety. This may include taking the system out of service or incorporating administrative controls to assure safety until the system can be brought into compliance. Thereafter, the inspection and testing intervals specified in Sections 1 and 2 apply.

## 5.0 FERMILAB RELIEF DEVICE DATABASE

Information regarding relief devices used on protected systems is stored in the Fermilab Relief Device Database that is administered by the ES&H Section. The database shall be updated by the relief device owner whenever a relief device is added, changed, inspected, tested, or removed from service. Instructions on how to enter a new vessel or device, how to update an existing vessel or device, and how to perform searches are contained within the User Guide located linked in the Help section of the database and shown below. A link to the Fermilab Relief Device Database is located on the ES&H Section website also shown below:

User Guide: <http://esh-docdb.fnal.gov/cgi-bin/ShowDocument?docid=5091>

Fermilab Relief Device Database: <https://www-bd.fnal.gov/cgi-msd/pvIndex.pl>

The functions of the database include:

All key specifications of the relief device are stored in the database such as the manufacturer, model number, device type, set pressure, flow rate capacity, and inlet/outlet pipe size. Supervisors and/or ES&H personnel are notified if any relief device specification is changed.

The database assigns the responsibility of every single relief device to a relief device owner. The owner receives email notifications when inspections or tests are due. If the owner fails to do the required inspection or test and enters the result in the database, escalating notifications are sent to supervisors and/or ES&H personnel.

The location of the relief device is specified. The building location, device tag name, and photographs are included so that the relief device can be readily located.

Inspection and test intervals can be adjusted based on the type of fluid service. For example, relief devices on corrosive fluid systems should be tested more frequently than those on inert fluid systems. The maximum inspection and testing intervals are specified in Section 4.0. Supervisors and/or ES&H personnel are notified if an inspection or test interval is changed.

The database provides the Teamcenter ID to the engineering note or engineering document which describes the protected system. The engineering note or the engineering document provides the relief device specifications and analyzes the required versus actual capacity of the relief device.

## 6.0 REFERENCES

- [1] CGA S-1.3-2020, Chapter 9 Maintenance requirements for pressure relief devices;
- [2] NB23 Part 2-2021, Chapter 2.5.8 Recommended inspection, and test frequencies for pressure relief devices;
- [3] API RD 576 – 2017, Inspection of Pressure-Relieving Devices, Chapter 6 Inspection and Testing;
- [4] API 510, 10-th edition, 2014 with Addendums, Chapter 6.6 Pressure-Relieving Devices, 6.6.3 Testing and Inspection Intervals.
- [5] ASME XIII-2021. 13.2 Pressurized Equipment for Which the Pressure is Self-limiting.
- [6] ASME XIII-2021. Mandatory Appendix I. Definitions.