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Advanced Reactor Design Criteria (ARDC) Development Process

Department of Energy

NRC Public Meeting

January 21, 2015

Need for a Licensing Framework for Advanced Reactors

- During 2012, DOE instituted an Advanced Reactor Concepts Technical Review Panel (TRP) process to evaluate viable reactor concepts from industry and to identify R&D needs
  - TRP members and reactor designers noted the need for a regulatory framework for non-light water advanced reactors
- Also in 2012, in response to Congressional direction, the NRC provided a report to Congress on advanced reactors
  - The NRC noted the need for regulatory guidance for non-light water reactor designs
- The TRP convened in spring 2014 reiterated the need for a licensing framework for advanced reactors

Licensing Framework Initiative

- 10 CFR 50 requires applicants to establish principal design criteria derived from the General Design Criteria (GDC) of Appendix A
- Since the GDC in Appendix A are specific to light water reactors (LWRs), this requirement is especially challenging for potential future licensing applicants pursuing advanced (non-light water) reactor technologies and designs
- NE and NRC representatives agreed in June 2013 to pursue a joint licensing initiative for advanced reactors

Purpose of Advanced Reactor Design Criteria (ARDC) Initiative

- **Overall purpose of this initiative is to establish clear guidance for the development of the principal design criteria (PDC) that advanced non-LWR developers will be required to include in their NRC license applications**

- **Completion of this effort and the NRC's future issuance of the associated regulatory guidance are expected to provide the following key benefits:**
  - Reduced regulatory uncertainty for advanced non-light water reactor developers
  - Improved guidance for NRC staff reviewing advanced reactor license applications
  - Improved timeliness and efficiency of licensing activities for both applicants and NRC staff

Licensing Initiative Team

Team Members:

- **Department of Energy**
  - DOE Office of Nuclear Energy
  - DOE Office of General Counsel
- **Laboratories**
  - Argonne National Laboratory
  - Idaho National Laboratory
  - Oak Ridge National Laboratory
- **Selected individual licensing consultants**

Phased Approach

- **"Phase 1" – DOE**
  - Expertise applied to research, analysis, evaluation, documentation
  - Deliverables – technical report to NRC
- **"Phase 2" – NRC**
  - Initiate regulatory development process
  - Issue regulatory guidance commensurate with an official NRC staff position
- **NRC attended key meetings and observed the development process**

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Technical Report Development - Timeline

DC Development Task	Task Completion Schedule
Kick-off meeting DOE /NRC	August 2013
Literature Search	August 2013
External Stakeholder Webinar	September 2013
DOE Request for Design Information	December 2013
Develop First Draft criteria and distribute to industry stakeholders	March 2014
First Stakeholder Workshop	April 2014
Address Stakeholder Feedback and Issue Second Draft criteria	June 2014
Second Stakeholder Workshop	July 2014
Issue Final DOE/Lab Report to NRC	December 2014

Content of DOE Final Report

The DOE/national lab final report on advanced reactor design criteria contains:

- A proposed set of Advanced Reactor Design Criteria, generally applicable to:
  - Sodium-cooled Fast Reactors (SFRs)
  - Lead Fast Reactors (LFRs)
  - Gas-cooled Fast Reactors (GFRs)
  - High Temperature Gas-cooled Reactors (HTGRs)
  - Fluoride High Temperature Reactors (FHRs)
  - Molten Salt Reactors (MSRs)
- A proposed set of Sodium-cooled Fast Reactor Design Criteria
- A proposed set of High Temperature Gas-cooled Reactor Design Criteria
- A technical justification for adaptations of the original GDC

ARDC Development Process

Agenda Item # 2

Department of Energy

NRC Public Meeting
January 21, 2015

Literature Search

- **Advanced non-LWR reactor design-related historical information was identified to provide regulatory history and design criteria insights**
- **Literature sources were identified**
- **Emphasis was placed on regulatory documents that included discussions related to development of principal design criteria**
- **Advanced reactor design standards were considered**
- **Design concepts researched:**
  - Sodium-Cooled Fast Reactor (SFR)
  - Fluoride Salt-Cooled High Temperature Reactor (FHR)
  - Modular High Temperature Gas-Cooled Reactor (modular HTGR)

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Key Literature for Design Criteria Development - SFRs and FHRs

