

SNS Modulator Fire of Friday, March 21, 2008

Fire Marshal Review

The SNS modulator located at SLAC is one of 15 units, with the other 14 units located and operated at the SNS project in Oakridge. All 15 units were fabricated under contract at Los Alamos National Laboratory. This SLAC unit generates RF power used to test and develop RF components for use with the next generation linear collider. The modulator is loaned to SLAC as part of a collaboration with SNS. It is located in End Station B.

At approximately 10:15 am on Friday, 3/21/08, a very loud noise was heard in and around End Station B. The Safety Officer, Keith Jobe, and others promptly investigated the incident and determined that an electrical explosion had occurred inside the SNS modulator, an experimental device that had been recently recommissioned following extensive servicing. The incident resulted only in localized damage within the modulator and was initially classified as non-ORPS reportable. The event was later recategorized as ORPS. This internal report was provided by the SLAC Fire Marshal, Ralph Kerwin.

Appendix A of this report addresses Keith Jobe's review of the technical aspects of the SNS modulator internal explosion. During a discussion on March 21st, Keith stated that the electrical explosion was initiated by an electrical component failure resulting in a short and complete discharge of the modulator's capacitor bank through a pair of IGBT semiconductor switches, resulting in the destruction of both switches.

Keith stated that this failure mode was anticipated by the SNS modulator designers at Los Alamos, who specifically designed the modulator and its enclosure to withstand such an occurrence. This failure did not result in any significant additional damage to the modulator beyond the switch. However, Keith states that in past occurrences with other modulators located at SNS, this failure mode has led to the destruction and ignition of oil-filled capacitors also located in the modulators. At the time of this event, Keith was actively pursuing a contract to provide a carbon dioxide suppression system for the modulator that would minimize fire damage should such a fire involving the capacitor oil occur in the future. The contractual documents were reviewed by the SLAC fire marshal prior to issuance.

The SNS modulator typically has a VESDA system to detect fire conditions inside the unit. The VESDA system sampling port had been disconnected from the modulator for the renovation and recommissioning operations. The disconnection of the VESDA port did not impede the response to this specific incident. However, the full recommissioning of the unit without reconnection of the VESDA port illustrates a weakness in the SLAC fire suppression system impairment tracking system (see Lessons Learned, Item 1).

The sequence of events from the run report relative to Engine 7 is as follows:

Alarm received	10:18:37
Engine 7 Dispatch	10:18:43
Engine 7 En Route	10:21:02
Engine 7 Arrival	10:25:49
Engine Clear	10:33:04

Engine 7 had a response time of 04:47 (arrival time minus en route time). Other responding apparatus included Truck 6, Rescue Unit 2, ALS Unit 1, Engine 6 and Engine 4. Response times were listed for Engine 6 as 04:35 and for Engine 4 as 05:58. An Engine 7 response time of under 4 minutes would normally be expected for this portion of the site. As of the time of this writing, the Fire Marshal has not interviewed the responding Engine 7 firefighters. PAFD Captain Rocky Hull

(not on shift that day) pointed out that most other vehicles were shown receiving roll call for departure at 10:22:03, and he stated that the PAFD dispatch logging system is subject to occasional error when multi-unit dispatches occur, because the times are entered manually by a single dispatcher.

The SLAC Emergency Management Coordinator and CGS Department Head arrived at the scene at the same time as PAFD Engine 7. The incident commander was able to determine very quickly after arrival that there were no life safety threats presented by the occurrence and relinquished incident command to SLAC. However, there was no organized effort on the part of SLAC personnel to control the movement of people into the building or around the SNS modulator. This points to an opportunity to improve scene management arrangements in future events, for which conditions may not be benign. (See Lessons Learned, Item 2.) In addition, the EMC stated that a portion of the event notification communication chain appeared incomplete. Beyond the initial calls given to the DFM, Fire Marshal and the 911 call to the fire department, there was no specific protocol for contacting interested parties such as the ORPS program manager and the EMC. (See Lessons Learned, Item 3).

ORPS CLASSIFICATION

Based on further evaluation, the Deputy Facility Manager on duty has determined that this will be an ORPS, classified as Group 10, Management Concern/Issue; Sequence # (2):

“an event...that does not meet any of the other reporting criteria, but is determined by the Facility Manager or line management to be of safety significance or of concern to other facilities or activities in the DOE complex.”

A significance category (SC) of 4 has been assigned (an occurrence that is not an Operational Emergency and has “*some impact*” on safe facility operations).

Lessons Learned/Opportunities for Improvement

Item 1. Fire Protection System Configuration Control – Include VESDA port detachment and reattachment in scope of fire protection system impairment program. Provide a means for tracking and ensuring recommissioning of these ports through cautionary labels, a tracking system, or other means. [Responsibility: Fire Marshal]

Item 2. Emergency Scene Management by SLAC Personnel – Develop a program for providing on-scene management of emergency scenes, both in support of the fire department (or sheriff’s office) and for situations in which the first responder has relinquished incident command of the scene. [Responsibility: Emergency Management Coordinator]

Item 3. Emergency Event Notification Protocols – Work with Security to expand list of emergency contacts following emergency situations or provide other means to ensure prompt notification of ORPS program manager and others. [Responsibility: Fire Marshal]

These items will be entered into CATS for tracking.

