

Radiation Monitor Annunciation Upgrade and Test Cell Shielding

NSTX-U-RQMT-RD-007-03

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Change Record

Rev	Date	Description of Change
0	4/4/18	Initial Release
1	7/22/18	Corrected a mis-labelled penetration on Fig. 6.1-2 (6495-6496)
		Split Section 5 into a 5.1 and a 5.2
		Added a requirement 5.1c
		Modified Table 2-3 to remove the preference for concrete in shielding the NTC windows (rows 11-16); now states either concrete or polyethylene.
		Modified Table 2-1 to remove the preference for concrete in shielding the NTC windows (rows 6 & 7). Adjusted the requirement for the north door in row 1; now states either concrete or polyethylene.
		Modified the first row of Table 2-2, to remove the preference for concrete.
		Added 4e regarding approval of polyethylene beads.
		In all the standard circular NTC penetrations, added that if the previous plugs cannot be located, then “alternatively fabricate plugs or install other shielding”.
		Removed all discussion of the HIS, and moved it to the new HIS RD, which is now Reference 4. Added Reference 4.
		Modified Table 2.6 to remove reference to NBPC shield door; it is now reference in Table 2.3.
		Added 4f requiring neutronics analysis for shielding for doors, labyrinths, and windows.
		Added 4h requiring shielding have documentation appropriate for future configuration management as an ASO credited control.
		Added 4i requiring labeling of non-permanent shielding components
		Added 4j requiring labyrinths to comply with life safety code requirements
2	12/19/18	Updated signatures as per changed roles at PPPL
		Removed reference to the MER and otherwise small changes in Section 1.2
		Changed the title of Ref. [4]
		Removed requirement for the shielding on the NBPC door
		Small clarifications to shielding requirements for the 12” circular penetrations and the NTC windows in all tables in Section 2.
		Updated row 1 of Table 2-1: removed mention of HIS components.
		For all windows, added text indicating if they are equipment or observation windows. For equipment windows, changed to direction to verifying the presence of shielding and adding additional shielding as practical.
		Moved 6494, 6495, 6496 into scope for Phase I; all equipment and vision windows are now in scope for Phase 1
		Moved the HHFW penetrations into Phase I
		Moved 1591-1594, 1634-1636 into Phase I
		Moved the MPTS penetration (6136) in Phase II
		Added requirement to immobilize the mobile shield blocks on the 100’ level on the northeast wall
3	2/5/19	Added a footnote in 5.1a
		Added 5.2h

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References

- [1] NSTX-U-RQMT-GRD-001, NSTX-U General Requirements Document
- [2] NSTX-U-RQMT-SRD-010, NSTX-U SRD - Test Cell
- [3] NSTX-U-PLAN-017, NSTX-U Recovery Project Shielding Plan
- [4] NSTX-U-RQMT-024, NSTX-U Personnel Safety System Requirements
- [5] ALARA: <https://www.nrc.gov/reading-rm/basic-ref/glossary/alara.html>

1: Scope

This requirement document covers the Radiation Shielding and Radiation Monitoring elements of the NSTX-U Recovery Project scope. This complements and augments information located in Ref. [1] & Ref. [2]. See Ref. [3] for additional details on the overall NSTX-U Shielding Plan.

1.1: Radiation Shielding

The radiation shielding will be used to provide enhanced shielding and minimize neutron radiation from the test cell during NSTX-U experimental operations. The scope of this element includes shielding installations at the north and south doors of the test cell, filling multiple penetrations on the north, northeast, and east walls, and completing auxiliary tasks needed to be done in relations to these.

Note that this work is divided into multiple phases with pauses in between the phases to assess the efficacy of various shielding improvements.

1.2: Access Control Modifications

As part of the overall shielding plan [3], some changes to the access control and Kirk key chains will be undertaken. These changes are designed to limit access to locations where shielding is inadequate (NSTX-U South High Bay), and to ensure that the positions of mechanized shield or seal doors are fully controlled during operations.

Specific requirements for this work will be tracked in a separate requirements document [4].