- **SFR Basis**
  - FFTF SER
  - PRISM licensing strategy, PSER, PSID, BNL evaluation of PRISM, SAFR (NUREG/CR-5364)
  - CRBR SER, PSAR, licensing lessons learned
  - ANS 54.1
  - ANS President's Committee SMR generic licensing issues (interim)
  - Sodium Fast Reactor Safety and Licensing Research Plan (SAND2012-4260)
  - GIF SDC-TF/2013/01
  - SAFR PSER
  - NRC knowledge management (ORNL TM)
  - Toshiba 4S safety design criteria
  - LMFBR conceptual design study (PNL-3511)
- **FHR Basis**
  - FHR generic design criteria (ORNL TM)
- **Various NUREGs and SECYs**

Key Literature for Design Criteria Development - Modular HTGRs

HTGR Basis

- General Atomics MHTGR licensing strategy, PSID, PSER, GDC reviews
- NGNP licensing specification development and effort to adapt Reg. Guide 1.206
- Next Generation Nuclear Plant – NRC's Assessment of Key Licensing Issues
- PBMR (Exelon) licensing strategy
- Fort St. Vrain licensing
- ANS 53.1
- Various NUREGs and SECYs

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DOE Information Request

- In addition to the literature search and a kickoff webinar (September 2013), DOE sent a notice to industry and external stakeholders in December 2013
- Requested non-proprietary descriptions and information of advanced reactor design concepts under development

List of Respondents:

Gen4 Energy	G4M Small Modular LBE Fast Reactor
UC-Berkeley	Mark 1 Pebble-Bed FHR (Mk1 PB-FHR)
GE Hitachi	PRISM SFR
Hybrid Power Technologies LLC	Hybrid Fossil/Nuclear (Helium cooled) Fueled Plant
X-Energy	Pebble Bed HTGR
Areva	Steam Cycle-HTGR (SC-HTGR)
General Atomics	EM2 Helium Cooled Fast Reactor
Transatomic Power	Advanced MSR
Flibe Energy	Liquid Fluoride Thorium Reactor (LFTR)
TerraPower	Traveling Wave Reactor SFR (TWR-P)

Categorization of the Existing GDC

- **GDCs in Appendix A were initially categorized into the following bins using liquid metal and modular high temperature gas-cooled reactors as the principle reference technologies:**
  - GDC is generic and applicable to all advanced reactors - no change needed
  - GDC is LWR specific, but can be modified to be applicable to advanced reactors with minor editorial changes to remove LWR terminology
  - GDC is LWR specific and a significant rewrite is needed to make it applicable to advanced reactors
  - GDC is not applicable to advanced reactor technology
- **The team identified new design criteria that may be needed for the principle reference technologies to assure unique advanced reactor issues and configurations are accounted for**
  - Included insights from related industry activities, such as ANS 54.1 development for SFRs

Design Criteria – Naming Conventions

The team established the following terms for use within this initiative:

- **Advanced Reactor Design Criteria (ARDC)**
- **Sodium Fast Reactor Design Criteria (SFR-DC)**
- **Modular High Temperature Gas-cooled Reactor Design Criteria (modular HTGR-DC)**

The DOE national lab team also considered other naming conventions for the criteria being developed:

- "General Design Criteria" was not selected since that term is used for the guiding set of criteria contained in the existing regulation - Appendix A
- "Safety Design Criteria" was not selected since that term is being used in various industry and international forums in a different context
- "Principal Design Criteria" was not selected, since that term refers to the detailed set of criteria that must be submitted to the NRC by each individual license applicant, based on the details of the proposed design
  - 10 CFR 50.34(a)(3), 52.47(a)(3)(i), and 52.79(a)(4) require that:
    - *Application for a construction permit, design certification, or combined license must include **principal design criteria** for the facility*

Relationship Between Existing GDC and PDC for Advanced Reactors

Existing General Design Criteria from 10 CFR 50 Appendix A

Advanced Reactor Design Criteria

(Section 9.1 of the report)

Technology Specific Design Criteria

(Section 9.2 and 9.3 of the report)

Principal Design Criteria

(Developed by Individual Advanced Reactor License Applicants)