Appendix A – Report of Keith Jobe, 3/28/2008

At 10:15 an explosion was reported at End Station B, involving electrical equipment. The source was the SNS Modulator, which appears to have had a significant electrical discharge of one of the 3 main circuit boards within its enclosure (system operates at 2.5 kVDC and 250 kJ). The discharge was contained in the enclosure as designed.

The enclosure was designed to provide containment protection in such an event and functioned as it was designed. No personnel were injured .

The discharge was heard as far away as building 128 (the NLCTA Control Room). The control room is outside the concrete end-station and all end station doors were closed. The Power Conversions Department engineer (Tony Beukers) responsible for recommissioning and testing the equipment appeared in the control room shortly following the discharge. The NLCTA Safety Officer (myself) and others immediately entered into the end station and the emergency response was initiated.

End Station B personnel responded immediately, notified 911, shut down the unit's power, discharged a CO2 extinguisher into the enclosure (a preemptive measure), and initiated the manual discharge of the capacitor banks per the protocols in the approved ELP (Equipment lockout procedure) .

Initial indications did not suggest any initiation of fire. There was dust or smoke visible within the enclosure as viewed through the enclosure's high-strength windows. A slight "smoke-smell" was present. The call to 911 was initiated to provide fire coverage in the case an undetected fire had been initiated within the equipment.

The modulator is the spare unit for the identical modulators in the Spallation Neutron Source (SNS) at Oak Ridge, Tennessee. SNS has had similar experiences with component failures - sometimes these failures included the ignition of oil-filled (non-PCB) capacitors in the immediate vicinity of the likely source of the explosion. The likely failure is a fault in the high-current transistor-switch (an IGBT) on the power board immediately upstream of the pulse transformers. Both SNS and SLAC are pursuing the acquisition of a fire protection system which provides carbon-dioxide flooding for the electronics enclosure.

This equipment was being recommissioned following a removal of the high-voltage electrical connections and the disassembly of the oil-filled tank for a capacitor replacement. The oil-tank and its components is completely separate from the equipment failure discussed above and was not involved in the incident. As part of the disassembly, the connection to the High Sensitivity Smoke Detector (HSSD) was removed by the fire technicians. The normal reassembly and recommissioning of the device (which has not been completed) has the HSSD's sample port reattached as part of the reassembly. The HSSD would have automatically signaled the fire department and sounded evacuation alarms in the building, had it been connected. This port was not reconnected at the time of the discharge.

The 911 call was correctly initiated by the Safety Officer and the communication was clear and complete. Security, Main Control Center (MCC), Fire Department, SLAC Medical, ES&H, Facilities, Public Affairs, SLAC Facility Manager, and the High Voltage Electricians all responded immediately and appropriately. There were no medical injuries and all damage appears to be confined to the source. The system is currently shutdown, de-energized, and locked-out. The Power Conversion engineers have been authorized to remove the power board and any other affected systems, and evaluate (and repair) the failure.

Based on the information currently available, this does not appear to meet the threshold criteria for an ORPS reportable incident.* (Evaluation by Brian Sherin, SLAC Facilities Manager Deputy)

Keith Jobe will be conducting a preliminary investigation and will provide an update next week.

Pictures of the modulator and the explosion from several photographers are available at
- <http://www.keithjobe.com/pictures/?album=2008-03-21>.

For those interested, additional photographs of
- the internals of the oil tank (at SLAC) can be found at
<http://www.keithjobe.com/pictures/?album=2008-03-18> and

- the installation at SNS at <http://www.keithjobe.com/pictures/?album=2005-07-21>

Regards
Keith Jobe
NLCTA Safety Officer

note: Credit to Brian Sherin for the initial version of this report

* ORPS Subgroup B: Fires/Explosions

- 1) Any unplanned fire or explosion...nuclear or hazardous material within a facility
- 2) Any unplanned fire or explosion in a nuclear facility...
- 3) Any unplanned fire or explosion in a non-nuclear facility that
 - a) activates a fire suppression system
 - b) takes longer than 10 minutes to extinguish following the arrival of fire protection personnel, or
 - c) disrupts normal operations in a high hazard facility
- 4) Any wild land fire...

