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ZPPR Cell Site Information

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MFC-776 Zero Power Physics Reactor (ZPPR) Cell

Nicholas V. Smith, Deputy Director – National Reactor Innovation Center

Address

Materials & Fuels Complex

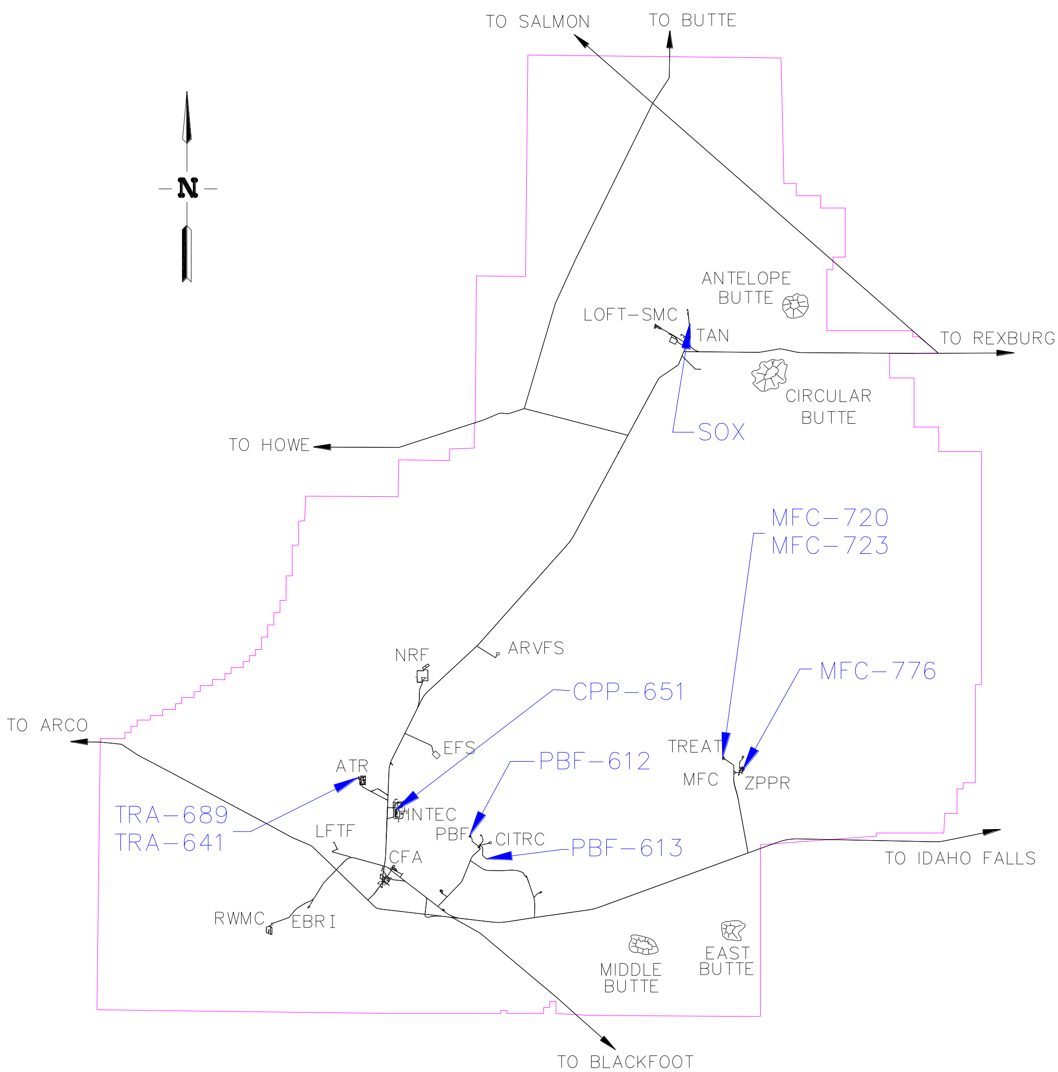

Figure 1. Idaho National Laboratory Site Map

Description

The ZPPR Cell, located in the Materiasl & Fuels Complex as shown in Figure 1, was operated between 1969 and 1990 before being placed into nonoperational standby. The ZPPR reactor and auxiliary equipment have since been removed from the facility. The ZPPR facility consists of a workroom, cell area, and material storage vault. Current facility activities are material inspections and packaging in the workroom/vault, National and Homeland Security testing and detection training in the cell area, and material storage in the vault.

