October 27, 2022

TP-LIC-LET-0046
Project Number 99902100

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

Subject: TerraPower "Principal Design Criteria" and "Reactivity Control" Presentation Material

This letter provides the TerraPower, LLC presentation material for the upcoming "Principal Design Criteria" and "Reactivity Control" pre-application engagement meeting (Enclosures 2, 3, and 4). The presentation material contains proprietary information and as such, it is requested that Enclosure 4 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 4 from public disclosure is included as Enclosure 1. The proprietary material has been redacted from the presentation material in Enclosure 3.

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
Director of Licensing, Natrium
TerraPower, LLC

Enclosures:
1. TerraPower, LLC Affidavit and Request for Withholding from Public Disclosure (10 CFR 2.390(a)(4))
2. "Principal Design Criteria" Presentation Material – Open Meeting – Non-Proprietary (Public)
3. "Reactivity Control" Presentation Material – Closed Meeting – Non-Proprietary (Public)
4. "Reactivity Control" Presentation Material – Closed Meeting – Proprietary (Non-Public)

cc: Mallecia Sutton, NRC
William Jessup, NRC
Nathan Howard, DOE
Jeff Ciocco, DOE

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, 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™ 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 4, 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 4 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 4 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: October 27, 2022

George Wilson

George Wilson
Vice President, Regulatory Affairs
TerraPower, LLC

ENCLOSURE 2

"Principal Design Criteria" Presentation Material – Open Meeting

Non-Proprietary (Public)

TerraPower

NATRIUM

Principal Design Criteria

a TerraPower & GE-Hitachi technology

NATD-LIC-PRSNT-0042

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Objectives

- Natrium™ reactor overview
- Process for Developing Natrium PDC
- Summary of PDC

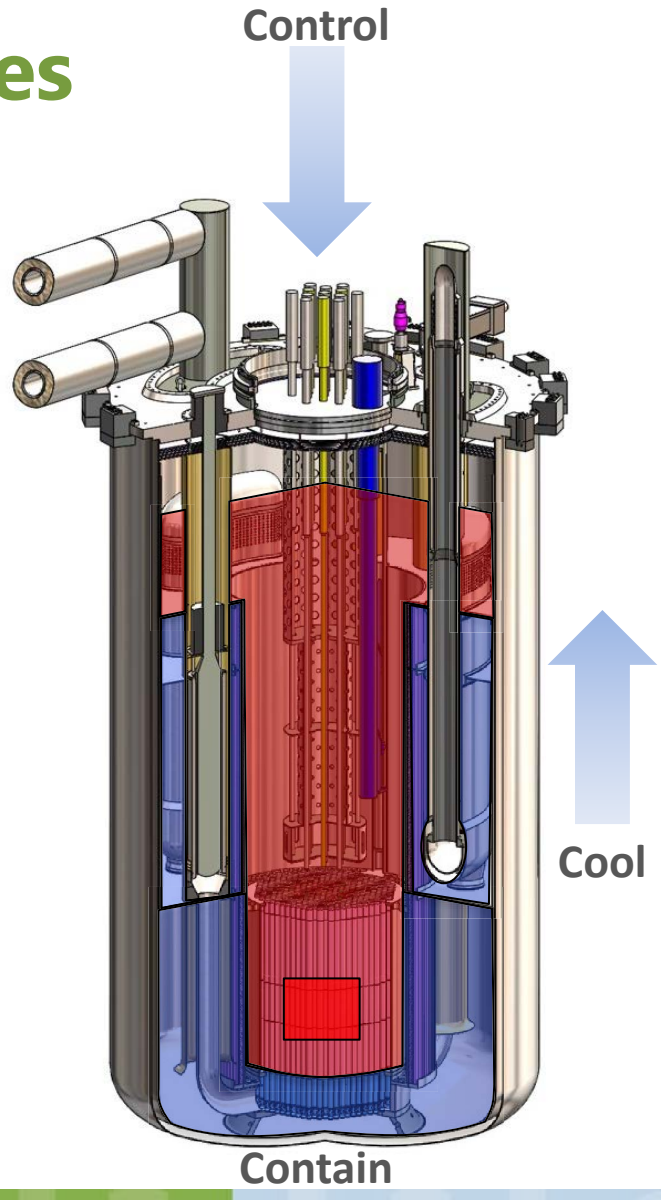
Natrium Reactor Overview

- The Natrium project is demonstrating the ability to design, license, construct, startup and operate the Natrium plant 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