1.3: Radiation Annunciation

The scope of work includes connecting the four test cell radiation monitors to a centralized relay, and installing high radiation illuminated warning signs both at the north and south entrance doors. The annunciation system is designed to satisfy 10 CFR 835 posting requirements, and hardware in this system need not be considered a safety interlock.

2: Radiation Shielding

- a. The radiation shielding job shall be divided into multiple phases. Details for only Phase I are provided; assessments following Phase I will allow the Phase II penetrations, if any, to be identified.
- b. The Phase I shielding is as follows
 - i. For the north wall of the test cell, the penetrations and doorways shall be remediated as indicated in Table 2-1 and Figure 2.1.

- ii. For the northeast wall of the test cell, the penetrations and doorways shall be remediated as indicated in Table 2-2 and Figure 2.2.

Table 2-1: North wall penetrations to address during Phase I

	Penetration #	Comment
1	North Door	May be accomplished by installation of an appropriate labyrinth and shielding structures at the north door, by developing methods/procedures to close the battleship door during operations, or by some combination of the two.. The card readers, as well as any other conduits or auxiliary system components, shall be moved as necessary to support the selected option.
2	1587	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
3	1588	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
4	1589	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
5	1590	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
6	1591	Shield as appropriate and consistent with penetration usage
7	1592	Shield as appropriate and consistent with penetration usage
8	1593	Shield as appropriate and consistent with penetration usage
9	1594	Shield as appropriate and consistent with penetration usage
10	6494	(Equipment Window) Verify presence of plug; install additional shielding as practical
11	6495	(Visualization Window) Fill with grout, standard density concrete or borated polyethylene beads; both inner and outer cavities optimal, but only one cavity if access limitations prevent both.
12	6500	(Equipment Window) Verify presence of plug; install additional shielding as practical
13	6501	(Equipment Window) Verify presence of plug; install additional shielding as practical