Physical Space Dimensions

The ZPPR cell area is cylindrical. It is roughly 50ft in diameter. A photo of the ZPPR Cell is shown in Figure 2. The floor plan layout is shown in Figure 3. The cell roof is composed of layers of gravel and sand. The gravel/sand roof is supported by a catenary cable network of steel cables. The catenary is 23ft 7in above the cell floor. The existing access points to the cell area are roughly 6ft x 6ft. There are a set of two 14inch duct tubes for HVAC into the cell. There is a 4ft deep pit area and 2ft deep trench.

Figure 2. Photo of ZPPR Cell

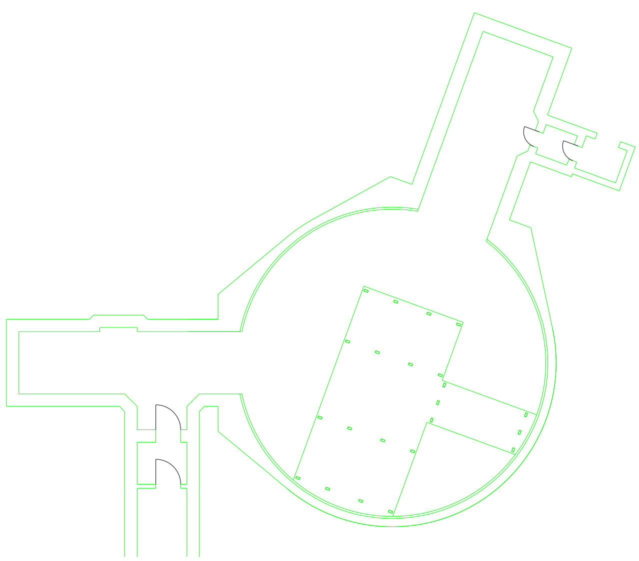

Figure 3. ZPPR Cell floor plan

Safeguards Category and Hazard Category

ZPPR is safeguards category 1 and hazard category 2.

Floor Loading Capacity

The floor loading capacity in the ZPPR cell is 3,000 pounds per square foot on concrete and 1,500 pounds per square foot on the steel plating over the pit.

Existing Electrical Power Capacity

ZPPR cell is fed from MFC-768 Power Plant Building. There are two lightly loaded 2MVA transformers providing power to multiple buildings at MFC. The switchgear feeding ZPPR cell is 600Amp 480V service.

Existing Cranes and Capacity

ZPPR cell has an overhead crane with a 5ton lift capacity.

Access to Argon, Nitrogen, and Instrument Air

The ZPPR cell does have access to instrument air. The ZPPR cell does not currently have access to argon or nitrogen. These utilities would need to be installed if needed.

Seismic Analysis

The HEU Fast Burst Reactor (FBR) report[1] found that the ZPPR cell has previously been analyzed to what is anticipated to be the equivalent of SDC-2 seismic qualification. Analysis will be needed to confirm it meets the needs of the reactor demonstration project or critical experiment. The cost to do this analysis is estimated at $300,000. From the report:

> *It is assumed that the installation of the FBR may meet the requirements of a major modification. Based on a positive Major Modification Determination, a seismic analysis will be required to verify that the facility meets current seismic code requirements sufficient to support the FBR[2]. DOE-STD-1020-2016, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities,"[3] Table 2-1 identifies the unmitigated consequence thresholds for determining seismic categorization. This standard references ANSI/ANS-2.26-2004[4] for the methodology to determine the Seismic Design Category (SDC). Based on the assumption that SPR-III or another ultra-low burn-up type reactor is used in the cell, it can be expected that the FBR would meet a SDC-2[5]. The existing SAR for SPR-III considers the rector a PC-2 piece of equipment[6] which is equivalent to the SDC-2. The ZPPR cell has previously been analyzed to what is anticipated to be equivalent to an SDC-2. A seismic analysis will be required to verify that the facility continues to meets or exceed the seismic needs for the FBR, assumed to be SDC-2.* ***A ROM estimate of $300K was suggested for this effort.***
>
> *Based on these assumptions, no facility seismic upgrades are anticipated for installation of the FBR, other than those required to anchor the FBR and supporting equipment.*

