TerraPower

September 19, 2022

TP-LIC-LET-0039
Project Number 99902100

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTN: Document Control Desk

Subject: TerraPower In-Vessel Instrumentation Presentation Material

This letter provides the TerraPower, LLC presentation material for the upcoming In-Vessel Instrumentation pre-application meeting (Enclosures 2 and 3). The presentation material contains proprietary information and as such, it is requested that Enclosure 3 be withheld from public disclosure in accordance with 10 CFR 2.390, “Public inspections, exemptions, requests for withholding.” An affidavit certifying the basis for the request to withhold Enclosure 3 from public disclosure is included as Enclosure 1. The proprietary material has been redacted from the presentation material in Enclosure 2.

This letter and enclosures make no new or revised regulatory commitments.

If you have any questions regarding this submittal, please contact Ryan Sprengel at rsprengel@terrapower.com or (425) 324-2888.

Sincerely,

Ryan Sprengel
License Application Development Manager
TerraPower, LLC

Enclosures:
1. TerraPower, LLC Affidavit and Request for Withholding from Public Disclosure (10 CFR 2.390(a)(4))
2. "In-Vessel Instrumentation" Presentation Material – Non-Proprietary (Public)
3. "In-Vessel Instrumentation" Presentation Material – Proprietary (Non-Public)

cc: Mallecia Sutton, NRC

ENCLOSURE 1

TerraPower, LLC Affidavit and Request for Withholding from Public Disclosure (10 CFR 2.390(a)(4))

Enclosure 1
TerraPower, LLC Affidavit and Request for Withholding from Public Disclosure
(10 CFR 2.390(a)(4))

I, George Wilson, hereby state:

1. I am the Vice President of Regulatory Affairs and I have been authorized by TerraPower, LLC (TerraPower) to review information sought to be withheld from public disclosure in connection with the development, testing, licensing, and deployment of the Natrium^{TM} reactor and its associated fuel, structures, systems, and components, and to apply for its withholding from public disclosure on behalf of TerraPower.

2. The information sought to be withheld, in its entirety, is contained in Enclosure 3, which accompanies this Affidavit.

3. I am making this request for withholding, and executing this Affidavit as required by 10 CFR 2.390(b)(1).

4. I have personal knowledge of the criteria and procedures utilized by TerraPower in designating information as a trade secret, privileged, or as confidential commercial or financial information that would be protected from public disclosure under 10 CFR 2.390(a)(4).

5. The information contained in Enclosure 3 accompanying this Affidavit contains non-public details of the TerraPower regulatory and developmental strategies intended to support NRC staff review.

6. Pursuant to 10 CFR 2.390(b)(4), the following is furnished for consideration by the Commission in determining whether the information in Enclosure 3 should be withheld:

   a. The information has been held in confidence by TerraPower.

   b. The information is of a type customarily held in confidence by TerraPower and not customarily disclosed to the public. TerraPower has a rational basis for determining the types of information that it customarily holds in confidence and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application and substance of that system constitute TerraPower policy and provide the rational basis required.

   c. The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR 2.390, it is received in confidence by the Commission.

   d. This information is not available in public sources.

   e. TerraPower asserts that public disclosure of this non-public information is likely to cause substantial harm to the competitive position of TerraPower, because it would enhance the ability of competitors to provide similar products and services by reducing their expenditure of resources using similar project methods, equipment, testing approach, contractors, or licensing approaches.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on: September 19, 2022

George Wilson

George Wilson
Vice President of Regulatory Affairs
TerraPower, LLC

ENCLOSURE 2

“In-Vessel Instrumentation” Presentation Material

Non-Proprietary (Public)

NATRIUM

In-Vessel Instrumentation

a TerraPower & GE-Hitachi technology

NATD-LIC-PRSNT-0029

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Portions of this presentation are considered proprietary and TerraPower, LLC requests it be withheld from public disclosure under the provisions of 10 CFR 2.390(a)(4)

Nonproprietary versions of this presentation indicate the redaction of such information using [[ ]]$^{(a)(4)}$

Objectives

- Natrium™ reactor overview
- Present the basis for [[ ]](a)(4)
- Present the [[ ]](a)(4)