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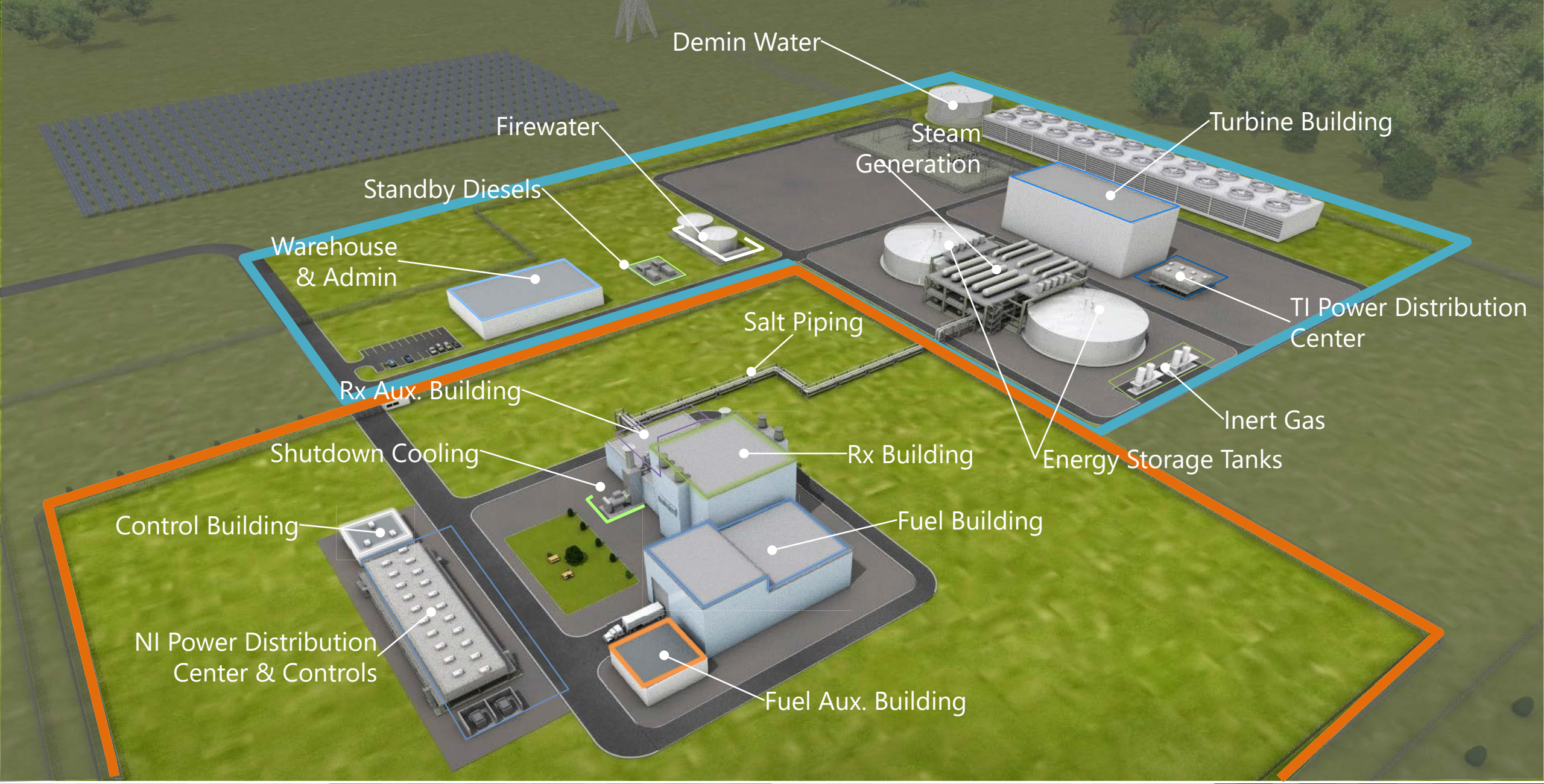