Figure 2-1: North wall penetrations to address in Phase I

Door Areas Requiring Remediation
Penetrations Requiring Remediation

From: E-FA1030, sheet 2

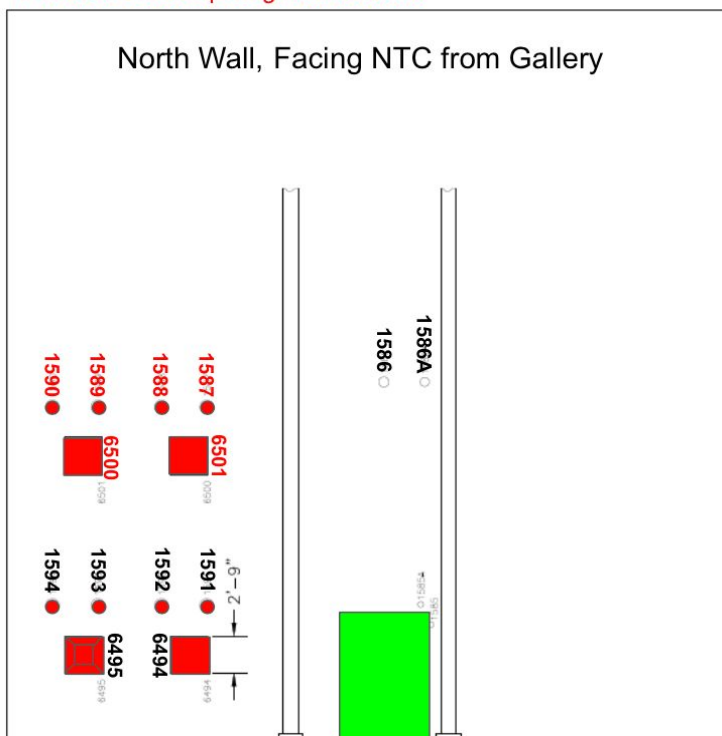
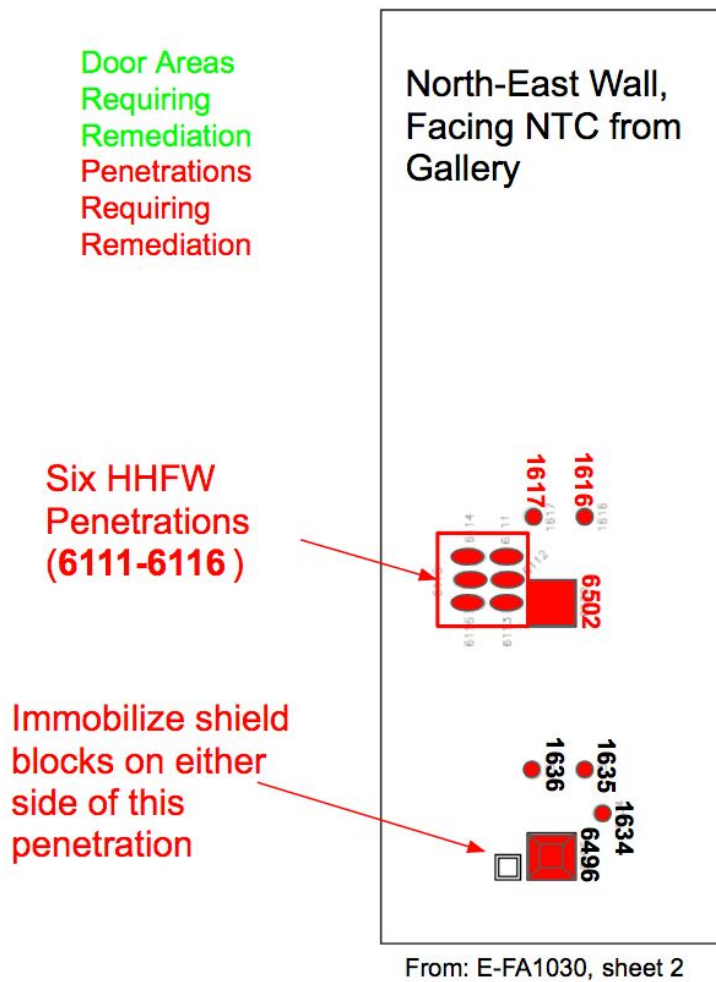


Table 2-2: Northeast wall penetrations to address during Phase I.

	Penetration #	Comment
1	6502	(Equipment Window) Verify presence of plug; install additional shielding as practical
2	6496	(Visualization Window) Fill with grout, standard density concrete or borated polyethylene beads; both inner and outer cavities optimal, but only one cavity if access limitations prevent both.
3	1616	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
4	1617	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
5	1634	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
6	1635	Shield as appropriate and consistent with penetration usage
7	1636	Shield as appropriate and consistent with penetration usage
8	6111	Shield around HHFW penetrations
9	6112	Shield around HHFW penetrations
10	6113	Shield around HHFW penetrations
11	6114	Shield around HHFW penetrations
12	6115	Shield around HHFW penetrations
13	6116	Shield around HHFW penetrations

Figure 2-2: Northeast wall penetrations to address in Phase I



- iii. For the east wall of the test cell, the penetrations and doorways shall be remediated as indicated in Table 2-3 and Figure 2.3