Presentation Table of Contents

- Temperature Monitoring
- Flux Monitoring
- Pressure and Flow Monitoring

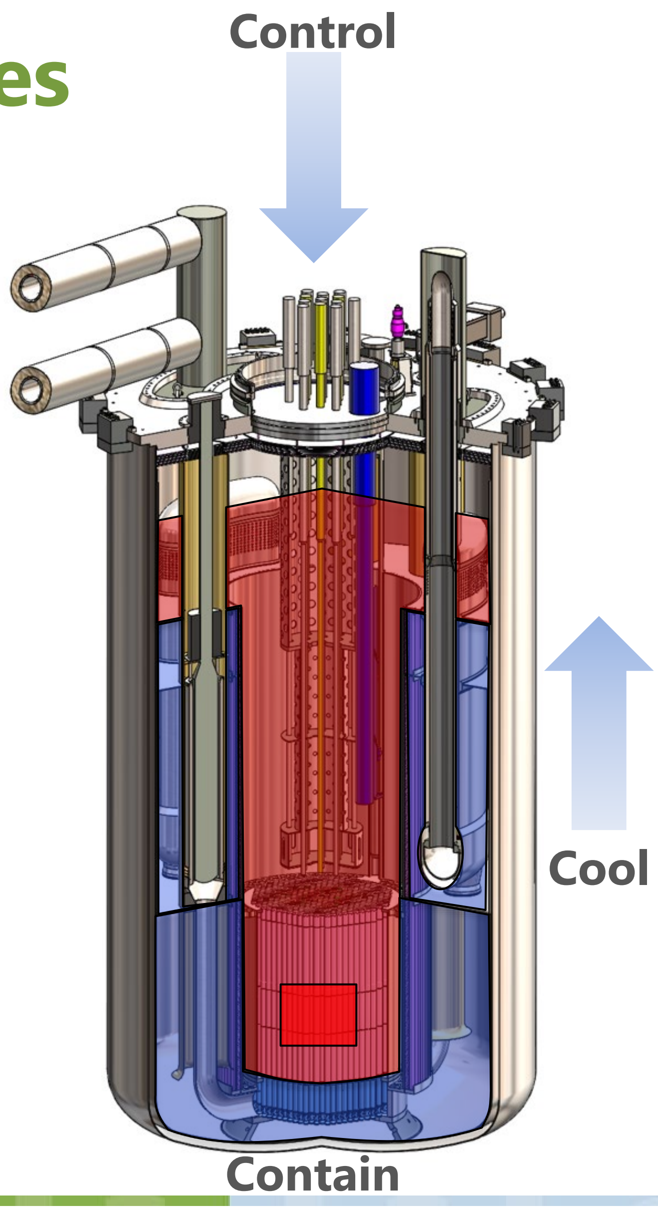
Natrium Reactor Overview

- The Natrium project is demonstrating the ability to design, license, construct, startup and operate a Natrium reactor within a seven-year timeframe.

- Pre-application interactions are intended to reduce regulatory uncertainty and facilitate the NRC's understanding of the Natrium design and its safety case.

Natrium Safety Features

- Pool-type Metal Fuel SFR with Molten Salt Energy Island
  - Metallic fuel and sodium have high compatibility
  - No sodium-water reaction in steam generator
  - Large thermal inertia enables simplified response to abnormal events
- Simplified Response to Abnormal Events
  - Reliable reactor shutdown
  - Transition to coolant natural circulation
  - Indefinite passive emergency decay heat removal
  - Low pressure functional containment
  - No reliance on Energy Island for safety functions
- No Safety-Related Operator Actions or AC power
- Technology Based on U.S. SFR Experience
  - EBR-I, EBR-II, FFTF, TREAT
  - SFR inherent safety characteristics demonstrated through testing in EBR-II and FFTF



Control

- Motor-driven control rod runback
- Gravity-driven control rod scram
- Inherently stable with increased power or temperature