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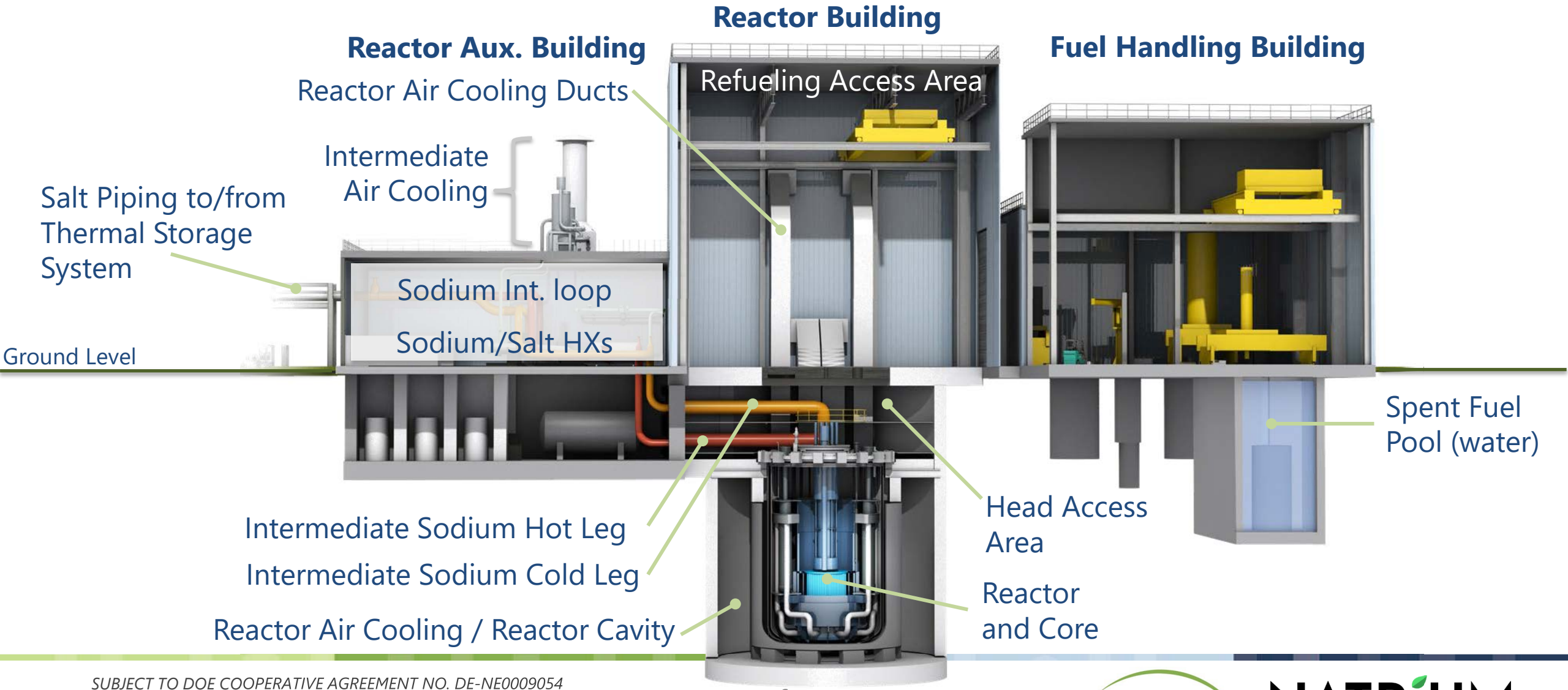
Plant Overview



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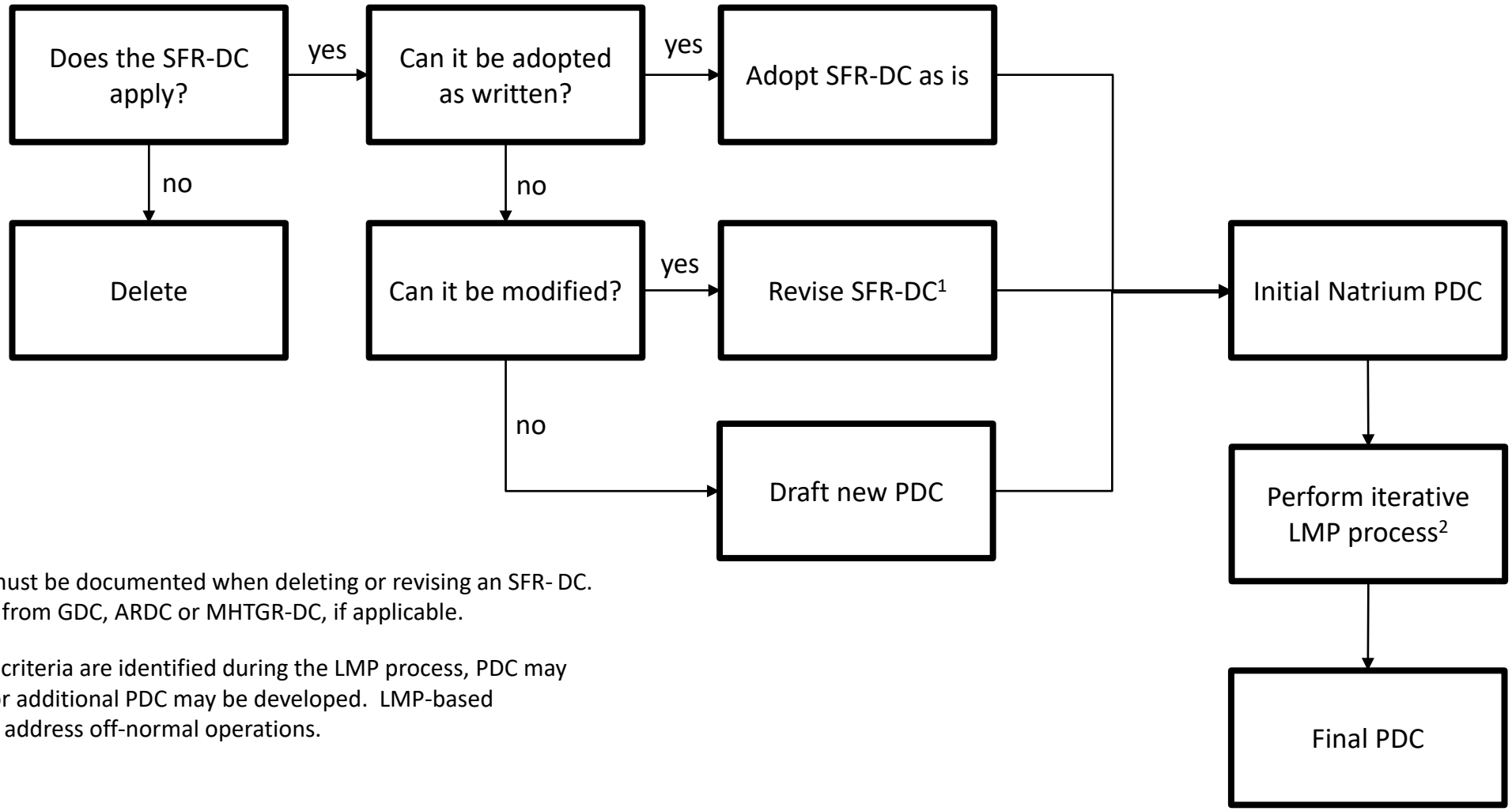
PDC Development

