SpinQuest Pre-Irradiation Target Material Storage

Dustin Keller

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Revisions

Revision Date	December 15, 2023
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Author	Dustin Keller
Changes in this revision	1. Made the training list consistent with other procedures involving ammonia usage
Changes in previous revision	1. Added ammonia-related training in the required training list 2. Added some clarification in the description of the actual procedure steps
Changes in v3	1. Minor wording change 2. Moved the training/equipment/PPE to the top of the document

Training requirement:

- Cryogenic Safety (FN000115)
- FN000475 / OJ Large (160L / 240L) Portable Liquefied Gas Dewar Handling
- General Employee Radiation Training (GERT: FN000241)
- Radworker Classroom (FN000470)
- Radworker Practical Factors (FN000471
- NM4 Experimental Enclosure Hazard Awareness Training (PDNM4001)
- SpinQuest Ammonia Target Handling [FN000761/RR/01]
- SpinQuest Ammonia Target Handling On the Job Training [FN000762/OJ/01]

Equipment Required

Portable dewars, target insert transport Dewar (blue foam), wrench, flex hose, ½" NPT tube.

PPE:

- Closed toe, Impermeable shoes, Safety goggles, face shield, Cryo-gloves.
- Long pants, no cuff
    - Tyvek OR Apron
    - Apron would require pants, (no cuff)

Introduction: We are bringing in a small sample of solid-state anhydrous ammonia for procedure practice necessary to gain extensive expertise beyond that gained from daily/weekly practice which has been performed with surrogate material (plastic beads of a similar size but different chemical properties than that of solid-state ammonia). The amount intended to be stored in the downstream end of NM4 in this initial storage procedure is a single target cell load (~10g). Detailed procedures have been developed and practiced for shipping, receipt, and transport of the material as well as loading/unloading, filling portable handheld and storage dewars, and handling the target material. The material will be able to be used and reused until all team members have demonstrated superior process expertise and readiness for the next phase of the experiment.

Ammonia Specifics:

The solid-state target material used in SpinQuest is frozen ammonia beads that are roughly 1 mm in diameter. Once out of liquid nitrogen, the beads could sublimate into gas in roughly 20 seconds as the sample temperature approaches 200K. Samples have been previously treated to have paramagnetic centers, which allow the sample to be polarized. These centers have a temperature dependence and should not be held out of LN2 for more than 10 seconds at a time, with every effort to keep this less than 5 seconds.

Dewar and Holder Types:

Sample Storage Dewar- *International Cryogenics sample storage* (ICSS) Dewar (see Figure 1). This type of Dewar has six slots that hold one cylindrical canister each, may hold up to 3 small (10 g) bottles. The canisters are hooked onto the top mouth of the Dewar with a rigid rod handle. The canisters have holes so the LN2 can flow through to cool and not get trapped when pulling out. This Dewar has a 20 L capacity and can hold samples safe and cold without being replenished for more than 20 days. Our maintenance procedure conservatively requires topping off every week.

Figure 1: Storage Dewar from International Cryogenics, Inc.

Target Insert-

The target insert contains three target cells (refer to Figure 2), each capable of holding approximately 10g of the target material (CH2/CD2 & NH3/ND3). One of the target cells is reserved for the empty target background study, so typically, the target insert does not exceed a capacity of 20g for NH3/ND3 or CH2/CD2, but it can accommodate up to 30g.

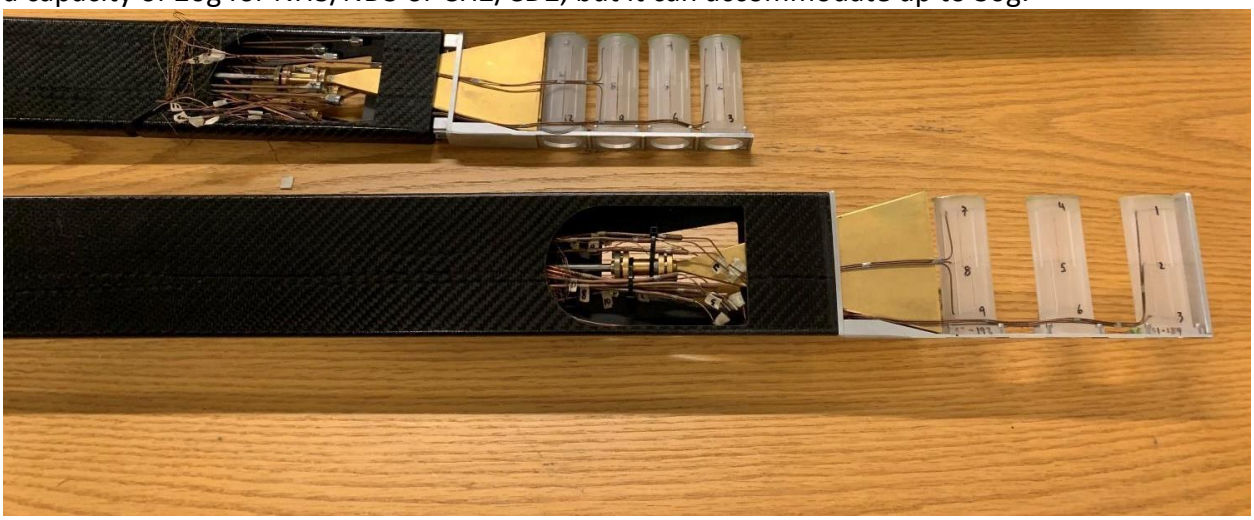

Figure 2: Target Insert

Storage Bottles-

The storage bottles (see Figure 3) are Nalgene sterile plastic bottles that hold up to 10 g of NH3/ND3 or CH2/CD2. They have holes in the bottles' bottom and tops so LN2 can flow through to keep the target material cold.

