National Spherical Torus Experiment

NSTX UPGRADE PROJECT

HAZARD ANALYSIS REPORT

August 31, 2010

Prepared By: Jerry D. Levine, Head, Environment Safety, Health & Security, PPPL

Jerry D. Levine

Digitally signed by Jerry D. Levine
DN: cn=Jerry D. Levine, o, ou, email=jlevine@pppl.gov, c=US
Date: 2010.08.31 16:28:32 -04'00'

NSTX Upgrade Project Hazard Analysis Report

This document comprises the Hazard Analysis Report for the National Spherical Torus Experiment (NSTX) Upgrade Project required by DOE O 413.3A, "Program and Project Management for the Acquisition of Capital Assets". It updates the Preliminary Hazard Analysis Report that was submitted to the DOE Princeton Site Office (PSO) on July 8, 2009 per DOE O 413.3A requirements for the NSTX Upgrade Project CD-1 decision. This Hazard Analysis Report will support the revision to the existing NSTX Safety Assessment Document (SAD) that will be done prior to Project Completion (CD-4).

The NSTX Upgrade Project was assessed by PPPL in 2009 with regard to the status of NSTX as a Below Hazard Category 3 Facility (Ref: Letter, A. Cohen to J. Makiel, 7/8/09). It was determined that based on the classification criteria of DOE-STD-1027-92, NSTX would continue to be designated a Below Hazard Category 3 Facility after implementation of the Upgrades, and the requirements of 10CFR830 Subpart B would not be applicable.

PPPL uses ESHD 5008 (PPPL Environment, Safety & Health Manual) Section 11 ("Operations Hazard Criteria and Safety Certification") as part of its implementation of the Integrated Safety Management (ISM) Guiding Principle for Operations Authorization of experimental projects. The PPPL approval process to commence NSTX operations after the Upgrades are in place will follow the applicable provisions of PPPL ESHD 5008 Section 11, which include:

- Preparation and review of the revised NSTX SAD and its approval by the PPPL Safety Review Committee.
- NSTX Activity Certification Committee (ACC) safety review of planned NSTX operations with the Upgrades. This will include review of the revised NSTX SAD, preoperational test plans, and operating procedures relevant to the safe conduct of operations. It will also include one or more safety walkthroughs to review the physical aspects of the Upgrades.
- A report by the ACC to the PPPL ES&H Executive Board (ES&H/EB) on the findings of its safety review, which will include a recommendation on a revision to the existing NSTX Safety Certificate authorizing NSTX operations with the Upgrades, and any relevant conditions or limitations on those operations.
- If approved by the ES&H/EB, issuance of the revised NSTX Safety Certificate authorizing operations with the Upgrades. This step would also be dependent on the outcome of the planned DOE Operational Readiness Assessment (ORA), as indicated in the June 30, 2010 letter from J. Faul to S. Prager (Subject: "NSTX Upgrade Project – Operational Readiness Assessment").

Hazard	**Barrier**
Ionizing Radiation	_ 2nd Neutral Beam Injector (NBI) Only: Estimate maximum of 0.0097 Ci/yr of tritium produced (based on 2.0E17 DD neutrons/yr projected generation rate). If released, dose at nearest business would be <3E-5 mrem/yr. 40CFR61 Subpart H limit is 10 mrem/yr, and EPA approval to construct is required at 0.1 mrem/yr. New Center Stack (CS) Only: Estimate maximum of 0.0969 Ci/yr of tritium produced (based on 2.0E18 DD neutrons/yr projected generation rate). If released, dose at nearest business would be <3E-4 mrem/yr. 40CFR61 Subpart H limit is 10 mrem/yr, and EPA approval to construct is required at 0.1 mrem/yr. New CS + 2nd NBI: Estimate maximum of 0.1938 Ci/yr of tritium produced (based on 4.0E18 DD neutrons/yr projected generation rate). If released, dose at nearest business would be ~5E-4 mrem/yr. 40CFR61 Subpart H limit is 10 mrem/yr, and EPA approval to construct is required at 0.1 mrem/yr. _ Personnel occupancy of the NTC and other areas deemed necessary by Health Physics will be excluded during plasma operation and neutral beam conditioning. _ Maximum offsite dose from operations will be (scaled based on NSTX SAD Table 3): 3E-4 mrem/yr for 2nd NBI Only; 3E-3 mrem/yr for New CS Only; and 6E-3 mrem/yr for New CS + 2nd NBI (limit is 10 mrem/yr). Maximum worker dose will be ≤1000 mrem/yr (limit is 5000 mrem/yr).
Electrical	_ In order to ensure the protection of personnel from electrical hazards, the selection of electrical equipment and the design and construction of electrical distribution systems complies with national codes and standards wherever possible. Access to hazardous areas is controlled by the NSTX Safety System. _ To prevent electrical hazards from being transmitted outside the NSTX Test Cell (NTC) boundary all instrumentation is isolated via optical and/or magnetic (magnetic transformer) means prior to exiting the NTC boundary. _ Electrical work practices conform with the requirements of ESHD 5008, Section 2 ("Electrical Safety").
Fire	_ The NTC fire detection system consists of ionization smoke detectors and rate of rise heat detectors located at the ceiling and aspirated smoke detection (VESDA) under the platforms. _ The NTC fire suppression is a pre-action type automatic water sprinkler system similarly located.