- Natrium advanced reactor will be licensed using 10 CFR Part 50 and NEI 18-04, as endorsed by RG 1.233.
- 10 CFR 50.34(a)(3) requires development of PDC for the facility.
- RG 1.232 provides insights into the NRC staff's views on how the GDC contained in 10 CFR Part 50 Appendix A could be interpreted to address non-LWR design features.
- RG 1.232 Appendix B, SFR-DC was used as a starting point for development of Natrium PDC.

PDC Development



[1] Justification must be documented when deleting or revising an SFR- DC. Use language from GDC, ARDC or MHTGR-DC, if applicable.

[2] If new design criteria are identified during the LMP process, PDC may be modified or additional PDC may be developed. LMP-based modifications address off-normal operations.

PDC Categories

- No change from RG 1.232
- RG 1.232 design criteria not applicable
- Change SAFDL to SARRDL
- Change “important to safety” to “safety-significant”
- Safety-significant language added to clarify scope
- Natrium-specific language

PDC Category Summary

Category	Number of PDC
No change from RG 1.232	18
RG 1.232 design criteria not applicable	15
Change SAFDL to SARRDL	5
Change “important to safety” to “safety-significant”	14
Safety-significant language added to clarify scope	7
Natrium-specific language	10

Total number of PDC = 68*

* PDC 78 is counted twice in the table above due to SARRDL and safety-significant change.

No Change from RG 1.232

PDC 11 - Reactor inherent protection.
PDC 21 - Protection system reliability and testability.
PDC 22 - Protection system independence.
PDC 23 - Protection system failure modes.
PDC 24 - Separation of protection and control systems.
PDC 25 - Protection system requirements for reactivity control malfunctions.
PDC 29 - Protection against anticipated operational occurrences.
PDC 35 - Emergency core cooling.
PDC 36 - Inspection of emergency core cooling system.
PDC 45 - Inspection of structural and equipment cooling systems.
PDC 60 - Control of releases of radioactive materials to the environment.
PDC 62 - Prevention of criticality in fuel storage and handling.
PDC 63 - Monitoring fuel and waste storage.
PDC 70 - Intermediate coolant system.
PDC 71 - Primary coolant and cover gas purity control.
PDC 74 - Sodium/water reaction prevention/mitigation.
PDC 79 - Cover gas inventory maintenance.
PDC 80 - Reactor vessel and reactor system structural design basis.

RG 1.232 Design Criteria Not Applicable

PDC 27 - Combined reactivity control systems capability.
PDC 38 - Containment heat removal.
PDC 39 - Inspection of containment heat removal system.
PDC 40 - Testing of containment heat removal system.
PDC 41 - Containment atmosphere cleanup.
PDC 42 - Inspection of containment atmosphere cleanup systems.
PDC 43 - Testing of containment atmosphere cleanup systems.
PDC 50 - Containment design basis.
PDC 51 - Fracture prevention of containment pressure boundary.
PDC 52 - Capability for containment leakage rate testing.
PDC 53 - Provisions for containment testing and inspection.
PDC 54 - Piping systems penetrating containment.
PDC 55 - Primary coolant boundary penetrating containment.
PDC 56 - Containment isolation.
PDC 57 - Closed system isolation valves.

As with the ARDC in RG 1.232 App. A, PDC 27 is incorporated into PDC 26.

