national accelerator laboratory

TM-350
2701

HYDROGEN POLICY GUIDE

R. W. Fast and M. A. Otavka

February, 1972

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission

CONTENTS

HYDROGEN POLICY GUIDE

1. Basic Philosophy

1.1 Refrigerated hydrogen targets will be primarily used in all experimental halls at NAL. The reduced hydrogen inventory and the total elimination of liquid hydrogen handling minimize the hazards. Either hydrogen or deuterium gas can be condensed to fill a target. Once filled, the heat is removed by a 20°K refrigerator using helium gas as the working fluid. The small hydrogen inventory enables hydrogen targets to be used in locations not suited for large volume, reservoir-filled targets. Refrigerated hydrogen targets are automatic and remotely operated. Refrigerated targets can be placed in areas normally isolated because of radiation since operating personnel need not enter the target area after the initial setup.

1.2 This "Hydrogen Policy Guide" deals only with refrigerated targets; reservoir-filled targets and bubble chambers are considered to be in a completely different category from a safety standpoint.

1.3 The "NAL Hydrogen Policy Guide" attaches great importance to some fundamental design aspects of the target proper:

1.3.1 The volume of vacuum space surrounding the hydrogen flask is chosen large enough so that spillage of the liquid hydrogen from the target into the vacuum container results in an immediate pressure rise of less than 1 atm. This feature, coupled with a special relief disc for the vacuum space, will result in an orderly venting of spilled hydrogen gas rather than in rupture of normally warm Mylar windows.

1.3.2 The target must be insulated with multi-layer insulation. As much of the surface area as is practical must be covered. The insulation, coupled with an adequate vent system for the hydrogen volume in the target, will prevent rupture of the hydrogen flask after loss of insulating vacuum.

1.4 Hydrogen Flammability

1.4.1 Hydrogen is flammable over a wide percentage range (4 to 75 Vol.%) in mixtures with air and oxygen. This fact introduces problems beyond the normal cryogenic problems encountered in the design of a cryogenic system. The magnitude of the potential problem is a function of the size and physical configuration of the system. Potential accidents become large when the system contains a large quantity of liquid hydrogen.

1.4.2 In order to ignite hydrogen it is necessary to provide a spark to the proper mixture of air (or oxygen) and hydrogen. The spark energy necessary to ignite the mixture is 20μJ.

1.4.3 A spill of hydrogen into the atmosphere without ignition is a rather harmless affair. The spilled hydrogen vaporizes quickly and the gas rises rapidly at a rate of some 5 ft. per second. If allowed to escape, the spilled hydrogen will disappear quickly.

1.4.4 A spill of hydrogen with immediate ignition generally results in a very hot local fire, but not in a damaging pressure wave. Injury to personnel is limited to those in direct contact with the fire. Equipment located at some distance from the fire will not be damaged.

1.4.5 A spill of hydrogen with a delayed ignition generally results in a large fireball at the moment of ignition, combined with a pressure wave. The magnitude of the pressure wave is a function of the quantity of the flammable mixture and the geometry and strength of the enclosure in which the delayed ignition occurs.

1.4.6 The ignition of solid air or oxygen in liquid hydrogen or cold vapor generates a very strong pressure wave. The magnitude of the energy released is a function of the quantity of oxygen or hydrogen involved.

2. General Requirements for Hydrogen Target Systems

2.1 Design, Fabrication, and Testing of Target System: Design of a target shall be in accordance with design criteria outlined in the "Design Guide for Liquid Hydrogen Filled Targets". This guide will be made available to all potential designers and users of liquid hydrogen targets to be installed at the National Accelerator Laboratory.

2.2 Safety Review: Before installation of the target system into an experimental area the system will be reviewed by NAL to assure compliance with the provisions of the "Design Guide".

2.3 Installation in Experimental Area: The target system will be installed in the experimental location in accordance with the provisions of 3, 4 and 5, following and 3.3 of the "Design Guide".

2.4 Target Operation: The target system will be operated in accordance with 3.4 of the "Design Guide".

3. <u>Hydrogen Gas Detection Systems:</u>

3.1 Function

3.1.1 The primary function of the hydrogen gas detection system is to monitor for hydrogen gas leakage.

3.1.2 Upon detection of a hydrogen gas leak, the detection system shall control other interlocked equipment and shall operate signals and alarms which require response by the operating personnel.