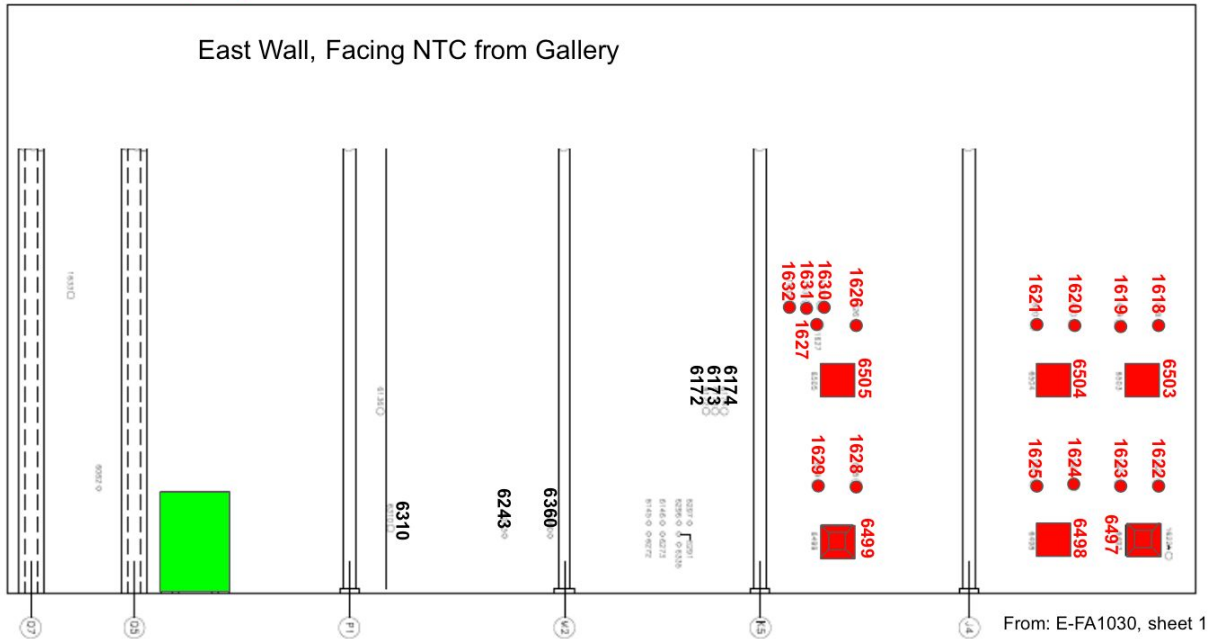
Table 2-3: East wall penetrations to address during Phase I.

	Penetration #	Comment
1	1618	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
2	1619	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
3	1620	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
4	1621	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical. ¹
5	1622	Shield as appropriate and consistent with penetration usage
6	1623	Shield as appropriate and consistent with penetration usage
7	1624	Shield as appropriate and consistent with penetration usage
8	1625	Shield as appropriate and consistent with penetration usage
9	1626	Shield as appropriate and consistent with penetration usage
10	1627	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
11	6497	(Visualization Window) Fill with grout, standard density concrete or borated polyethylene beads; both inner and outer cavities optimal, but only one cavity if access limitations prevent both
12	6498	(Equipment Window) Verify presence of plug; install additional shielding as practical
13	6499	(Visualization Window) Fill with grout, standard density concrete or borated polyethylene beads; both inner and outer cavities optimal, but only one cavity if access limitations prevent both
14	6503	(Equipment Window) Verify presence of plug; install additional shielding as practical
15	6504	(Equipment Window) Verify presence of plug; install additional shielding as practical
16	6505	(Equipment Window) Verify presence of plug; install additional shielding as practical
17	1628	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
18	1629	Verify presence of concrete plug of $\geq 1'$ thickness; install plug or shielding of equivalent effectiveness if not present; install additional shielding as practical
19	1630	Shield as appropriate and consistent with penetration usage
20	1631	Shield as appropriate and consistent with penetration usage
21	1632	Shield as appropriate and consistent with penetration usage
22	South Door	1: Construct a shielding labyrinth to provide neutron shielding to the SE door to the Gallery area. 2: Move card readers and/or PSS components, as well as any additional system components [4]. 3: The design shall not impede the ability to remove the floor plug to the MER mezzanine in the south high bay, or impede the ability of the crane to utilize that feature for access to the mezzanine.

Figure 2-4: East wall penetrations to address

¹ Note is mislabeled in E-FA1030 Rev. 1, sheet 1

Door Areas Requiring Remediation
Penetrations Requiring Remediation



c. Update drawings as per Table 2-5. Other drawing updates may be required.

Table 2-5: Required drawing updates to E-FA1030 sheets 1 and 2.