RG 1.232, App. C (MHTGR-DC 16):

"GDC 38, 39, 40, 41, 42, 43, 50, 51, 52, 53, 54, 55, 56, and 57 are not applicable … since they address design criteria for pressure-retaining containments in the traditional LWR sense."[1]

[1] PDC associated with pressure-retaining containments in the traditional LWR sense were deleted. Additional MHTGR-DC criteria were added to the Natrium PDC in accordance with the guidance in RG 1.232, App. C for applicants using a functional containment approach.

SAFDL to SARRDL

PDC 10 - Reactor design.
PDC 12 - Suppression of reactor power oscillations.
PDC 33 - Primary coolant inventory maintenance.
PDC 34 - Residual heat removal.
PDC 78 - Primary Coolant System Interfaces.

Reactor design.

The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable system radionuclide release ~~fuel~~ design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

Use of Safety-Significant

- To clarify the scope of SSCs that perform risk-significant functions (i.e., safety-related or non-safety-related with special treatment), including those that perform functions that are necessary to meet defense-in-depth criteria, NEI 18-04 explicitly defines the term "safety-significant."

- The use of this term is endorsed in RG 1.233, and its use is judged to *describe more consistently the SSCs that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public*.

“Important to Safety” to “Safety-Significant”

PDC 1 - Quality standards and records.
PDC 2 - Design bases for protection against natural phenomena.
PDC 3 - Fire protection.
PDC 4 - Environmental and dynamic effects design bases.
PDC 16 - Containment design.
PDC 18 - Inspection and testing of electric power systems.
PDC 20 - Protection system functions.
PDC 44 - Structural and equipment cooling.
PDC 61 - Fuel storage and handling and radioactivity control.
PDC 72 - Sodium heating systems.
PDC 73 - Sodium leakage detection and reaction prevention and mitigation.
PDC 75 - Quality of the intermediate coolant boundary.
PDC 77 - Inspection of the intermediate coolant boundary.
PDC 78 - Primary Coolant System Interfaces.

Structural and equipment cooling.

A system to transfer heat from safety-significant structures, systems, and components ~~important to safety~~ to an ultimate heat sink shall be provided, as necessary, to transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions.

Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure that the system safety function can be accomplished, assuming a single failure.

“Safety-Significant” Added to Clarify Scope

PDC 14 - Primary coolant boundary.
PDC 15 - Primary coolant system design.
PDC 28 - Reactivity limits.
PDC 31 - Fracture prevention of primary coolant boundary.
PDC 30 - Quality of primary coolant boundary.
PDC 32 - Inspection of primary coolant boundary.
PDC 76 - Fracture prevention of the intermediate coolant boundary.

Primary coolant boundary.

The safety-significant elements of the primary coolant boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

Natrium-Specific Language

PDC 5 - Sharing of structures, systems, and components.
PDC 13 - Instrumentation and control.
PDC 17 - Electric power systems.
PDC 19 - Control room.
PDC 26 - Reactivity control systems.
PDC 37 - Testing of emergency core cooling system.
PDC 46 - Testing of structural and equipment cooling systems.
PDC 64 - Monitoring radioactivity releases.
PDC 81 - Reactor building design basis.
PDC 82 - Provisions for periodic reactor building inspection.

Testing of emergency core cooling system.

A system that provides emergency core cooling shall be designed to permit appropriate periodic functional testing to ensure (1) the structural ~~and leaktight~~ integrity of its components, (2) the operability and performance of the system components, and (3) the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including operation of any associated systems and interfaces necessary to transfer decay heat to the ultimate heat sink.

Natrium-Specific Language

Monitoring radioactivity releases.

Means shall be provided for monitoring the reactor building ~~containment~~ atmosphere, spaces containing components for primary system sodium and cover gas cleanup and processing, effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.

Provisions for periodic reactor building inspection.

The reactor building shall be designed to permit (1) appropriate periodic inspection of all important structural areas ~~and the depressurization pathway~~, and (2) an appropriate surveillance program.

References

- NEI 18-04, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development”
- NEI 21-07, “Technology Inclusive Guidance for Non-Light Water Reactors”
- RG 1.233, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors“
- RG 1.232, "Developing Principal Design Criteria for Non-Light Water Reactors“
- "Principal Design Criteria for the Kairos Power Fluoride Salt- Cooled, High Temperature Reactor" (ML20167A174)

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Acronym List

ARDC – advanced reactor design criteria
CFR – Code of Federal Regulations
EBR – Experimental Breeder Reactor
FFTF – Fast Flux Test Facility
GDC – general design criteria
LMP – Licensing Modernization Project
MHTGR-DC – modular high-temperature gas-cooled reactor design criteria
NEI – Nuclear Energy Institute
PDC – principal design criteria
RG – Regulatory Guide
SAFDL – specified acceptable fuel design limits
SARRDL – specified acceptable system radionuclide release limits
SFR – sodium-cooled fast reactor
SFR-DC – sodium-cooled fast reactor design criteria
TREAT – Transient Reactor Test

ENCLOSURE 3

"Reactivity Control" Presentation Material –
Closed Meeting

Non-Proprietary (Public)

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NATRIUM

Reactivity Control

a TerraPower & GE-Hitachi technology

NATD-LIC-PRSNT-0043

Portions of this presentation are considered export controlled information (ECI). ECI must be protected from public disclosure per the requirements of 15 CFR 730 and 10 CFR 810.