[1] TEV-3176 "ZPPR Support for High Enriched Uranium Fast Burst Reactor Business Case" 03/01/2012
[2] See DOE-STD-1020-2012, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities", Section 2.2
[3] DOE-STD-1020-2016, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities," Department of Energy.
[4] ANSI/ANS-2.26-2004, "Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design". See Table 1.
[5] Meeting held on 9/18/17 with Jason Andrus, Michael Baily, Ben Coryell and Evan Nef and follow-up email dated 9/25/17 between Jason Andrus to Evan Nef
[6] SPRF SAR 2014B Annual Update, 6/2/15, Section E.5.2

Notes on ZPPR HVAC System

The HEU FBR report[1] identified four primary functional needs for the HVAC system[7] in ZPPR Cell to accommodate the project. These were cooling, radiation control, habitable environment and accident protection. From the report:

> *In a meeting with the ZPPR Industrial Hygiene lead[8] it was noted that the cell currently has sufficient airflow to meet habitable environment requirements. If the airflow maintains current levels of flow, no further improvements would be required for that purpose.*
>
> *DOE-HDBK-1169- 2003 guides the confinement methodology for hazardous materials including radiological materials. That methodology requires specific filtration systems for potentially contaminated areas. To support the FBR, the ZPPR cell would be considered a secondary confinement area[9]. Table 2.9 of the handbook notes that "Under emergency conditions, the building must be capable of being maintained at a vacuum of 0.1 to 0.3 in. wg relative to the atmosphere". In discussions with mechanical engineers familiar with the facility[10], it was noted that the cell currently maintains the required pressure differential from the atmosphere. Options were discussed in regards to HVAC scenarios including operations with the FBR.*
>
> *In the current configuration, approximately 1000 cfm of flow is pulled from the cell. Another 4000 cfm is pulled from the ZPPR workroom and vault (MFC-775). Due to the corridor connecting the MFC-776 (Cell) and MFC-775 (workroom and vault), and based on those flow rates, the pressure differential directs flow from the cell to the workroom/vault area, on the assumption that a radiological release is more probable in the workroom/vault area. With minor adjustments to the HVAC system it could be re-configured to increase flow rates in the cell and reduce them from the workroom/vault, thus directing the flow toward the Cell area. In this way, the requirement for accident protection would be met.*
>
> *The alternative scenario is to improve the HVAC system to remove the activated air. Access to the cell is limited as is the current ducting system. Installation of new ducting is anticipated to be troublesome and costly. Additionally, increased airflow would require new air supply units, exhaust fans and an upgraded exhaust stack.* ***The cost for this upgrade is anticipated to be on the order of $5M.***
>
> *The heat load removal scenarios are anticipated to be similar to the air activation scenario, in that the current HVAC system would remove the heat load over time, but an improved HVAC system would be required to remove the head load in a more timely fashion.*

Upgrades Needed

As inferred by the name, ZPPR cell was not designed to handle thermal power production by reactors. Upgrades to add cooling capacity to the cell would be required. Depending on the largest component brought into the facility, a larger door to bring equipment in and out may be required. Some additional security, cameras and alarms, would likely be required in the ZPPR cell. Since the removal of the original ZPPR reactor, several concepts have been considered to take advantage of the space. Table 1 contains Rough Order of Magnitude (ROM) cost estimates which were developed in 2012 to deploy an LEU Pulsed Neutron Environment (PNE) in the ZPPR cell. Table 2 contains ROM cost estimates developed in 2012 to deploy an HEU Fast Burst Reactor in the ZPPR cell. Lastly, Table 3 contains ROM cost estimates developed in 2019 to deploy a Zero Power Critical Test Capability in the ZPPR cell. Although these projects were considering different applications, there is some value to knowing what others expect this type of project to cost.

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[7] Meeting with Chris Long, Brian Cummings, Jason Andrus, Keeshia Goodenough, Tony Hill, Evan Nef 8/16/17

[8] Meeting with Steve Yarnell and Evan Nef, 8/17/17

[9] DOE-HDBK-1169- 2003 Figure 2.3, page 2-11

[10] Meeting with Mark Borland, Carl Baily, Jenn A Hanson, Tim Hyde, Tony Hill, Evan Nef 8/22/17

Table 1. Cost Estimate from TEV-3106 to deploy LEU Pulsed Neutron Environment (PNE) in ZPPR Cell[11]