Retain Underlying Safety Principle

- **All proposed advanced reactor design criteria seek to preserve the underlying safety principle(s) originally expressed in the corresponding GDC**
- **Advanced reactor design criteria also recognize that safety design solutions can differ substantially from those associated with LWRs**
  - Advanced reactors employ simplified, passive, and inherent safety features
  - Challenges to advanced reactor safety systems can greatly vary
  - System components and nomenclature may be very technology-specific
- **Proposed ARDC are intended to provide guidance for developing principal design criteria requirements for the SSCs that are important to safety in non-light water cooled nuclear power plants**

Approach Used to Develop SFR-DC

- **Reviewed design criteria previously evaluated by NRC in their reviews, and ANS standards committee efforts**
  - SER for CRBR - NUREG 0968
  - PSER for PRISM - NUREG 1368
  - PSER for SAFR - NUREG 1369
  - American National Standards Institute/American Nuclear Society, ANSI/ANS-54.1-1989, "General Safety Design Criteria for Liquid Metal Reactor Nuclear Power Plants," April 1989
  - ANS working group ANS 54.1 - revision (working draft)
- **Technology-specific design criteria sought to incorporate minimal change from:**
  - Existing LWR GDC (Appendix A of 10CFR50)
  - ARDC
  - Recommended changes in the PRISM PSER
    - Reflects CRBR SER and 1989 version of ANSI/ANS 54.1
  - Current working draft of ANS 54.1

Approach Used to Develop Modular HTGR-DC

- **In general, modular HTGR-DC retain the deterministic structure of the Appendix A GDC**
- **Deterministic structure was modified in some cases to align with recent NGNP proposals to the NRC:**
  - Multi-module integrated risk
  - Functional containment
  - Consideration of multiple failures (beyond single failure criterion)
- **In addition, the modular HTGR-DC were assessed using functional analysis to ensure completeness**

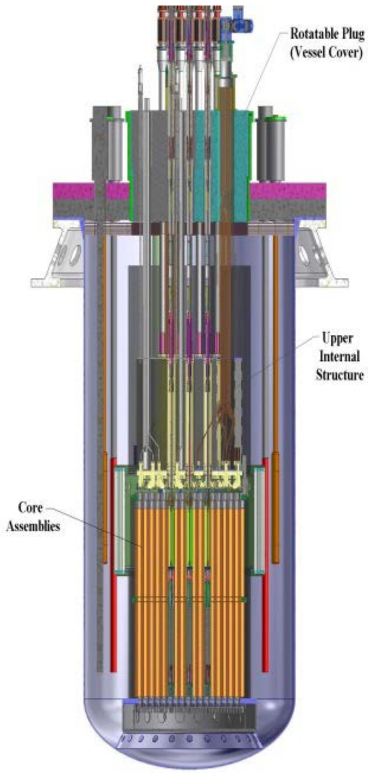
Workshops and Opportunities for Stakeholder Involvement

Workshops

- Webinar - Planned regulatory framework process discussed
- Workshop 1 - First draft of criteria was presented
- Workshop 2 - Revised criteria that included stakeholder comments were presented
- Attended by Industry, NRC, NEI, EPRI and other stakeholders

Industry involvement

- Participated in both workshops
- Provided comments on draft criteria
- Participated through ANS Standards development activities to review advanced reactor design criteria and technology specific design criteria



AFR-100 Advanced Sodium-cooled Fast Reactor

Stakeholder Feedback Following Workshop 1

Stakeholder organizations that submitted comments and inputs on the draft design criteria presented in Workshop 1:

American Nuclear Society
AREVA
Argonne National Laboratory
Flibe Energy
CBI Federal Services
General Atomics
General Electric
Gen4 Energy, Inc.
Hybrid Power Technologies LLC
Japan Atomic Energy Agency
Korea Atomic Energy Research Institute
TerraPower
Toshiba
X-energy