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 [[ ]]$^{(a)(4)}$, [[ ]]^{ECI}, or [[ ]]$^{(a)(4),\ ECI}$.

Table of Contents

PRINCIPAL DESIGN CRITERIA 26 DEVELOPMENT AND PROPOSED CHANGES

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10 CFR 50, Appendix A General Design Criterion 26 and 27

- "Two ***independent reactivity control systems of different design principles*** shall be provided."

- "One of the systems shall use control rods, preferably including a positive means for inserting the rods, and ***shall be capable of reliably controlling reactivity changes*** …"

- "The second reactivity control system shall be ***capable of reliably controlling the rate of reactivity changes*** …"

Regulatory Guide 1.232, ARDC 26

- "A ***minimum of two*** reactivity control systems or means shall …"
- "A means which is ***independent and diverse*** from the other(s) …"
- "The term 'independent and diverse' indicates ***no shared systems or components*** and a design which is different enough such that ***no common failure modes exist*** between the system or means in ARDC 26 (2) and safety-related systems in ARDC 26 (1) and (3)."

Summary of Previous Pre-Application Engagements

NRC Staff Position

- A reactor cannot meet SFR-DC 26 as written by relying on shared control rods to satisfy SFR-DC 26 (1) and (2).
  - *"No shared systems or components"*: The rods are a shared component
  - *"…no common failure modes exist…"*: Potential common mode failures of the rods

