# Unreviewed Safety Issue Determination

**I. Title of USID**:

**USID for NPD-Gamma Liquid Hydrogen Target**

**II. Description of Proposed Activity (or discovered condition)**:

It is proposed to move an existing liquid hydrogen experimental neutron beam target, called NPD-Gamma, from Los Alamos National Laboratory (LANL) to Oak Ridge and install it into an experiment enclosure to be designed and constructed at SNS beam line 13. The existing target has been in a neutron beam at LANSCE and is slightly radioactive. In addition to the target, items such as the refrigerator that cools and maintains the liquid hydrogen at 30 K will also be moved and installed in the SNS north instrument hall. In addition to the instrument enclosure, items such as lines to vent the hydrogen outside the building will be installed as new construction. The liquid hydrogen inventory is in the neighborhood of 20 liters of liquid hydrogen (about 1.5 kg of $H_2$). The existing hydrogen and vacuum vessels are designed to ASME requirements but are not code stamped.

The primary hazard associated with the use of hydrogen is its flammability in air. Hydrogen can burn in air at concentrations between 4% (lower flammability limit) and 75% by volume. Uncontrolled release of hydrogen to air is likely to result in a burn because of the very low ignition energy of hydrogen in air. Complete combustion of the entire 1.5 kg mass would release about 180 MJ of thermal energy. The 1.5 kg of hydrogen involved would take up the following volumes if released and mixed with air at 1 atmosphere and 273 K temperature and the stated concentrations by volume:

- Volume at 273 K, 1 atmosphere (100% $H_2$ , no air)= 16.8 $m^3$ (diameter of sphere = 3.2 m)
- Volume at lower flammability limit (4% $H_2$ in air) = 420 $m^3$ (diameter of sphere = 9.3 m)

The safety properties of hydrogen are well known and described extensively in the literature. Hydrogen is a widely used industrial gas. National standards such as NFPA 50A and 50B are available for designing installations to adequately mitigate the standard industrial hazard of hydrogen. It is expected that the NPD-Gamma hydrogen target and associated equipment and spaces will be designed to meet the applicable NFPA requirements except as permitted in an equivalency or exemption approved for SNS. Design and operational features will minimize the risk to workers in the instrument hall.

The purpose of this USID is to consider whether the introduction of a hydrogen target into the SNS instrument hall constitutes an unreviewed safety issue. The emphasis is on whether the hydrogen in the NPD-Gamma target can significantly affect the previously reviewed analyses of the safety of the target mercury hazard, as documented in the Final Safety Assessment Document for Neutron Facilities (FSAD-NF), or whether the hydrogen target introduces a new hazard above and beyond the standard industrial hazard of the hydrogen.

**III. Does the proposed activity or discovered condition affect information presented in the FSAD-NF or the FSAD-PF, e.g. regarding equipment, administrative controls, or safety analyses.** If so specify the applicable FSAD and relevant sections.

The use of significant quantities of flammable gas in the instrument halls is not covered in the FSAD-NF – either in Section 3.3.13, Instrument Systems, or in Chapter 7, Instrument System Hazards. Cryogenic and oxygen deficiency hazards associated with neutron instrument operation are covered in FSAD-NF Section 7.2.

**IV. Does the proposed activity or discovered condition affect any of the requirements of the ASE?** If so, list the affected sections

No.

**V. USI Determination Evaluation Criteria**:

1. Could the change significantly increase the probability of occurrence of an accident previously evaluated in the authorization basis? Yes✓ No_
   **Justification**: For both general and specific reasons, the use of $H_2$ in the instrument hall can be expected to increase the probability of occurrence of fire, which is considered an accident in the FSAD-NF. Fire in the instrument hall is a concern for SNS because of the significant amounts of hydrogenous shielding material used in some instrument stations. Hydrogen can easily burn if released into an air mixture because of its very low ignition energy in air. Inadvertent release of a significant quantity of hydrogen gas could ignite a fire, but the precautions taken with design and operation of the NPD-Gamma experiment are expected to make $H_2$ releases originating from within the NPD-Gamma experiment unlikely. This would not represent a significant increase in frequency of fire originating in the instrument hall. However, events such as hydrogen cylinder handling or a crane load drop impacting the NPD-Gamma experiment apparatus could cause a significant hydrogen release which could ignite, cause a fire involving other combustibles in the area and also perhaps take out part of the sprinkler system. With no credited controls on the instrument hall crane, the frequency of a crane accident near or over beam line 13 should be counted as anticipated—medium as defined in the FSAD-NF (greater than once per 100 years but less than once per 10 years), thus moving the frequency of the event Medium Size Fire (event TS1—2) from Unlikely to Anticipated.

2. Could the change significantly increase the consequences of an accident previously evaluated in the authorization basis? Yes__ No✓
   **Justification**: It does not seem reasonable to postulate that hydrogen from the NPD-Gamma experiment could burn or explode in the presence of target mercury. Therefore, consequences of previously identified accidents should not increase.

3. Could the change significantly increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the authorization basis? Yes✓ No__
   **Justification**: A hydrogen combustion event in the beam line 13 instrument enclosure could possibly cause failure of its sprinklers, depending on how the sprinklers are mounted, etc. Whether the failure of the sprinklers would allow a large fire to develop depends on amount of combustibles in the beam line 13 instrument enclosure, which hasn't been defined yet. The instrument hall sprinklers are a credited engineered control (CEC).

4. Could the change significantly increase the consequences of a malfunction of equipment important to safety previously evaluated in the authorization basis? Yes__ No✓
   **Justification**: A hydrogen combustion event of the magnitude feasible with the NPD-Gamma target could not further increase the unmitigated source terms reported in the FSAD-NF.

5. Could the change create the possibility of a different type of accident than any previously evaluated in the authorization basis that would have potentially significant safety consequences? Yes✓ No__
   **Justification**: The following suppositions are not thought to be likely but without analysis they cannot be discounted. An earthquake could possibly cause release of hydrogen from the system into the instrument enclosure and at the same time cause failure of the guide tube. Vacuum remaining inside the failed guide tube cold possibly allow the released hydrogen to be drawn into the guide tube. Ignition of a flammable gas inside a guide tube has not been evaluated or analyzed.

**Justification**: The possibility of a hydrogen combustion event causing failure of instrument hall sprinklers has not been evaluated previously in the authorization basis.

7. Could the change significantly reduce the margin of safety as defined in the Accelerator Safety Envelope (list any affected part(s) of ASE in the Justification)? Yes __ No✓
**Justification**: Fire related controls are not addressed in the ASE.

**VI. USI Determination:** A USI is determined to exist if the answer to any of the 7 questions above (Section V) is "Yes." If the answer to all 7 questions is "No", then no USI exists.

- Do the proposed liquid hydrogen target constitute a USI? **Yes.**

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| RM Haight | 12/12/2006 |
| Preparer | Date |
| | 12/14/2006 |
| NSSD Instrument Support Manager | Date |
| | 12/13/2006 |
| Beam Line 13 Instrument Scientist | Date |
| | 12/18/2006 |
| Independent Reviewer | Date |

**Approvals:**

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|---|---|
| | 8 January 2007 |
| Signature of the SNS Division Director | Date |
| | 4 Jan, 2007 |
| Signature of SNS Operations/ESH&Q Manager | Date |