ARDC Report Content & Format

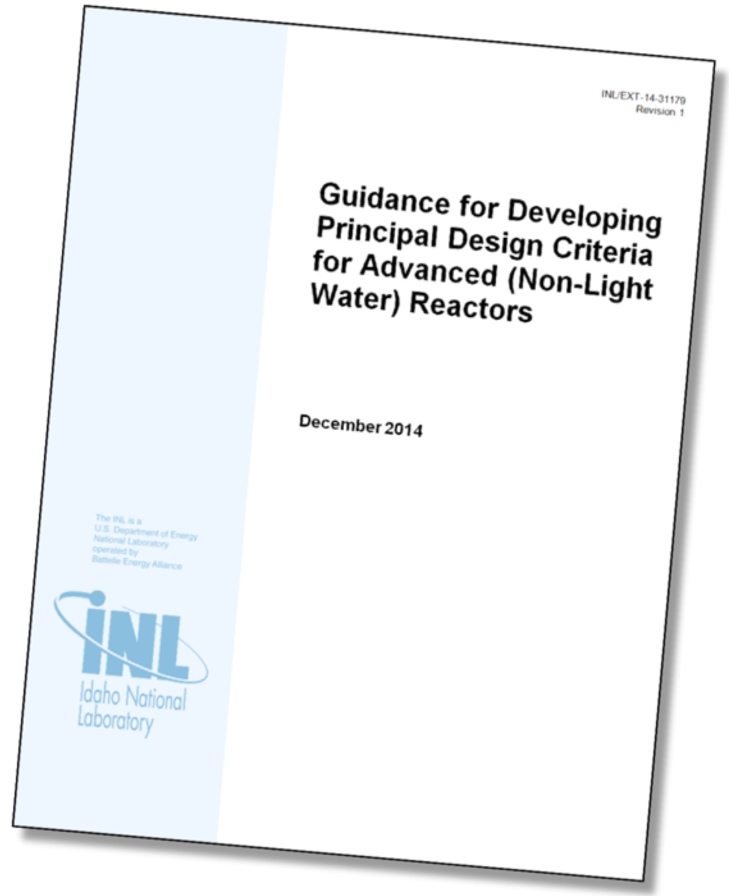
Agenda Item # 3

Department of Energy

NRC Public Meeting
January 21, 2015

Phase 1 – DOE Final Report

- **Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors**
- **Issued December 2014**
- **ML14353A224**


INL/EXT-14-31179
Revision 1

Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors

December 2014

The INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance

INL Idaho National Laboratory

Content of DOE Final Report

The DOE/national lab final report on advanced reactor design criteria contains:

- A proposed set of ARDC that are generally applicable to:
  - Sodium-cooled Fast Reactors (SFRs)
  - Lead- and LBE-cooled Fast Reactors (LFRs)
  - Gas-cooled Fast Reactors (GFRs)
  - Modular High Temperature Gas-cooled Reactors (modular HTGRs)
  - Fluoride High Temperature Reactors (FHRs)
  - Molten Salt Reactors (MSRs)
- Proposed sets of technology-specific criteria adapted from the ARDC for:
  - Sodium-cooled Fast Reactors
  - Modular High Temperature Gas-cooled Reactors
- Technical justification for all proposed design criteria adaptations are provided

Content of DOE Final Report (cont.)

The key portions of the report include:

- Overview of the task
- Project organization and interface
- Assumptions and definitions
- Approach for completing the task
- Advanced (Non-LWR) Reactor Design Criteria
- Sodium Fast Reactor and modular High Temperature Gas-Cooled Reactor design criteria
- Tables containing the proposed criteria and associated rationale for the proposed adaptations
  - ARDC set
  - SFR-DC set
  - Modular HTGR-DC set
  - Design Criteria Comparison Table

Content of DOE Final Report (cont.)

- **To facilitate the NRC's review, the DOE-lab team has aligned the proposed ARDC with the structure of 10 CFR 50 Appendix A, including the following considerations:**
  - Worked to restrict/minimize the number of proposed changes to those needed for improved regulatory certainty and clarity
  - No change to regulation is proposed

Key Definitions

Important to Safety: Based on existing 10 CFR 50 Appendix A language, this designation refers to structures, systems, and components (SSCs) that provide reasonable assurance the facility can be operated without undue risk* to the health and safety of the public. SSCs with this designation are safety related and are relied upon to remain functional during design basis accidents.

*Undue risk is associated with the inability to ensure the capability to prevent or mitigate the consequences of accidents which could result in offsite radiological consequences exceeding the limits set forth in 10 CFR 50.34 (or 10 CFR 52.79).

Key Definitions (cont.)

Functional Containment: A barrier, or set of barriers taken together, that effectively limit the physical transport and release of radionuclides to the environment across a full range of normal operating conditions, anticipated operational occurrences, and accident conditions. Functional containment is relied upon to ensure that dose at the site boundary as a consequence of postulated accidents meets regulatory limits.