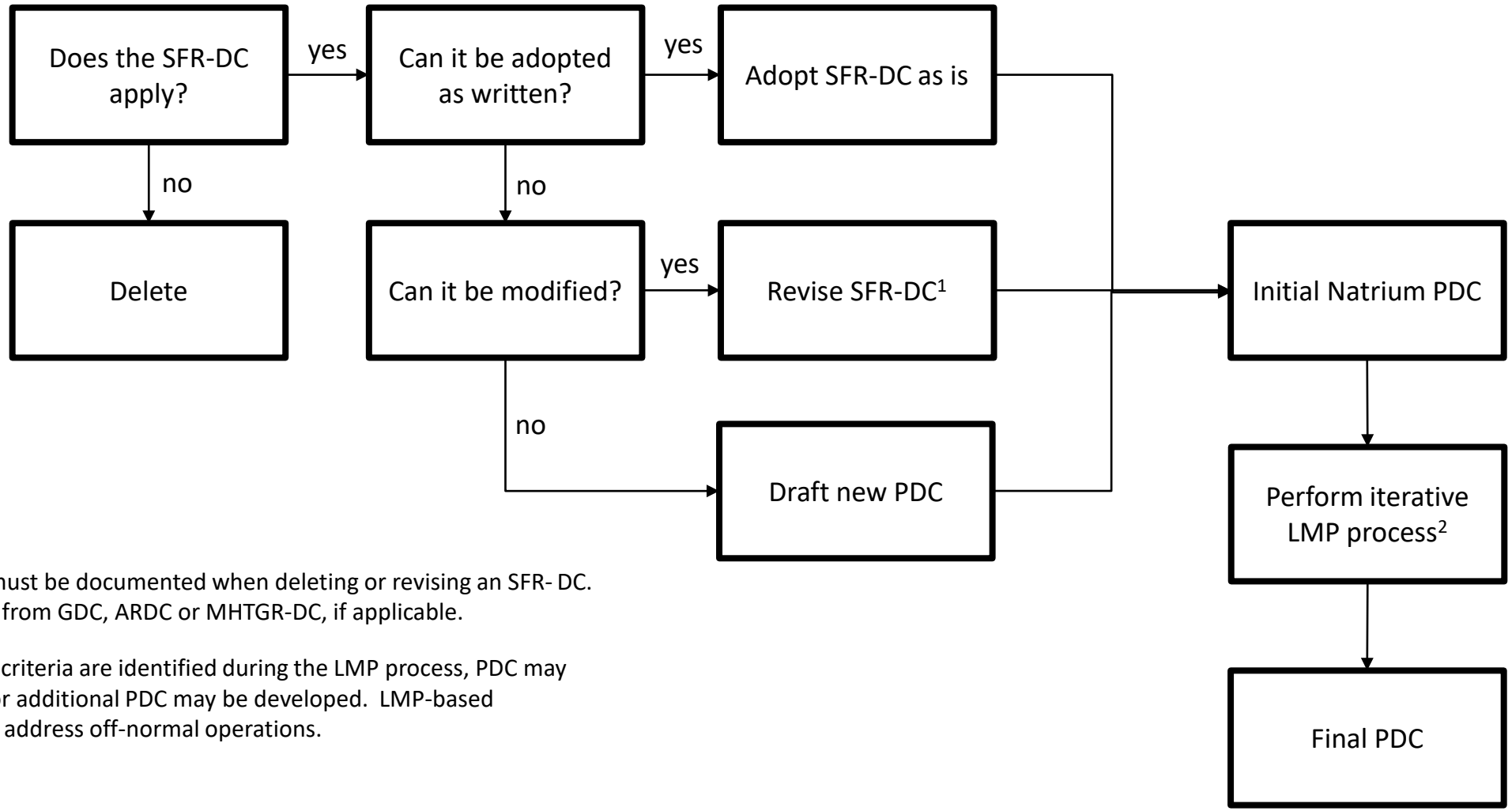
Possible Paths Forward

(may not be an exhaustive list)

- Include a new reactivity control system or means in the design
- Credit a different, existing system or means capable of reactivity control
- Propose modifications to the PDC
  - TerraPower posed the question whether PDC 26 could be modified to include runback.
    - Possibly, but more would have to modified, and justification would need to be provided.

- NEI 18-04, Rev. 1: Regulatory Guide 1.232 should be used as one input by designers to initially establish principal design criteria for a facility based on the specifics of its unique design.
- RG 1.233: Designers may likewise use the design criteria from RG 1.232 and confirm or refine them throughout the design process to develop the final PDC provided in an application.

PDC Development



[1] Justification must be documented when deleting or revising an SFR- DC. Use language from GDC, ARDC or MHTGR-DC, if applicable.

[2] If new design criteria are identified during the LMP process, PDC may be modified or additional PDC may be developed. LMP-based modifications address off-normal operations.

Proposed PDC 26 Reactivity Control Systems Language*

[[

]](a)(4)

**Reflects changes from RG 1.232 SFR-DC*

PRA, DEFENSE LINE EVALUATION, AND DEFENSE IN DEPTH

Means of Inserting Negative Reactivity

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Baseline PRA Evaluation of Reactivity Control Reliability

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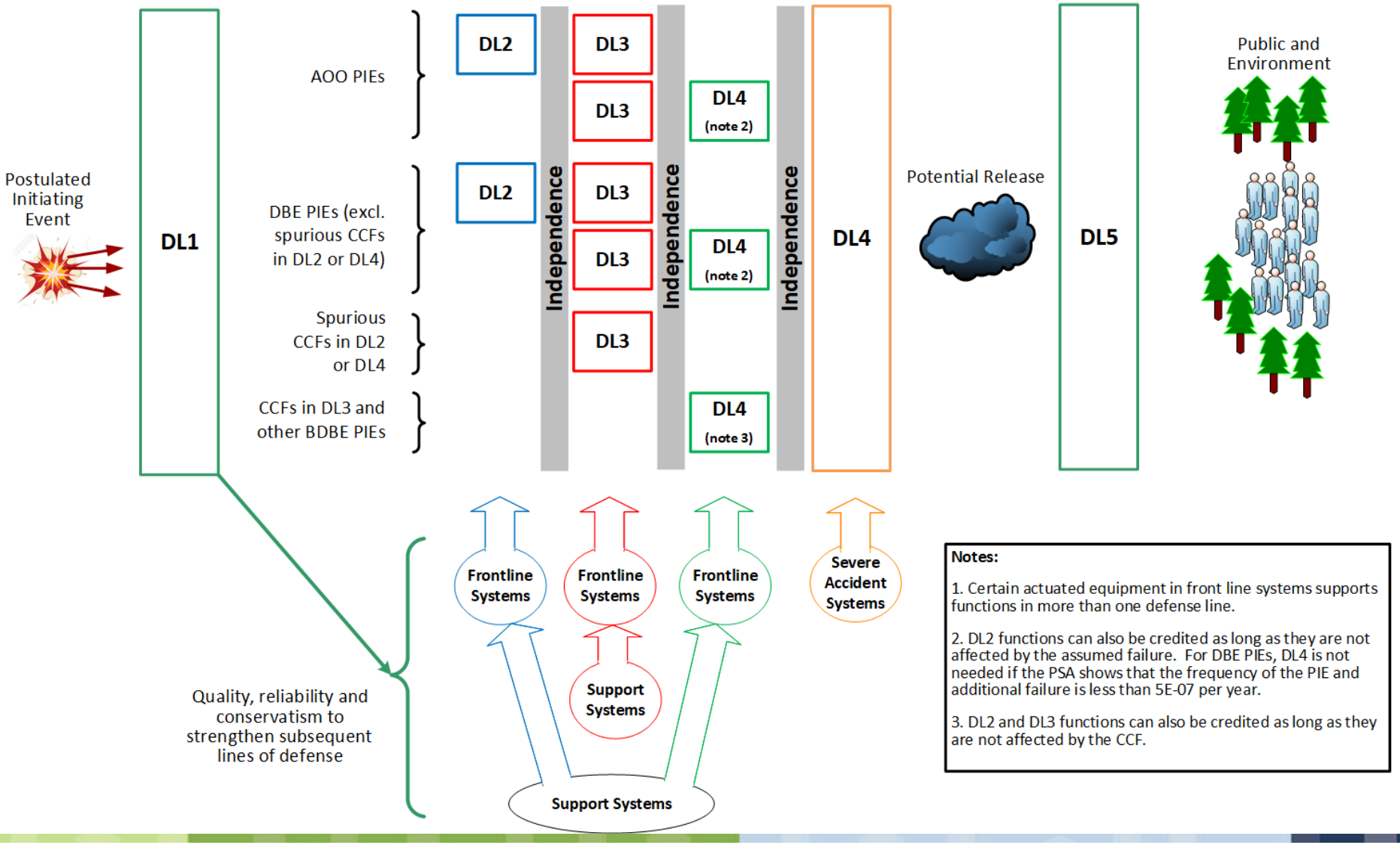
Defense-Lines Concept



