

GUIDELINES FOR THE DESIGN, REVIEW AND APPROVAL OF LIQUID CRYOGENIC TARGETS

INTRODUCTION

Liquid cryogenic targets are frequently used in fixed target experiments and beamlines. Typically these targets are filled with hydrogen or deuterium. The hazards posed by these targets include the normal cryogenic hazards, pressure safety considerations, as well as the hazards associated with flammable gases. Targets are generally fragile vessels installed in the midst of experiment apparatus. Frequently, the experiment requirements are at odds with normal engineering practices, e.g. standard pressure vessel safety factors vs. the need for vessel walls as thin as possible. Therefore, special precautions are necessary to ensure safe operation. These precautions take the form of specialized methods for design, fabrication, testing, secondary containment, personnel access, and stringent requirements on material specification and quality control. These techniques have been developed over many years within the Research Division Mechanical Support Department, and are continually refined. As a consequence, these techniques and technical requirements are specified in the Research Division Operating Manual chapter RD_ESH_010, which serves as a technical appendix to this chapter.

Procedures for controlling normal cryogenic hazards associated with cryogenic targets are given in [Chapter 5032](#) of the Fermilab ES&H Manual. [Chapter 5032](#), in concert with the this chapter, serve to define all requirements for design, review, approval and operation of liquid cryogenic targets.

DEFINITIONS

Cryogenic - at a temperature below -150°C.

Cryogenic target - A vessel of any size holding a cryogenic liquid used in an experiment or beamline as a target.

Cryogenic personnel - Those engaged in or responsible for the production, use, transport or storage of cryogenic fluids and materials.

Safety Report - A written analysis demonstrating the target meets the requirements of [Chapter 5032](#) and RD_ESH_010.

RESPONSIBILITIES

The division/section head responsible for the area of operation of the target is responsible for ensuring the requirements of this chapter are met. The head shall arrange for the review of the target by a Liquid Hydrogen Target Safety Review Panel (hereafter called the "Review Panel"). The head shall certify that the target complies with this chapter by a written memo authorizing the operation of the target. The head shall ensure that changes to RD_ESH_010 are appropriately reviewed by the Review Panel and/or the Cryogenic Safety Subcommittee.

The Review Panel is responsible for verifying that the target meets the engineering requirements specified in the Research Division Operating Manual Chapter RD_ESH_010.

The department head responsible for the design of the target shall ensure that the safety report is maintained and filed for future reference.

The ES&H Section shall audit divisions/sections on their compliance with this chapter.

The Cryogenic Safety Subcommittee and the Review Panel shall serve the division/section head and the ES&H Section in a consulting capacity in all matters related to cryogenic targets. These committees may recommend appropriate modifications to this chapter as necessary. Changes in this chapter shall be recommended by the Laboratory Safety Committee after consultation with affected division/section heads.

REQUIREMENTS

1. Design, Fabrication and Testing
 - a. The techniques and requirements of RD_ESH_010, sections II and III, shall be adhered to.
2. Safety Analysis and Review
 - a. A safety analysis and review in accordance with [Chapter 5032](#) of the Fermilab ES&H Manual shall be performed on every cryogenic target system. Those responsible for the design, fabrication, testing, installation, and operation of the target system shall prepare the safety analysis in accordance with the technical appendix of [Chapter 5032](#). The analysis shall be reviewed by the Review Panel, and conclusions reported to the appropriate division/section head.
 - b. The safety review of the cryogenic target shall be conducted using the procedure given in the technical appendix to [Chapter 5032](#). The review will begin as early in the conceptual design stage as deemed appropriate

by the designer of the target system and the Review Panel chair. The documentation specified in Chapter 5032TA, and detailed in Part 5 below, shall be provided to the Review Panel following a schedule which will permit a thoughtful and unhurried review. The target designers and the Review Panel should meet at a frequency which will facilitate the review process.

- c. A Target Safety Review book shall be maintained for each target system. This book shall contain all required documents and any other documents considered appropriate by the Review Panel.

3. Authorizations and Permits

- a. The safety review of the target system will result in several milestones at which the target designers will be given authorization to proceed. At least the following four milestones shall be present in the review process:

Milestone	Authorizing Person	Authorizing Vehicle
Accept Design	Review Panel Chair	Memo or signed assembly drawing
Testing with cryogenics in test facility	Department Head	Memo
Installation	Department Head	Memo
Operation	Division Head	Memo

4. Operation

- a. Operating procedures shall be documented in the Target Safety Review book. Operating procedures define all phases of cooldown, filling, warm-up and steady-state operations. Sub-atmospheric operation of a target must be specifically addressed in the procedures by a combination of administrative and engineered controls. All operating functions except transferring liquid from the target to the reservoir shall be done by qualified cryogenic personnel. The transfer of liquid to the target vessel or the reservoir may be performed by other suitably trained personnel (i.e. experimenters).

- b. Emergency procedures for each target system will vary depending on the area in which the target is operated. Therefore, area specific procedures shall be written, reviewed and documented in the Target Safety Review book. Operators of the target shall be provided with a call-in list of qualified personnel who are available at all times.

5. Target Safety Review Book

- a. The Target Safety Review book is the primary means of transmitting safety information about the target to the Review Panel. A book shall be provided to each member of the Review Panel. The target designer shall maintain a master book that contains i) all required documentation and ii) all correspondence to/from the Review Panel, and iii) notes from all meetings held.
- b. The Target Safety Review book shall contain all of the required documents of [Chapter 5032TA](#), including the following:
 - 1. Structural calculations on all parts of the target
 - 2. Venting calculations for the target
 - 3. Venting calculations for the vacuum space
 - 4. Venting calculations for the secondary containment
 - 5. Complete drawings of the target, vacuum system and secondary containment
 - 6. Instrument and valve summary
 - 7. Interlock list
 - 8. Operating procedures
 - 9. Emergency procedures
 - 10. Operational call-in list
 - 11. Material certification data on parts
 - 12. FMEA, what-if analysis
 - 13. Flow diagram
 - 14. Testing results