SAD Updates December 2014

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3.0 Facility & Systems Description

Added after chapter title:

The NSTX-U requirements are outlined in the "General Requirements Document" (GRD), Reference 2. The GRD additionally references a design point spreadsheet which provides parameters for design and analysis (http://w3.pppl.gov/~neumeyer/NSTX_CSU/Design_Point.html). Section 7.2 of the GRD describes the design verification process that ensures compliance with PPPL procedures and industry standards. The verification process includes multiple levels of design reviews and resolution of resulting "CHITS" in accordance with PPPL procedure ENG-033. Supporting calculations are filed at the project web page, http://nstx-upgrade.pppl.gov/Engineering/Calculations/index_Calcs.htm . Coil structural qualification must satisfy the NSTX structural design criteria, Reference 13. These reviews and calculations form the basis for the acceptable operating space for NSTX-U. To ensure coil operations within qualified boundaries, a Digital Coil Protection System (DCPS) is a part of the Upgrade project. This system is described in Section 3.6 of this SAD. Reliability of the NSTX-U experiment is largely determined by the reliability of the DCPS. Reliability requirements are specified in the GRD.

Table 1:

Parameters made consistent with the GRD, the 10 sec pulse length was removed.

Aspect ratio changed to 1.5 per the GRD

10 second pulse length discussion:

The GRD requires and allows a pulse length of 5 seconds. A future upgrade to a plasma pulse length of up to 10 seconds at reduced toroidal field would allow investigation of fully relaxed current profiles, a condition

3.2.1.1 Passive Stabilizers

add:

" Passive plates have been instrumented with accelerometers to ensure the NSTX-U disruption loads do not exceed the capacity of the plates and their mounting hardware."

3.2.2 Vessel and Torus Support Structure

The casing is 625, not 718

Table 3 and next paragraph corrected

3.2.3.3.4 Center Stack Casing

Corrected 2kV DC CHI from GRD

3.3.1 HHFW

Changed 6MW to the Plasma to 4MW to the plasma per the GRD

added:

"Because of higher fields and disruption loads associated with NSTX-U, a compliant center conductor has been added."

3.3.2 CHI
There are now only 3 connections and they are not spaced equally in the toroidal direction.
Vessel is electrically connected via three toroidally distributed connections to a single point connection,

3.4.5 Cooling Water System added:
"All coils and bus bars are inertially cooled during normal operation, with cooling needed for the next shot provided between shots. If cooling is lost during a shot, the coil temperature would be limited by I^2 t integrals in the coil power supply control system, and the Digital Coil Protection System (DCPS). Coils and bus bars require active cooling during bake-out"

add:
"e. Providing active cooling for the center stack casing during shots to remove plasma heating of the tiles. NSTX did not require active cooling of the casing. The NSTX-U requires active cooling as a consequence of the higher plasma current, heating power, and extension of the pulse length."

added:
"both the TF and OH coil cooling systems have features that mitigate thermal shock by initially introducing warmed water in the cool down cycle. "

3.6.1 AC Power System

Removed per Charlie Neumeyer:
"(maximum pulsed load is <350 MVA as compared to the rating of one MG of 475MVA, maximum energy required is 1109 MJ [compared with 2250 MJ available from one MG unit; only 10% of the pulsed lifetime of the MG units had been used prior to initial NSTX operations])."

Charlie notes that 1 MG set is sufficient.

3.6.3 DCPS
This section was re-written:

3.6.3 Digital Coil Protection System (DCPS)

The Digital Coil Protection System (DCPS) allows the NSTX-U device to be operated over a wide operating space. The high performance level of NSTX-U is made possible by the DCPS since it allows higher coil performance than would be permitted by traditional protection. The DCPS is needed to ensure the integrity of the device mechanical structures during operations and addresses coil Lorentz force interactions and component stresses, not just individual current limits. Design and reliability requirements are outlined in the "Coil Protection System Requirements Document" NSTX-CSU RQMT-CPS-159

- NSTX-U requires more comprehensive methods of protection due to:
  - Longer pulse length
  - Double the plasma current
  - Double the toroidal field
  - New TF, OH, and Divertor coils

- DCPS executes a set of protection algorithms utilizing a modern digital computer system to constrain operations within a complex operating envelope

NSTX-U will use a combination of mechanical reinforcement, periodic field inspection, and the DCPS to ensure the mechanical integrity of the NSTX-U device mechanical structures. FMEA's can be found in Appendix 1 under Digital Coil Protection System (DCPS) FMEA.

3.7 Central Instrumentation and Control

Added:
d. Power Supply Real Time Controller

Added:

3.7.8 Power Supply Real Time Control System

The Power Supply Real Time Control (PSRTC) system acts on the power supply equipment at D-site, and thereby provides control of the application of voltage to the NSTX coils either in direct response to commands from the NSTX Plasma Real Time Controller (PRTC), or as required to produce a programmable current through the coils via feedback control. In addition to controlling the interaction of the power supply equipment with the coils, the PSRTC provides control of the application of voltage and the delivery of current to the Coaxial Helicity Injection (CHI) system on NSTX-U.

4.8 Magnetic Field Hazards
Removed: "in a strong sub radiofrequency (<30kHz) magnetic" per Charlie Neumeyer.

9.0 References

Updated 2 and added 13 and 14

2. National Spherical Torus Experiment Upgrade (NSTXU) General Requirements Document, NSTX_CSU-RQMTS-GRD Rev 5 June 14 2012.

13. NSTX Structural Design Criteria Document, NSTX_DesCrit_IZ_080103.doc, Feb 2010 I. Zatz

14. Coil Protection System Requirements Document" NSTX-CSU RQMT-CPS-159