Pre-Conceptual Design of Demonstration Reactor Test Bed

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

NRIC

DELIVER

EMPOWER
Pre-Conceptual Design of Test Beds

Phase 1 - Requirements Definition

Phase 2 - Technical Solution Definition

Phase 3 - Product Realization

Phase 4 - Technical Planning and Readiness

Currently soliciting technical requirements information from potential demonstrators

Feedback will inform design of:

- Heat Rejection Systems
- Mechanical/Structural
- Lifting and Crane Support
- Electrical
- Gas Supply
- Operations Support

Demonstration Test Bed Requirements Gathering Initiative

NBRC needs your input to effectively enable your demonstration.

In 2020, the Nuclear Reactor Innovation Center (NBRC) initiated projects to develop test beds to provide capable facilities to support reactor demonstrations. Two existing facilities at Idaho National Laboratory were chosen for initial test beds: the Experimental Breeder Reactor-II (EBR-II) dome and the Zero Power Physics Reactor (ZPPR). Both provide unique capabilities to enable a wide range of demonstration projects. To support preparing these facilities for demonstrations, NBRC is gathering requirements from potential users. Your response, along with those of other potential users, will influence project decisions and become part of the formal requirement documentation.

Please note which requirements may be negotiable and feel free to contact NBRC with follow-up questions or clarifications.

Reactor demonstration projects are assumed to be modularly constructed, delivered, and installed into the test bed facilities. Other baseline technical assumptions for the facilities are as follows:

- Currently soliciting technical requirements information from potential demonstrators
- Feedback will inform design of:
  - Heat Rejection Systems
  - Mechanical/Structural
  - Lifting and Crane Support
  - Electrical
  - Gas Supply
  - Operations Support

### Heating and Cooling

Our thoughts for regarding heat rejection are that the demonstration site’s HVAC system would be capable of rejecting a specific amount of thermal energy dissipated from reactor operations. The site’s HVAC system would then interface with the reactor’s heat removal system, if any.

1.1. Planned maximum thermal power (steady-state) of the reactor system (e.g., 500 kW)?

1.2. Please describe the planned cooling system for the reactor. Consider the following questions:

1.2.1. If the reactor system includes a heat removal system, is it planned to be a closed loop?

1.2.2. If gas is used for the primary cooling and is not a closed loop, what is the flow rate? This information supports understanding requirements for rejecting noncondensables to the environment outside of the demonstration facility?

1.3. Describe any environmental (dew point, ambient temperature, humidity, etc.) requirements for inside the demonstration site?

### Mechanical/Structural

2.1. What are the general dimensions of the reactor system?

2.2. What are the general dimensions of the largest component?

2.3. What are the general dimensions of components needing transport via shelled cook?

2.4. To still in understanding floor loading limitations, what is the rough weight of the heaviest component? Optionally, floor loading requirements can be provided.

2.5. To still in understanding floor loading limitations, what is the rough weight of the combined system? Optionally, floor loading requirements can be provided.

### Parameter Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EBR-II</th>
<th>ZPPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Reactor Thermal Power (MW)</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Maximum Floor Loading (lbs) [total/roof]</td>
<td>Not evaluated / 3,750</td>
<td>500,000 / 3,000</td>
</tr>
<tr>
<td>Mobile Transfer Port and Location</td>
<td>Near ground-level door/roof</td>
<td>Roof hatch</td>
</tr>
<tr>
<td>Largest Dimension of Objecting (L)</td>
<td>9</td>
<td>Up to 20</td>
</tr>
<tr>
<td>Usable Area Inside Containment (ft²)</td>
<td>~4,000</td>
<td>1,200</td>
</tr>
<tr>
<td>Onsite Power Available</td>
<td>200 kVA @ 480V</td>
<td>200 kVA @ 480V</td>
</tr>
<tr>
<td>Target Ready-for-Demonstration Date</td>
<td>End of 2023</td>
<td>End of 2023</td>
</tr>
</tbody>
</table>

*May be negotiable depending on needs.*
EBR-II Test Bed (ETB) Information

- 80 ft diameter, 1 ft thick rebar reinforced concrete walls with steel plating on exterior
- Reactor can be co-located with existing capabilities at MFC
  - Fuel production, hot cells, characterization, and machine shop
- Floor loading capacity of 3,750 psf
- Available utilities, including electrical power, communications, and compressed gas systems
- ~4,800 sqft of floor space inside dome
- Near ground level entry point for installation of equipment
- Safeguards Category 2, Hazard Category 2
General Requirements: EBR-II Test Bed (ETB) for Demonstration Reactors