3.2 Type:

3.2.1 NAL has standardized on a hydrogen detection system based upon the principle of catalytic combustion of a heated platinum filament having a high temperature coefficient of resistance. Combustible materials passing over the filament are burned raising its temperature and, as a result, its resistance. This change in resistance is calibrated to reflect percent of hydrogen in the airstream passing over the filament. All hydrogen equipment used at NAL shall be compatible with this hydrogen detection system.

3.3 Location and Sensitivity of Sensing Heads:

3.3.1 Filament detection heads shall be located in the area of the beam windows above the vacuum shell of the target, see 5.2. If the head or heads detect a hydrogen concentration in air of 10% of lower explosive limit (LEL), interlocks will close the hydrogen gas supply valve.

3.3.2 When a hood is used over the target, a detector head shall be located in the vent pipe of the hood. Detection of hydrogen in air exceeding 10% of lower explosive limit will activate interlocks to close the hydrogen gas supply valve.

3.4 Operation, Maintenance, and Testing

3.4.1 Each detection head shall continuously sample the surrounding area where installed. Each head shall be set to alarm with a maximum response time of four seconds when checked with a 1% hydrogen sample.

3.4.2 All hydrogen detection equipment shall be maintained and periodically tested.

4. Vents and Ventilation:

4.1 Hydrogen Vents:

4.1.1 Each target shall be equipped with a vent line from the hydrogen space and one from the vacuum space of the target. The vent line from the hydrogen space shall be a line with 3/4-inch internal diameter for targets between 2 and 6 liters contained liquid, and 1/2-inch internal diameter for targets with less than 2 liters of contained liquid. The vent line from the vacuum space shall be of 2-inch internal diameter. Both lines shall extend to a distance of at least 6-feet above the target or a minimum of 8-feet above floor level.

4.1.2 Vacuum pump discharge will be vented at a point 6-feet above the target or a minimum of 8-feet above the floor. It is permissible to duct the vacuum pump discharge into the vacuum space vent line.

4.2 Building Ventilation:

4.2.1 When the target is located in a building, special ventilation of the building for removal of hydrogen gas is not required when the ratio of building volume to free hydrogen volume of the target contents exceeds 400. Areas of the building where hydrogen gas pockets might collect must, however, be adequately vented.

4.2.2 When the ratio of the building volume to free hydrogen volume of target falls between 400 and 14, the building will be equipped with a vent located at the high point of the building.

A. The vent will have a minimum diameter of 10-inches. The vent will be equipped with an exhaust fan, capable of moving air through the 10-inch vent duct at a velocity of 20 ft/sec minimum. Total minimum air flow rate through the vent tube will be 600 scfm.

B. The vent will be located at the high point of the building and project a minimum of 3 feet above the roof of the building. The vent pipe may be equipped with a rain cover.

4.2.3. A building volume larger by less than a factor of 14 must be considered as a special case. Target systems planned for such locations will be considered on an individual basis. A flame suppression system or inert gas enclosure may be required.

4.3 Figure 1 shows a typical target in a beam enclosure with its vent system.

5. <u>Building/Enclosure Requirements</u>:

5.1 Volume of building relative to total hydrogen volume will determine the need for building vent systems, in accordance with 4.2, above.

5.2 Hydrogen detectors will be used, as follows:

5.2.1 Building larger by a factor of 400 or more: Provide one detector for each vacuum chamber window if distance between windows exceeds 4 ft.

5.2.2 Building larger by a factor of 14-400: Provide three detectors, one for each vacuum chamber window and one in the vent stack.