Key Definitions (cont.)

<u>Modular HTGR</u>: Refers to the category of HTGRs that use the inherent high temperature characteristics of tristructural isotropic (TRISO) coated fuel particles, graphite moderator, and helium coolant, as well as passive heat removal from a low power density core with a relatively large height-to-diameter ratio within an uninsulated steel reactor vessel. The modular HTGR is designed in such a way to ensure during design basis events (including loss of forced cooling or loss of helium pressure conditions) that radionuclides are retained at their source in the fuel and regulatory requirements for offsite dose are met at the Exclusion Area Boundary.

Key Definitions (cont.)

Postulated Accidents: Based on existing 10 CFR 50 Appendix A language, this term refers to the design basis accidents a nuclear facility must be designed and built to withstand without loss of the systems, structures, and components relied upon to ensure public health and safety.

ARDC Table – Section 9.1

- **Section 9.1 of the report consists of a table for Proposed ARDC Language**
- **The ARDC table includes columns for:**
  - Current GDC Language
  - Proposed ARDC Language
  - Rationale for Modification (of GDC language)
- **If the proposed language for a given criterion is the same as the current GDC language, then the proposed language column states "Same as GDC"; otherwise, the GDC language is revised (in the Proposed ARDC Language Column) using blue for inserted text and redline/strikeout for removed text**
- **The Rationale for Modification column provides information to justify the proposed adaptations of the current GDC text that exist in the Proposed ARDC Language column**

ARDC Example – Same as GDC
GDC 1 – Quality Standards and Records

Current GDC Language	Proposed ARDC Language	Rationale for Modification
Quality standards and records. Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions. Appropriate records of the design, fabrication, erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.	Same as GDC	

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ARDC Example – Redline/Strikeout GDC 11 – Reactor Inherent Protection

Current GDC Language	Proposed ARDC Language	Rationale for Modification
Reactor inherent protection. The reactor core and associated coolant systems shall be designed so that in the power operating range the net effect of the prompt inherent nuclear feedback characteristics tends to compensate for a rapid increase in reactivity.	*Reactor inherent protection.* The reactor core and associated ~~coolant~~ systems that contribute to reactivity feedback shall be designed so that in the power operating range the net effect of the prompt inherent nuclear feedback characteristics tends to compensate for a rapid increase in reactivity.	Wording changed to broaden applicability from "coolant systems" to additional factors (including structures or other fluids) that may contribute to reactivity feedback; these systems are to be designed to compensate for rapid reactivity increase.

Use of Brackets

- **Brackets have been added around certain text to identify portions of original GDC language where advanced reactor designs may need to provide alternative descriptions to address underlying criterion requirements. This approach is intended to address topics such as:**
  - Technology-specific terminology issues
  - LWR-specific example lists
  - Technology-specific approaches to safety design
- **Brackets are intended to maintain the underlying safety basis of the criterion**
- **It should be noted that this use of brackets is similar in concept to the format and structure utilized by the current operating fleet and the NRC staff for the Standardized Technical Specifications**

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ARDC Example – Use of Brackets ARDC 12 – Suppression of Reactor Power Oscillations

Current GDC Language	Proposed ARDC Language	Rationale for Modification
Suppression of reactor power oscillations. The reactor core and associated coolant, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed.	*Suppression of reactor power oscillations.* The reactor core and associated **[coolant]**, control, and protection systems shall be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed.	Brackets have been added around "coolant" to identify a portion of original GDC language where advanced designs may need to provide alternative descriptions to address underlying criterion requirements. Helium lacks influence in modular HTGR power oscillations but SFR reactor coolant may contribute to power oscillations. Criterion applies to both technologies according to the respective design factors that influence power oscillations.