Notes:

1. Certain actuated equipment in front line systems supports functions in more than one defense line.

2. DL2 functions can also be credited as long as they are not affected by the assumed failure. For DBE PIEs, DL4 is not needed if the PSA shows that the frequency of the PIE and additional failure is less than 5E-07 per year.

3. DL2 and DL3 functions can also be credited as long as they are not affected by the CCF.

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Defense Line Evaluation

[[

]](a)(4)

- Event categories: AOO=Anticipated Operational Occurrences, DBE=Design Basis Event, BDBE=Beyond Design Basis Event, OQE=Other Quantified Event (Part of Integrated Risk Measure), RESIDUAL (Negligible portion of integrated risk)
- The color coding below shows the approximate event bands for sequences

Defense Line Evaluation for Rod Withdrawal

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]](a)(4)

Defense Line Evaluation for Loss of Offsite Power

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Defense Line Evaluation for Loss of Flow

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Changes in DID emphasis and expected risk impact

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]](a)(4)

CONTROL ROD DRIVE SYSTEM

CRDM Overview

[[

]](a)(4), ECI

CRD Scram Function (SR)

[[

]](a)(4), ECI

CRD Scram Function (SR)

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]](a)(4), ECI

CRDM Motor-Driven Functions

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]](a)(4), ECI

CRD System Architecture

[[

]](a)(4), ECI

Power Supply for Drive-In Motors

[[

]]$^{(a)(4)}$

SECONDARY CRA OVERVIEW, DESIGN PROCESS, AND TESTING

Secondary CRA Overview

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]](a)(4), ECI

Primary Control Assembly and CRA Overview

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]](a)(4), ECI

Proposed Secondary CRA Design Concepts

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]](a)(4), ECI

CRA Design Process

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Secondary CRA Testing

[[

]](a)(4), ECI

[[

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Conclusion

[[

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Acronym List

AC – Alternating Current
AOO – Anticipated Operational Occurrences
ARDC – Advanced Reactor Design Criteria
ARDP – Advanced Reactor Demonstration Program
BDBE – Beyond Design Basis Event
BOEC – Beginning of Equilibrium Cycle
BOL – Beginning of Life
CCF – Common Cause Failure
CRA – Control Rod Assembly
CRD – Control Rod Driveline
CRDM – Control Rod Drive Mechanism
DBA – Design Basis Accident
DBE – Design Basis Event
DID – Defense in Depth
DL – Defense Line
DOE – Department of Energy
FMEA – Failure Modes and Effects Analysis
GDC – General Design Criteria
GD&T – Geometric Dimensioning and Tolerancing
HX – Heat Exchanger
INL – Idaho National Laboratory
IRF – Inherent Reactivity Feedback
LBE – Licensing Basis Event
LMP – Licensing Modernization Project
LVDT – Linear Variable Differential Transmitter
LWR – Light-Water Reactor
MHTGR – Modular High Temperature Gas Reactor
NEI – Nuclear Energy Institute
NIC – Nuclear Island Control
NRC – Nuclear Regulatory Commission
NSRST – Non-Safety-Related with Special Treatment
NST – Non-Safety-Related with No Special Treatment
OQE – Other Quantified Event
PDC – Principal Design Criteria
PRA – Probabilistic Risk Assessment
RG – Regulatory Guide
RPA – Rotatable Plug Assembly
RPS – Reactor Protection System
SFR – Sodium Fast Reactor
SOV – Solenoid Operated Valve
SR – Safety-Related
SSC – Systems, Structures, and Components