1	Add penetrations above south high bay door to penetration drawings; assign numbers
2	Correct two instances of penetrations 1620
3	Correct cardinal directions on drawings
4	Survey test cell walls and assess completeness of NTC penetration drawings

- d. The mobile shield block on the northeast wall shall be immobilized.
- e. Following the Phase I Shielding steps, the neutron generator testing of the NSTX-U test cell shielding shall be repeated. During these tests:
 - i. The efficacy of Phase I shielding shall be assessed by repeating measurements at previously identified problematic locations.
 - ii. Additional penetrations for which are candidates for shielding shall be assessed. These may include, but may not be limited to, those listed in Table 2-6.

Table 2-6: Wall penetrations and similar that may be assessed for inclusion or modification in a Phase II shielding plan

Penetration Number	Penetration Location & Notes
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1		NBPC Door from South High Bay
2	1586	North Wall
3	1586a	North Wall
4	1586	North Wall
5	1586A	North Wall
6	1591	North Wall
7	1592	North Wall
8	1593	North Wall
9	1594	North Wall
10	6310	East wall
11	6172	East Wall
12	6173	East Wall
13	6174	East Wall
14	6360	East Wall
15	6243	East Wall
16	6297	East Wall
17	6296	East Wall
18	6146	East Wall
19	6145	East Wall
20	6291	East Wall
21	6273	East Wall
22	6272	East Wall
23	6335	East Wall
24	6062	East Wall
25	1633	East Wall
26	6139	East Wall
27	1622A	East Wall
28	6138	East Wall (this is the MPTS laser entrance penetration)
29	---	All South and West Wall Penetrations

3: Adjustments to NSTX-U Access Control

The scope in this section has been moved to Ref. [4].

4: Shielding Methods and Design

- a. Tables in Section 2 may have suggested methods to fill penetrations/windows; other methods will also be acceptable upon concurrence with Health Physics, and as validated via design review.

- b. All radiation shielding shall be designed so as to accommodate any required fire stops, as applicable.
- c. The functionality of piping, cabling, and other services using penetrations shall not be impeded by the installation of shielding.
- d. Where concrete or polyethylene beads are used to fill penetrations, steps shall be taken to ensure that the penetration volumes are fully filled.
- e. Any polyethylene components in the shielding shall be approved by the fire protection engineer.
- f. Shielding designs for doors, labyrinths, and windows shall be verified by neutronics analysis.
- g. Shielding designs shall be consistent with an ALARA philosophy [5].
- h. All shielding installations shall be documented in a fashion consistent with future configuration management as a credited control under the ASO.
- i. Any non-permanent element of the neutron shielding (i.e. removable plug, borated polyethylene sheets mounted to walls, etc) shall be clearly labeled as part of the test cell shielding.
- j. Labyrinths shall have widths, heights, lighting, and fire protection consistent with applicable life safety and architectural codes.

5: Radiation Annunciation

5.1 Requirements on Instrumentation

- a. Radiation annunciation shall use the on relay outputs of the eight existing Ludlum 375 real time dose monitoring systems², located on the four walls of the test cell.
- b. The real time dose monitors shall be configured by Health Physics to close relay in any unit when the radiation level exceeds a predetermined level. The determination of this level is the responsibility of Health Physics.

² There are 4 neutron monitors and 4 gamma monitors, installed and maintained by the PPPL Health Physics Group

- c. The annunciation system shall be capable of connecting to any of the Ludlum 375 models, which are often interchanged as part of a calibration program.

5.2 Requirements for Annunciation

- a. Signs shall be located outside the north and south test cell entrance doors.
- b. These signs when activated shall read “Danger, High Radiation Area”. Signs to be selected in consultation with health physics.
- c. The closure of the output relay on any one of the eight real time dose monitors shall trigger the illumination of the postings.
- d. When radiation levels drop below the setpoint limits the monitor contacts shall “open” and the lighted sign shall cease illumination.
- e. The annunciation lights shall be electrically isolated from components within the test cell as per Section 4.2.3 of the GRD [1].
- f. The system shall be designed so that additional illuminated signs could be added at other D-site locations, if necessary.
- g. The system may use magnetic or solid state relays, but shall not use any programmable devices
- h. Provision shall be made to bypass any individual monitor if it fails or otherwise becomes inoperative during the run. This bypass shall not affect the ability of the other monitors to activate the signs.