- ETB shall be capable of **hosting operational nuclear reactors** that meet Requirements & Limitations for use Criteria
  - Module size compatible with equipment door (est. 14’ x 14’)
  - Less than 20% enriched fuel
  - Less than 10MWt power production
- ETB shall provide dynamic capability to remove heat from containment
- ETB shall include a staging area for installation and removal of reactors
- ETB shall provide an integrated control room for operation of reactors and support systems
- ETB shall provide 200 kVA electrical service at 480V
- ETB shall be capable of handling externally clean used fuel containers from reactors
- ETB shall be capable of handling radioactive samples for Post Irradiation Examination (PIE) of reactor materials
- ETB shall include staff necessary for operations of reactors and maintenance of test bed systems
- ETB shall provide a system for physical and digital protection of demonstrator’s intellectual property
Concept of Operations: EBR-II Test Bed (ETB) for Demonstration Reactors

- Reactors will be installed in the dome via a loading zone capable of handling trailer mounted containers (ex. Connex)
- Reactors will be removed utilizing the same path
- The ETB will consist of safety related structures and equipment to enable the critical operation of non-power reactors
- Intended to reduce time and money required to permit, install, commission, operate, and decommission demonstration reactors
- Safety basis broad enough to cover range of reactors
- INL to receive shipment of assembled demonstration unit and take ownership at MFC
- INL to install and commission the reactor in collaboration with innovator
- INL to train operators in collaboration with innovator
- INL to operate the reactor according to experimental plan developed with innovator
- INL to execute deactivation plan at end of life
ZPPR Test Bed (ZTB) Information

• Built as Safeguards Category 1, Hazard Category 2 facility for reactor operations

• HEU and Pu Fuel Capable

• Co-located with other MFC Capabilities:
  – Fuel production, hot cells, characterization, and machine shop

• Floor loading 3,000 psf or 500,000 lbs total

• 200 kVA, 480V electrical service

• Class 1E battery backup power and non-safety-related 100kW diesel generator

• Compressed gas systems

• ~1,300 sqft floor space

• Co-located Control Room

• Roof entry point for installation of equipment and reactor packages
General Requirements for ZPPR Test Bed (ZTB) for Demonstration Reactors

- ZTB shall be capable of hosting operational nuclear reactors that meet Requirements & Limitations for use Criteria
  - Module size compatible with equipment door (est. 20' diameter via roof hatch)
  - Greater than 20% enriched fuel
  - Less than 500kWt power production
- ZTB shall provide dynamic capability to remove heat from containment
- ZTB shall include a staging area for installation and removal of reactors
- ZTB shall include a staging area for installation and removal of reactors
- ZTB shall provide an integrated control room for operation of reactors and support systems
- ZTB shall provide 200 kVA electrical service at 480V
- ZTB shall be capable of handling externally clean used fuel containers from reactors
- ZTB shall be capable of handling radioactive samples for Post Irradiation Examination (PIE) of reactor materials
- ZTB shall include staff necessary for operations of reactors and maintenance of test bed systems
- ZTB shall provide a system for physical and digital protection of demonstrator’s intellectual property
Concept of Operations: ZPPR Test Bed (ZTB) for Demonstration Reactors

- Reactors will be installed in the cell via a roof mounted entry point
- Reactors will be removed utilizing the same path
- The ZTB will consist of safety related structures and equipment to enable the critical operation of non-power reactors
- Intended to reduce time and money required to permit, install, commission, operate, and decommission demonstration reactors
- Safety basis broad enough to cover range of reactors
- INL to receive shipment of assembled demonstration unit and take ownership at MFC
- INL to install and commission the reactor in collaboration with innovator
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LEGEND

45% RG CHILLED WATER AND DOWOTHERM DRY COOLER COOLING SYSTEMS PROCESS AND INSTRUMENTATION DIAGRAM

NOTE

PRELIMINARY
Progress on Test Bed Pre-Conceptual Design to date:

- Initiated Technical Requirements Gathering from Stakeholders
- ETB General Requirements Document
- ETB Initial ConOps Document
- ZTB General Requirements Document
- ZTB Initial ConOps Document
- ZTB Functional & Operational Requirements Document
- ZTB System Breakdown Structure
- ZTB Heat Rejection Architecture Design of Alternatives
Additional projects to enable rapid demonstration of reactor concepts proposed by industry

- **Risk reduction in DOE authorization process for demonstration reactors**
  - Utilize generic, enveloped, demonstration reactor parameters to initiate DOE facility authorization process

- **Risk reduction in NEPA process for demonstration reactors**
  - Utilize generic, enveloped, demonstration reactor parameters to initiate NEPA process

- **Preparation of new fuel production infrastructure**

- **Provision of satellite office space for on-site collaboration with industry partners**
  - Meeting space enabling industry to work and host events for potential customers, investors, and others