Figure 3: Nalgene sterile plastic bottles
(Reference: https://www.grainger.com/product/NALGENE-Bottle-1-oz-Labware-Capacity-56GW69)

Dewars and location:

The target group will inventory each Dewar, noting the number of storage bottles in each slot. The Dewars store material has six slots with six canisters, each holding up to three storage bottles. The storage dewars hold 20L of LN2, while the transfer Dewar holds 10L of LN2 with one canister holding up to three storage bottles. Each storage Dewar will be labeled accordingly:

Table 1: Target Material Storage Dewars Inventory							
Dewar No.	**Dewar Purpose**	**Material**	**Number of Bottles**	**Amount**	**Number of Slots**	**Quantity of LN2**	**Storage Location**
1	Holding	NH3/ND3 CH2/CD2	1 12	10g 120g	6	20L	NM4 Hall
2	Shipping	NH3/ND3	3	30g	1	4.1L	N/A
3	Transfer	NH3/ND3	3	30g	1	10L	N/A

Table 1: Table summarizing the storage of target material for SpinQuest. Dewars 1 will hold 10g of solid-state ammonia along with the 12 bottles of CH2/CD2.

Note: Only 10 g of solid-state ammonia will be in any of the designated areas as only 10 g will be onsite.

Note: Both online (Online Inventory for target material @ FNAL) and hard copy inventory should be updated every single time that a storage dewar content has changed.

1) **Shipping Dewar**:

This MiTeGen (CX100) is a dry cryogenic shipping dewar specifically designed for transporting samples at LN2 temperature without any free LN2. Upon receiving the shipping Dewar, which may contain a total of 30g of NH3/ND3 or CH2/CD2 and holds LN2 in the absorbent up to 4.1L (See Table 1), it will be stored in the NM4 Hall after the target material has been transferred to the approved storage location. The shipping dewar (Dewar 2, See Table 1) will not carry more than 30g of NH3/ND3 or CH2/CD2.

2) Transfer material Dewar

The ICSS is specifically designed to transport target material between approved storage locations. The Dewar can hold 10L of LN2 and accommodate one canister with three storage bottles, totaling 30g of NH3/ND3 (See Table 1). The target material will arrive at Fermilab and then be transferred using Dewar 3, following the procedure outlined below.

2) NM4 Hall (NW side):

The lower floor of NM4 (NW side) houses a well-ventilated area at the downstream end of the hall (refer to Figure 4). FNAL Engineer conducted ventilation ODH management calculations (docdb 3040) for 35ml of Ammonia. According to the calculations, storing and handling amounts below 30ml of Ammonia (<35g of solid Ammonia) in this area, situated within 15 ft from the air intake, is permissible. The area can also accommodate up to 180 liters of liquid

nitrogen (LN2) for ammonia storage and manipulation, with a maximum LN2 volume of 50 liquid liters during any ammonia-related procedure.

Figure 4: The proposed location on the lower floor at NM4

Store 10 g of solid-state ammonia in NM4 storage area:

Take material from shipping dewar to NM4 storage area: Prior to opening the shipping dewar put on protective gear and using a 10L portable handheld Dewar (Dewar 3) filled with LN2, according to DocDB# 10358, top off the Dewar #1 (NM4 holding dewar). Note that during this procedure the ammonia beads remain in their canister and are not opened. The procedure is as follows:

1. Put on safety gear, including safety goggles, a face shield, cryogenic gloves, and a Tyvek suit or apron, before handling cryogenics.
2. Connect the flex hose to the 180L LN2 portable Dewar following DocDB# 10358.
3. Fill the 10L handheld transfer Dewar (Dewar 3) with LN2.
4. Close the valve on the LN2 Dewar and carefully transport Dewar 3 to the NM4 hall target material storage area.
5. Fill the material handling tube with LN2 so that the single bottle from the shipping dewar can be switched over.
6. Open the shipping dewar (Dewar 2) and remove the packing in the top of the canister.
7. Place the bottle in the open tub full of LN2.
8. Move the Dewar #1 close to the tube and open the dewar top and remove the paper towel in the top of the canister.
9. Cool the material handling tongs, then grab the 10-gram bottle and place it in the Dewar #1 canister without pulling the canister out of the LN2.
10. Place the paper towel back on the top of the canister and put the dewar lid and dewar cover back in place.
11. Move the dewar back to the storage location next to the HVAC inlet.
    Hazard: Frostbite can occur due to cryogenic hazards from overfilling or spills.
    Mitigation: Open the LN2 flow at a very low rate, ensuring to fill it appropriately.