APPENDIX B – PHOTOS

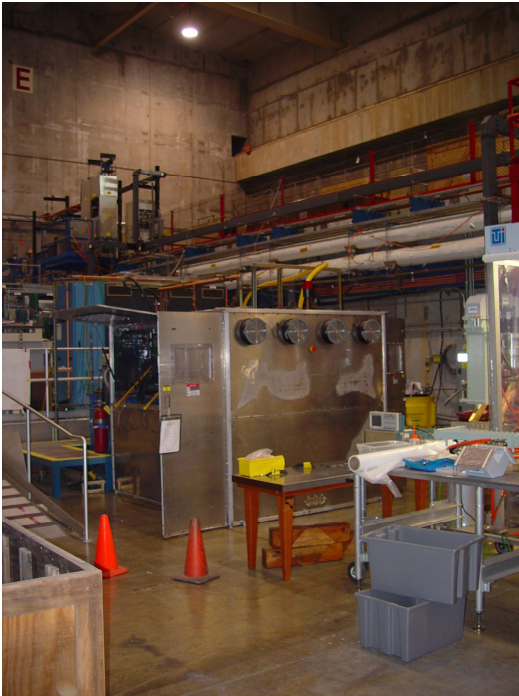


Photo 1 – SNS Modulator in ESB

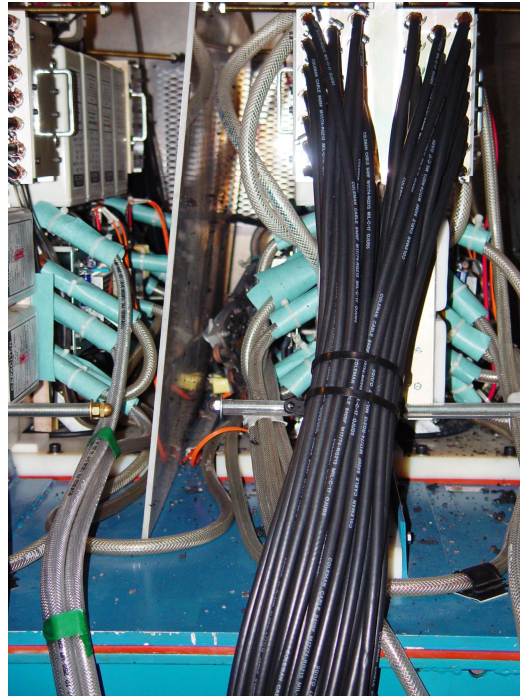


Photo 3 – Center Module (note fragments)

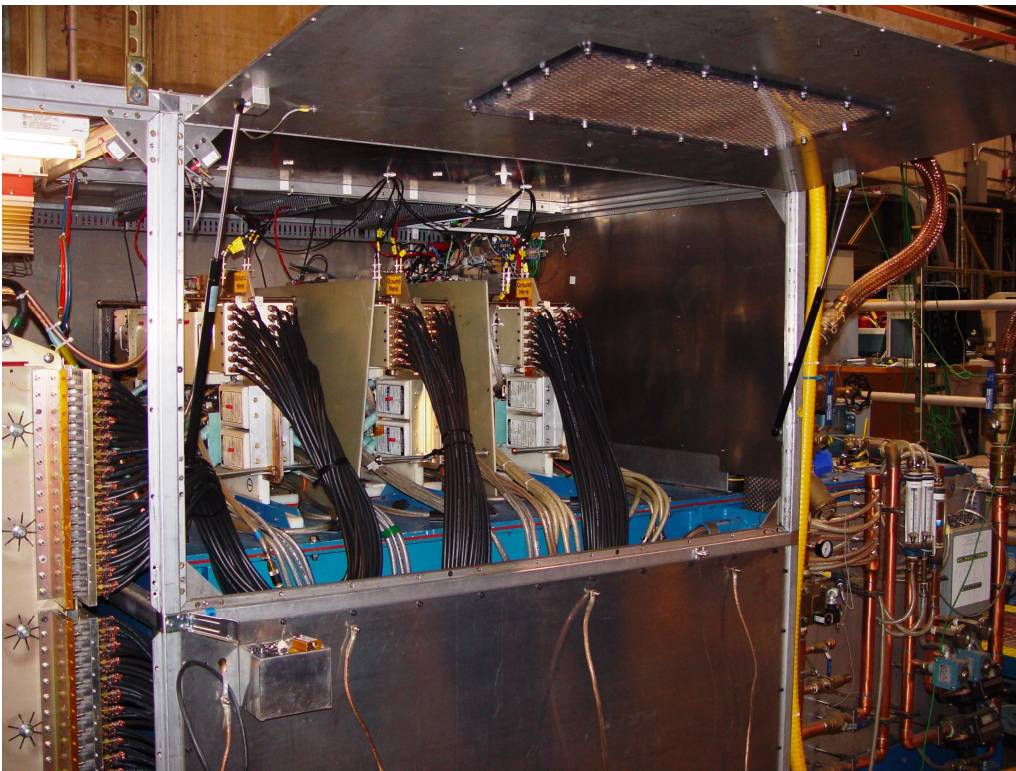


Photo 2 – Face of SNS Modulator With Side Panel Open
(Center Module has the blown switches; damage not visible in this photo)