5.2.3 Building volume larger by a factor of less than 14: Provide one detector above the target.

5.3 Electrical Classification:

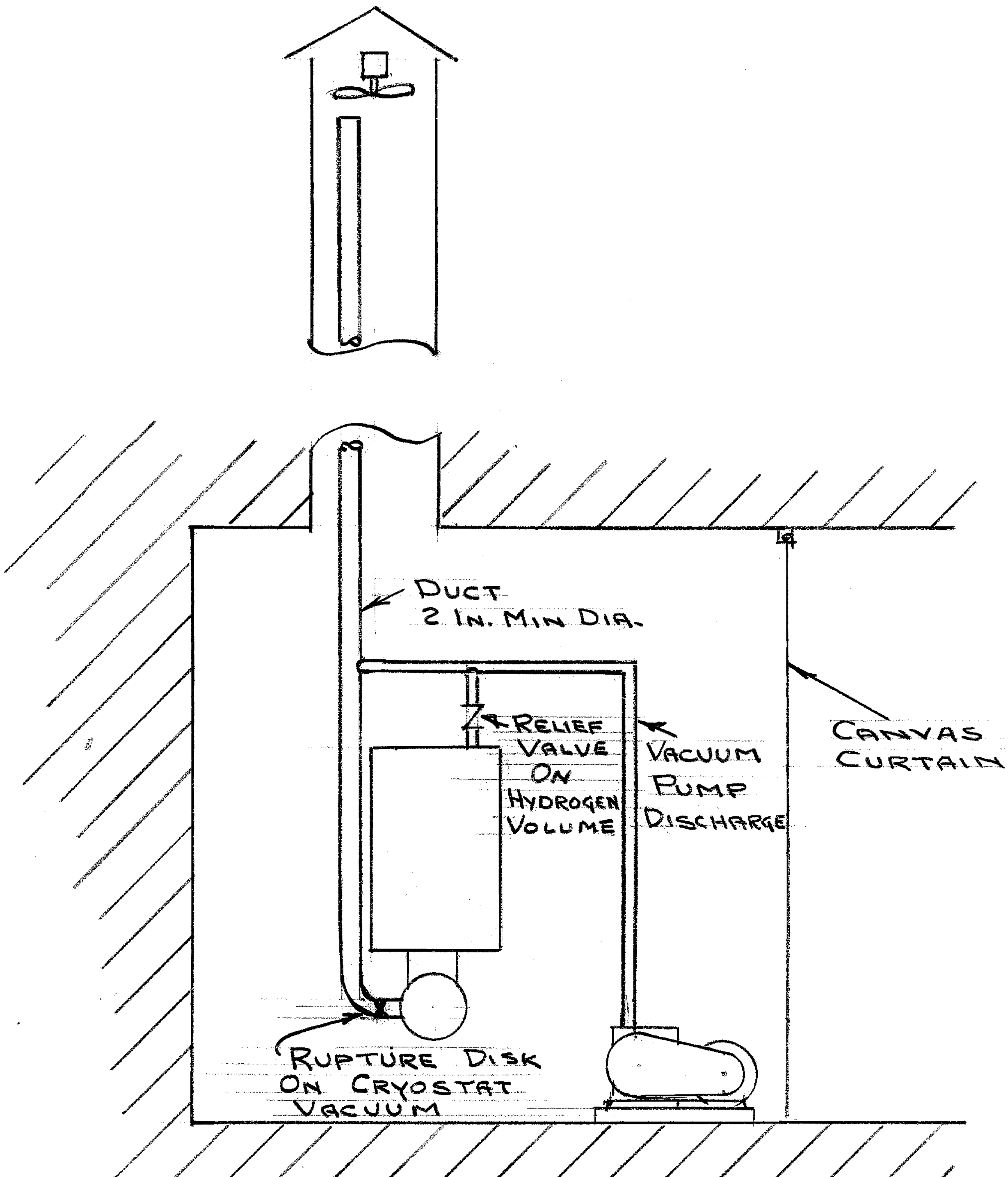
5.3.1 The area around a target normally is expected to be free of hydrogen. The electrical classification of this area shall be Class 1, Group B, Division 2.

5.3.2 Electrical/electronics equipment to be used in the vicinity of the target (within a 5-feet radius) shall meet the requirements of 5.3.1.

5.3.3 Electrical/electronics equipment shall preferably be located at low elevations, below the target.

5.4 Personnel shall be protected from failures of the system with sudden release of the hydrogen by means of appropriate shielding. In general, it will only be necessary to shield the potential discharge from windows by directing the effluent from a broken window into the proper direction and away from personnel. In addition personnel shall not be allowed in front of beam windows when the flask contains liquid hydrogen.

5.5 Access to the target shall be at least from two completely separate directions. Access aisles shall be at least 4 feet wide.


DUCT
2 IN. MIN DIA.
RELIEF
VALVE
ON
HYDROGEN
VOLUME
VACUUM
PUMP
DISCHARGE
CANVAS
CURTAIN
RUPTURE DISK
ON CRYOSTAT
VACUUM