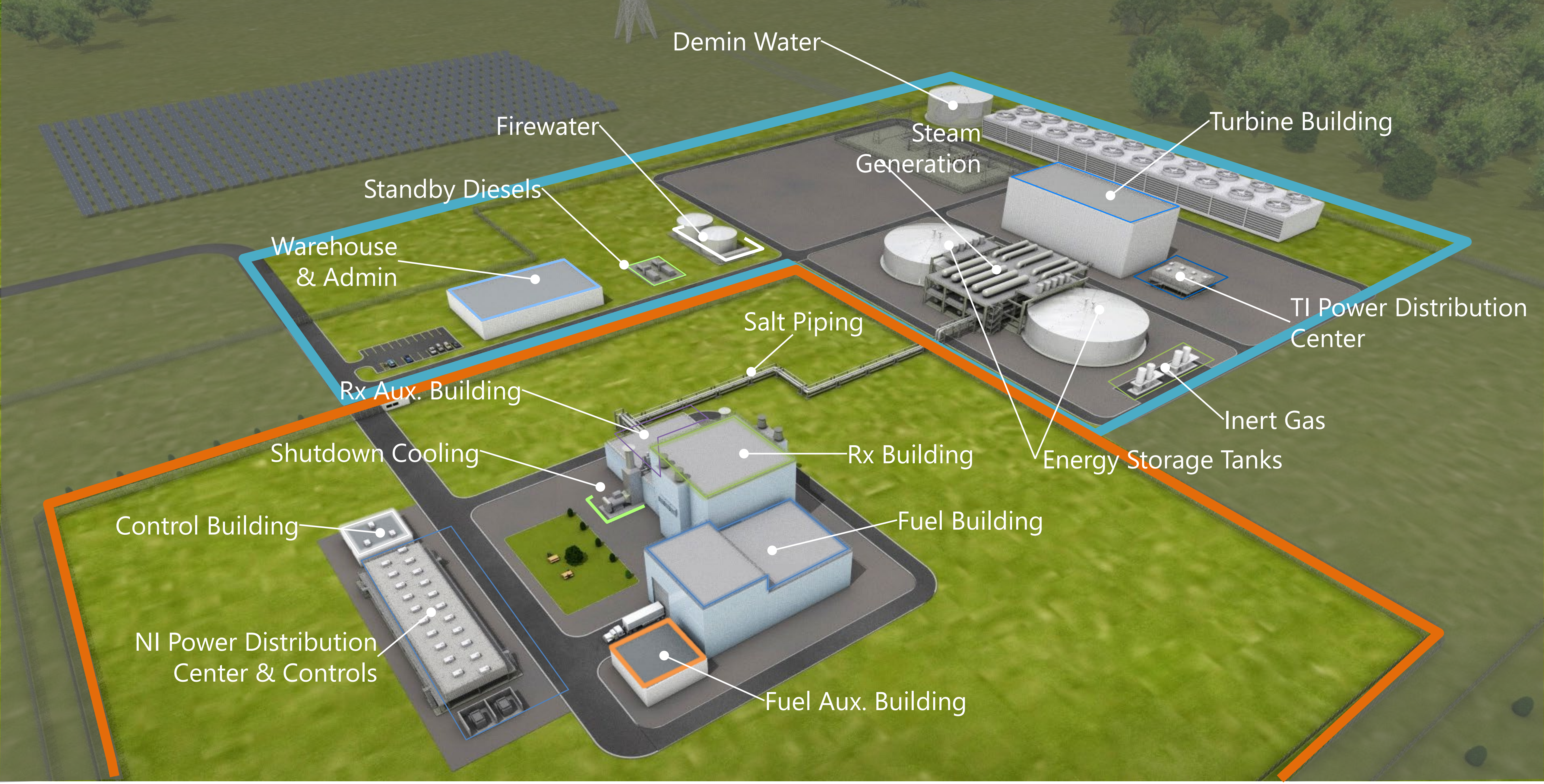
Cool

- In-vessel primary sodium heat transport (limited penetrations)
- Intermediate air cooling natural draft flow
- Reactor air cooling natural draft flow – always on