Hazard	Barrier
Earthquake	_ The NTC, along with the rest of the D-Site experimental complex structures, has been determined to have adequate capacity to remain functional under the overall loads due to an earthquake with a horizontal ground acceleration of 0.13g. _ The NSTX platform has been designed for 0.09g, the seismic requirements of the NSTX torus structure. Equipment associated with the NSTX Upgrades will be designed and built consistent with these requirements.
Vacuum Windows	_ Personnel injury due to flying debris from failed windows, or from an individual being drawn to, or into, the opening is addressed via window design/testing features and/or installation of protective covers. See ESHD 5008, Section 9, Chapter 14.
Magnetic Fields	_ Personnel are prevented from entering the NTC during plasma operations by an access control system. _ During a hot access (access while coils are energized but plasma formation is prevented), the magnetic field strength that personnel are exposed to shall not exceed the ACGIH threshold limit value for routine occupational exposure. See ESHD 5008, Section 4.
RF Fields	_ RF systems have been designed with leakage levels that comply with IEEE Standard C95.1-1991 (outside the test cell) and are routinely checked for leakage. In addition, RF transmission into the NTC is prevented whenever personnel have access to the NTC.
Mechanical	_ During a hot access into the NTC, personnel are required to stay in a protective enclosure to protect against magnetically propelled projectiles or possible arc splatter that may attend an electrical bus failure. _ Gas cylinders are stored/installed in accordance with PPPL safety procedures (ESHD 5008, Section 9, Chapter 2) to prevent breaking the cylinder heads, which could propel the cylinders due to a rapid release of gas.
Hot Fluids	_ The Low Temperature Bakeout Heating/Cooling System, which is run with water at temperatures up to 150°C, was hydrostatically tested to at least 1.5 times its operating pressure prior to operations. The High Temperature Bakeout Heating/Cooling System, which uses pressurized helium at temperatures up to 420°C, was pneumatically tested to 1.3 times its operating pressure prior to operations. _ Precautions are taken to prevent personnel contact with hot surfaces, including restricting access to areas where hot pipe or components are present, posting of warning signs, and personnel training.

Hazard	Barrier
Gases/Cryogenics /Lithium	_ The content of the largest gas cylinder (311 cubic ft.) constitutes less than 0.1% of the volume of the NTC (approximately 354,000 cubic ft.). Thus, oxygen concentrations in the NTC would remain at safe levels for personnel even if a gas cylinder's entire contents were released to the room. _ Since SF_6 is heavier than air and can displace oxygen, leakage of the gas could be hazardous to personnel occupying an enclosed area below the leak point. Personnel protection is provided by strategic location of SF_6 detection in the NTC to provide local evacuation alarms. _ Trimethylboron (TMB) used in the boronization process is toxic (7ppm TLV, based upon the TLV of the reaction product B_2O_3) and pyrophoric in air. Protective measures include low TMB inventory (≤50 g), prior leak checking of components that will be TMB pressurized above 1 atm, use of portable leak detectors, limiting NTC access during boronization to only TMB trained personnel, interlocks that halt TMB injection on loss of plasma discharge or glow discharge current, and nitrogen purging of the stack vent line during TMB injection. _ Cryogenic system subsections which may be isolated by valves or other means are provided with pressure relief devices. Appropriate personal protective equipment is used by personnel engaged in handling cryogenic fluids. Pressure relief devices have been installed to preclude rupture of sections of the system by excessive internal pressure. All piping has been designed for maximum operating pressure and tested in accordance with applicable ANSI codes. Only materials suitable for cryogenic service are used if in contact with cryogenic fluids or subject to cryogenic temperatures. Consequently, severe rupture of cryogenic system lines are highly unlikely. Even if such a rupture occurred and theoretically released all the liquid helium (17,200 cubic ft) in a dewar associated with a NBI to the NTC, the concentration of oxygen in the NTC could drop from 20.9% to 19.9% (assuming no active ventilation in the room), which is not considered oxygen deficient. However, the operation of cryogenic system pressure detection, closure of system valving to isolate affected areas, presence of burst discs to relieve pressure, and the operation of NBI vacuum pumping systems to exhaust gas leaking into the beam box to the stack would be expected to prevent large scale releases to the NTC.

Hazard	**Barrier**
Gases/Cryogenics /Lithium	- Lithium hazards include fire or explosion hazards due to the high reactivity of lithium, and health hazards due to the corrosive and toxic nature of the stable end products of lithium reactions. Safety precautions include avoiding contact with sources of moisture, conducting fabrication and transport of pellet material under an argon atmosphere, receipt and disposal of lithium material in sealed containers, presence of special (LITH-X) fire extinguishers during lithium loading activities and transport to the NTC, venting & cleaning of the vacuum vessel prior to allowing worker entry after lithium experiments, and performing work activities according to approved procedures and using proper PPE.
Lasers	– High energy laser diagnostics systems are operated by trained personnel under Laser Safe Operating Procedures (LSOPs) approved by the PPPL Laser Safety Officer. LSOPs specify protective measures to prevent laser exposures to personnel, and to isolate hazards during operation, maintenance and testing. Entry to the NTC during Multi Pulsed Thomson Scattering (MPTS) diagnostic laser operations are performed only under carefully controlled hot access conditions.

In general, proper system design, construction and the presence of features that mitigate the effect of failures (e.g. redundancy, energy isolating barriers, etc.) will ensure the safety of personnel. Personnel will generally be excluded from areas such as the NSTX Test Cell (NTC), the NSTX bus tunnel in the Test Cell Basement and other relevant areas when hazards exist, by the use of hardwired interlocks, procedures, signage, indicator lights and training. Entry to hazardous areas will be strictly controlled and limited to very special circumstances by highly trained personnel using carefully prescribed procedures and protective measures.