SFR-DC and Modular HTGR-DC Tables Sections 9.2 and 9.3

- **Sections 9.2 and 9.3 of the report consists of tables for:**
  - Proposed SFR-DC language
  - Proposed modular HTGR-DC language
- **Each design criteria table includes columns for:**
  - Proposed ARDC language
  - Proposed SFR-DC or modular HTGR-DC language
  - Rationale for modification
- **The Rationale for Modification column provides information to justify the revisions to the proposed ARDC text that exist in the proposed design-specific language column**

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Technology-Specific Design Criteria Example: No Changes to ARDC

ARDC 20 – Protection System Functions

Proposed ARDC Language	Proposed SFR-DC Language	Rationale for Modification
Protection system functions. The protection system shall be designed (1) to initiate automatically the operation of appropriate systems including the reactivity control systems, to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences and (2) to sense accident conditions and to initiate the operation of systems and components important to safety.	ARDC with no further SFR-specific clarification provided.	

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Technology-Specific Design Criteria Example: Use of Brackets

ARDC 30 – Quality of Reactor Coolant Pressure Boundary

Proposed ARDC Language	Proposed Modular HTGR-DC Language	Rationale for Modification
*Quality of reactor **[coolant pressure]** boundary*. Components which are part of the reactor **[coolant pressure]** boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor **[coolant]** leakage.	ARDC with additional modular HTGR-specific clarification provided: *Quality of reactor **[~~coolant~~helium pressure]** boundary*. Components which are part of the reactor **[~~coolant~~helium pressure]** boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor **[~~coolant~~helium]** leakage.	The reactor HPB is the one of multiple modular HTGR fission product release barriers; the release barrier configuration is summarized in slides presented to NRC during a July 2012 public meeting (ML12223A146) with associated NRC meeting summary (ML12219A205). System factors discussed in section 2.3.3 of INL/EXT-10-17997, "NGNP Mechanistic Source Terms White Paper, July 2010, ML102040260, note the HPB integrity is relevant to this criterion due to its role in functional containment and its contribution in controlling graphite chemical attack via contaminant ingress. The adapted criterion addresses the need for high quality HPB component fabrication.

Technology-Specific Design Criteria

- **Advanced reactors may have design features important to safety that are not encompassed by the LWR-focused GDC**
- **Design-specific "70" series encompass new design criteria that may be necessary for a specific advanced reactor technology**
  - Expands existing design criteria set to address new principles important to safety
  - Tailored to accommodate emerging reactor designs
  - Eliminates need for a "radical re-interpretation" of existing design criteria to address new technology applications and thereby reduces risk of losing an underlying safety principle

Identifying New Technology-Specific Design Criteria

- **Factors considered in technology-specific design criteria**
  - Safety design goals and approach of the specific reactor technology
  - Design variations within each reactor technology class
- **General steps in development**
  - Key safety functions, systems, and design characteristics are identified for the technology
  - Compare those safety elements and details to ARDC and ascertain “gaps”
  - If existing ARDC cannot be adapted to clearly address the safety attributes of the system, a new technology-specific DC is proposed
- **The process was conducted for two advanced reactor concepts (modular HTGR and SFR)**
- **Based on reviewed information, the resulting proposed technology-specific design criteria are understood as necessary for safety and broadly representative of their respective reactor technology classes**

Need for Additional SFR Design Criteria

- **Based on the comments made during the regulatory reviews of the CRBR and PRISM reactors, it was determined that additional provisions would be needed to address SFR-specific issues not covered by the LWR-focused GDC**
  - Design of the intermediate loop
  - Design of sodium heating system
  - Design of systems to accommodate for the reactive nature of the sodium coolant in both the primary and intermediate heat transport systems
- **In the first version of the ANS 54.1 standard, such criteria were incorporated into the most appropriate SFR GDC**
- **In the current draft version of ANS 54.1, these additional technology-specific criteria are presented as additional criteria (70-79) to the SFR-DC set**

Status of Additional SFR-DC in the Current Report

- **In the original version of the SFR-DC, the criteria were taken from the current draft of ANS 54.1**
- **Comments during the second workshop indicated that most of these additional criteria were good practices (for use in a design standard); many did not have safety implications but were for investment protection or to address operational issues**
- **An action item from the workshop resulted in a teleconference between the DOE team and the commenters and other interested parties**
- **This led to the elimination of some criteria, consolidation of a few others, and wording changes to the remainder to shift their focus on their impact on the systems important to safety (SFR-DC 70-74)**

Need for Additional Modular HTGR Design Criteria

- **Two approaches were employed**
  - Examinations of ARDC were conducted to assess their potential applicability to modular HTGRs under normal and accident conditions
  - Functional analysis using risk-informed insights gained over 25-30 years; approach followed the methods contained in the MHTGR PSID (General Atomics)
- **Results of both approaches were combined to identify the need for any unique design criteria**
- **Three new modular HTGR-DC are proposed**