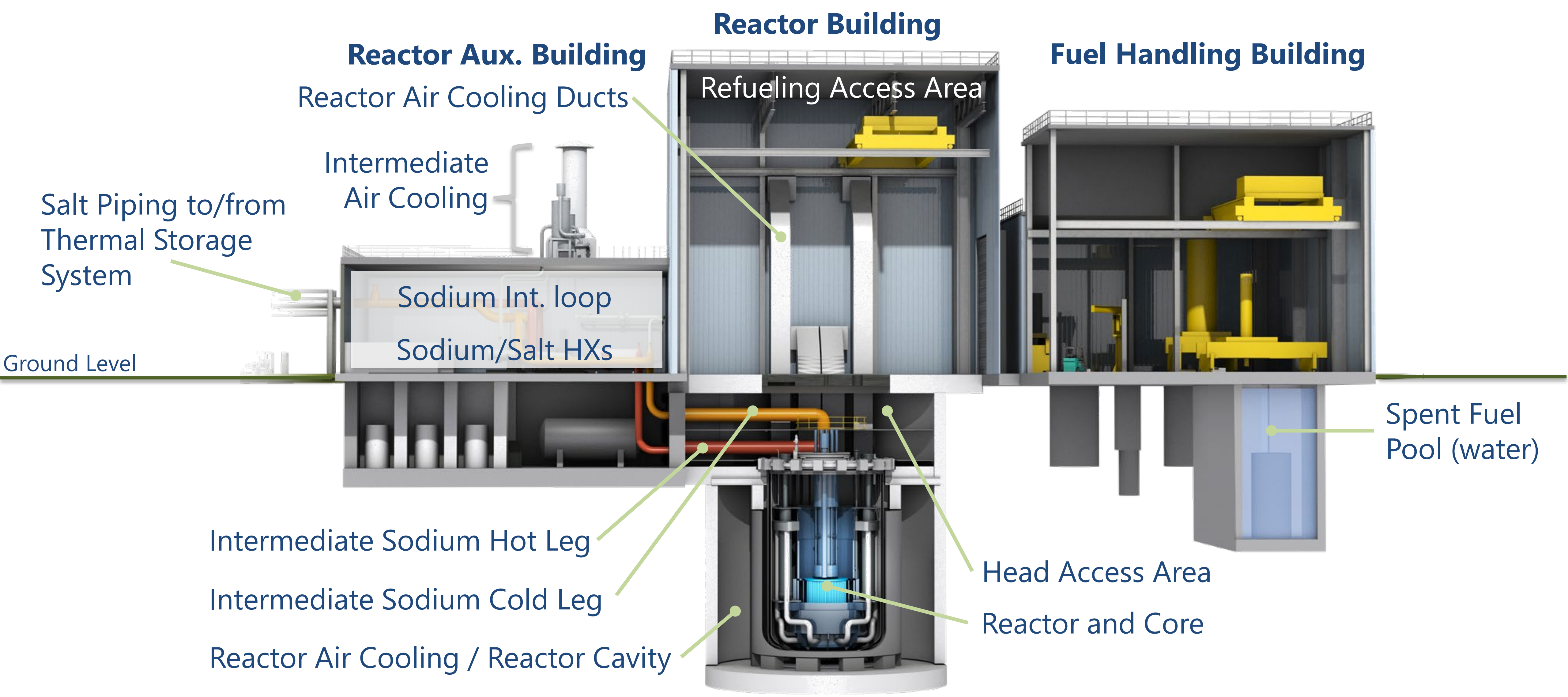
Contain

- Low primary and secondary pressure
- Sodium affinity for radionuclides
- Multiple radionuclides retention boundaries

TerraPower NATRIUM



TerraPower NATRIUM



TerraPower NATRIUM

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Thermocouple Locations

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Past Experience

- FFTF utilized three detector channels with **segregated source-range and wide-range detectors**.
- To achieve adequate service life and sensitivity, FFTF design required retraction of the in-vessel source range detectors.
- Current High Temperature Fission Chamber detectors (HTFC) can support a full-service life without retraction in peak fluence conditions.

Natrium Design

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Type	Unit		CFUC 06
Neutron Sensitivity	Current mode	$A/n.cm^{-2}.s^{-1}$	2E-13
	Fluctuation Mode	$A^2.Hz^{-1}/n.cm^{-2}.s^{-1}$	4E-26
	Pulse Mode	$c.\ s^{-1}/n.cm^{-2}.s^{-1}$	1
Pulse Operating Range		$n.cm^{-2}.s^{-1}$	1-10E5

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Historic Perspective on DND

From Argonne National Laboratory
"Fuel column and plenum breaches in metallic fuel elements can be **readily differentiated by analysis of their fission gas** release characteristics."
"Reactor operations can be continued for months with breached metallic fuel because of low fission gas activity and **no evidence of breach extension or fuel loss to the coolant**."