Activity	**Nominal Cost (1000's)**	**Basis**
Facility Modifications	$200	See Assumption App. B[11]
Establish Safety Basis	$2,500	See Assumption App. B[2]
Establish operations controls/readiness	$500	See Assumption App. B[2]
Security Upgrades	$50	See Assumption App. B -less $25K
Environmental Impact Statement/Permits	$2,000	See Assumption App. B[2]
Reactor Control Infrastructure	$750	Update control room, infrastructure
Rad Control Systems	$100	See Assumption App. B[2]
Sample Retrieval System	$100	Rabbit piping from cell to sample room using existing piping penetrations
Relocation of existing NNSA/NHS programs ****__May not be required in 2020__***	$11,600	Relocation to CPP-651 (see Appendix D[2])
Sub-Total:	$17,800	
Mng. Reserve (10% of project cost)	$1,780	Std.
PM (6% of project cost & MR)	$1,168	See Assumption App. A[2]
Nominal Estimate Grand Total:	$20,754	
Rough Estimate Range:	**$42M to $10.4M**	**(+100%/-50%):**

Table 2. TEV-3176 Cost Estimate to Deploy HEU FBR[1]

Description	**Low Range ***	**Point Value ***	**High Range ***
Project Management	$ 662,920	$ 736,578	$ 1,104,866
Engineering	$ 179,701	$ 199,667	$ 299,501
Environmental	$ 712,394	$ 791,549	$ 1,187,324
ZPPR Modification	$ 1,426,383	$ 1,584,870	$ 2,377,304
Radcon Equipment	$ 263,366	$ 292,629	$ 438,943
Safeguards & Security	$ 754,132	$ 837,924	$ 1,256,886
Safety Analysis Report (SAR)	$ 2,442,953	$ 2,714,392	$ 4,071,588
Operating Procedures	$ 129,477	$ 143,863	$ 215,794
Ops Crew Qualification Training	$ 140,749	$ 156,388	$ 234,582
Operational Readiness	$ 350,182	$ 389,091	$ 583,636
Subtotal	**$ 7,062,256**	**$ 7,846,951**	**$ 11,770,427**

[11] TEV-3106 "INL Facility Support for Pulse Neutron Environment (PNE) Business Case" 03/01/2012.

Table 3. NASA (No Facility Specified) Estimate to deploy Zero Power Critical Test Capability[12]

Zero Power Critical (ZPC) Facility Modifications	Costs
Security/Material Storage	$300K to $350K
Control Room	$300K to $400K
Install HVAC and monitored Stack	$3M to $4M
Reconnect Utilities	$5M to $7M
Project Team Infrastructure (offices, conference room, etc.)	$300K to $400K
Fire Suppression System	$200K to $500K
Install radiation monitors, criticality monitors, and life safety systems	$2M to $4M
ZPC Test Equipment	
ZPC Trays and Non-Nuclear Test Element Fabrication	$150K to $300K
Fabricate Tray Nuclear Material and Thin Film Coupons	$4M to $7M
Split Table	$400K to $500K
Instrumentation and control package	$1M to $1.5M
Data Collection and Storage Capabilities and Equipment Laydown area	$100K to $150K
ZPC SAR/NEPA Development	
SAR Development and Finalization	$750K to $1M
NEPA (Categorical Exclusion/Environmental Assessment)	$200K to $300K
ZPC Testing	
MSA	$200K to $250K
ORR	$200K to $250K
Waste Management	$100K to $150K
Conduct Test Plan *	$200K to $250K
ZPC Limited Characterization	
IMCL	$500K to $1M
AL	$100K to $200K
Total	**$19M to $29.5M**

* - Costs are based on one (1) test to include: Criticality, Material Reactivities, Doppler Coefficients, and Disturbed Core

Additional Considerations

Positive	Negative
• Excellent radiation protection. • Fuel production and reactor could be located at the same site. • Connected to ZPPR workroom, vault, control room by corridor system. • Co-located with MFC for access to infrastructure. • Safeguards category 1 makes working with HEU possible.	• Currently utilized for NNSA/DHS training. • Likely requires upgrades to cooling capacity and larger containment penetration to get equipment in and out. • Activation of concrete may be an issue. • Safeguards category 1 makes access difficult.

[12] Reese, Craig L. "INL/EXT-19-53988 Cost and Schedule Estimates for Establishing a Zero Power Critical Testing Capability at the Idaho National Laboratory to Support NASA Nuclear Thermal Propulsion Design Development" May 2019.