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SFR-DC Example
72 – Sodium Heating Systems

Proposed ARDC Language	Proposed SFR-DC Language	Rationale for Modification
N/A	*Sodium heating systems.* Heating systems shall be provided as necessary for systems and components important to safety, which contain or could be required to contain sodium. These heating systems and their controls shall be appropriately designed to assure that the temperature distribution and rate of change of temperature in systems and components containing sodium are maintained within design limits assuming a single failure.	NUREG-1368 (page 3-56) (ML063410561) Section 3.2.4.2 suggested the need for a separate criterion for sodium heating system. Also, a separate criterion was included in NUREG-0968 (ML082381008) (Criterion–7 Sodium Heating Systems).

Modular HTGR-DC Example
71 – Reactor Building Design Basis

Proposed ARDC Language	Proposed Modular HTGR-DC Language	Rationale for Modification
N/A	*Reactor building design basis.* The design of the reactor building shall be such that during postulated accidents it structurally protects the geometry for passive removal of residual heat from the reactor core to the ultimate heat sink and provides a pathway for release of reactor helium from the building in the event of depressurization accidents.	The reactor building functions are to protect and maintain passive cooling geometry and to provide a pathway for the release of helium from the building in the case of a line break in the reactor helium pressure boundary. This newly established criterion assures that these safety functions are provided. It is noted that the reactor building is not relied upon to meet the offsite dose requirements of 10 CFR 50.34 (10 CFR 52.79).

Design Criteria Comparison Table Section 9.4

- **The table provided in Section 9.4 provides the Appendix A GDC language and the proposed language for ARDC and example SFR-DC/modular HTGR-DC in a format that enables direct comparison of the related design criteria**
  - The first column contains GDC number and the second column contains the current GDC language; the second column also serves as a reference for comparison with the other columns
  - The third column from the left contains proposed ARDC language; if the proposed ARDC language for a given criterion is the same as the current GDC language, then the proposed ARDC language column states "Same as GDC"; otherwise, the GDC language is revised using blue for inserted text and redline/strikeout for removed text
  - The last two columns contain the proposed SFR-DC and modular HTGR language and demonstrate how the ARDC can be applied to a specific advanced reactor technology
  - If the proposed SFR-DC language is the same as the ARDC, then the proposed SFR-DC language column states "ARDC with no further SFR-specific clarification provided" A similar statement is made in the modular HTGR column, where applicable
- ***Any additional SFR-DC or modular HTGR text revisions in Section 9.4 are relative to the ARDC language, <u>not</u> the original GDC language***

Example: Comparison Table

GDC 64 – Monitoring Radioactivity Releases

Current GDC Language	Proposed ARDC Language	Proposed SFR-DC Language	Proposed mHTGR-DC Language
Monitoring radioactivity releases. Means shall be provided for monitoring the reactor containment atmosphere, spaces containing components for recirculation of loss-of-coolant accident fluids, effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.	*Monitoring radioactivity releases.* Means shall be provided for monitoring the [**reactor containment**] atmosphere, [**spaces containing components for recirculation of loss-of-coolant accident fluids,**] effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.	ARDC with additional SFR-specific clarification provided: *Monitoring radioactivity releases.* Means shall be provided for monitoring the **[reactor containment]** atmosphere, **[spaces containing components for ~~recirculation of loss-of-coolant accident fluids~~ 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.	ARDC with additional modular HTGR-specific clarification provided: *Monitoring radioactivity releases.* Means shall be provided for monitoring the **[reactor ~~containment~~building]** atmosphere, **~~[spaces containing components for recirculation of loss-of-coolant accident fluids,]~~** effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.

Summary

- **Purpose of this initiative is to establish clear guidance for the development of principal design criteria (PDC) that can be used by advanced non-light water reactor developers**
- **NRC's future issuance of the associated regulatory guidance for advanced reactors will significantly reduce regulatory uncertainty for both industry stakeholders and the NRC staff**
- **DOE's licensing team collected information, conducted research, and performed analysis that resulted in a technical report that can used by NRC as input in developing that regulatory guidance**
- **Questions?**