From Oak Ridge National Laboratory
"In a pool plant reactor, the coolant transport time of breach site delayed neutrons from core exit to delayed neutron detectors located in the IHX is too great compared to decay constants for reliable detection. **The gas tagging system described above provides a more feasible approach for detecting failed fuel pins**."

From the PRISM PSID
In regard to a delayed neutron detection system indicating fuel exposure to bulk coolant: "**May not indicate a failure for a considerable time, if ever**."

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Engineering Perspective on DND

For oxide fuel breaches, there are more precursors released into the coolant and continued release (washout). This makes the detection of initial release and the increasing breach size, making DND detection feasible.

Metal fuel is more compatible with sodium coolant and the failure mechanisms are less severe. **Fuel breaches do not propagate** through the fuel or across assemblies and fewer precursors are released, both initially and subsequently. Those that are released have a half-life that further reduces visibility.

All fuel breaches release fission gases, which would be readily **detected through cover gas gamma spectroscopy and fission gas monitoring.** Identification of the failed assembly can be accomplished using a tag gas.

Tag Gas ID Systems

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Isotope	Half Life (s)
Br-87	55.65
Br-88	16.29
Br-89	4.40
I-137	24.1
I-138	6.23

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In-Core Neutron Flux Monitoring

- FFTF took advantage of the extremely flat power profile (indicative of long mean free path lengths) to **eliminate the need for a dedicated in core monitoring system**.

- From FFTF HEDL-400:
  "The Flux Monitoring System also provides for insertion and withdrawal of passive and/or active dosimeters (self-powered detectors, and activation wires and foils) used to determine neutron flux, fluence and spectrum in-core for mapping both radial and axial coordinates. Readout of activational packets such as wires and foils is accomplished in a counting room provided by System 21."

- This methodology was repeated for Clinch River:
  "The CRBRP flux monitoring system is a conventional ex-vessel three-range system based on FFTF design."

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International Detection Systems

Reactor	Detector	Location	Range of Coverage
PHENIX	High temperature fission chambers	In-vessel, lateral neutron shield	Shutdown, first period of startup
	Boron-lined chambers	Under the vessel, in a graphite block	Intermediate range
	Ionization chambers	Under the vessel, in a graphite block	Power range for safety and control
SUPER-PHENIX	Helium counters	Under the vessel, below neutron guides	Startup
	Fission chambers	Under the vessel, below neutron guides	Intermediate and power range
	High temperature fission chambers	Special central sub-assembly	Core loading and startup testing
EFR	High temperature fission chambers	Above-core-structure (ACS)	Shutdown to full power (10 decades) and apt to be used with a high gamma field of 10^5 R/h
FBTR	Fission counters	Detector pits in biological shield concrete	Shutdown, startup to 2 kW
	Compensated ionization chambers	Detector pits in biological shield concrete	200 W to 200 MW for safety 50 W to 50 MW for control
	Boron-coated counters of 4 cps/nv connected in parallel	Detector pits in biological shield concrete	Startup after long shutdown
PBR	Temporary detectors	Temporary installation for initial startup	

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Normal Power Distribution

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Radial Power Profile

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Design Considerations for Flux Tilting

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Pressure Monitoring

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SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Flow Monitoring

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Questions?

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Acronym List

ARCAP – Advanced Reactor Content of Application Project
ARDC – Advanced Reactor Design Criteria
ARDP – Advanced Reactor Demonstration Program
BF3 – Boron Tri-flouride
CFR – Code of Federal Regulations
DID – Defense-in-Depth
EBR – Experimental Breeder Reactor
FFTF – Fast Flux Test Facility
GDC – General Design Criteria
IHX – Intermediate Heat Exchanger
IVTM – In-Vessel Transfer Machine
LBE – Licensing Basis Event
LMP – Licensing Modernization Project
NSRST – Non-Safety Related, Special Treatment
PAM – Post Accident Monitoring
PDC – Principal Design Criteria
PSAR – Preliminary Safety Analysis Report
RIPB – Risk-Informed, Performance-Based
SFR – Sodium Fast Reactor
SR – Safety Related
SSC – Structures, systems, and components
TICAP – Technology Inclusive Content of Application Project
TREAT – Transient Reactor Test

ENCLOSURE 3

“In-Vessel Instrumentation” Presentation Material

Proprietary (Non-Public)