INL/CON-24-78525-Revision-0

ANS Summer Meeting 2024: MARVEL Documented Safety Analysis (DSA)

June 2024

MW (Mike) Patterson

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Idaho National Laboratory

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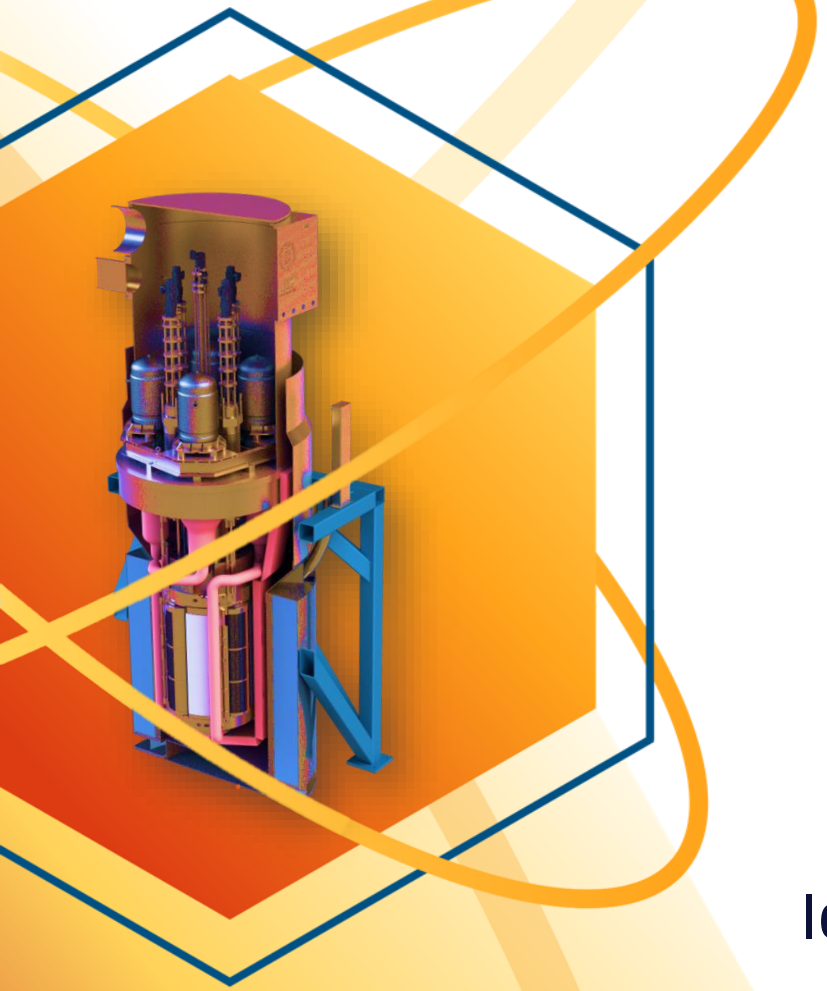
http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

(Microreactor Applications Research, Validation & EvaLuation),



ANS Summer Meeting 2024: MARVEL Documented Safety Analysis (DSA)

June 17, 2024

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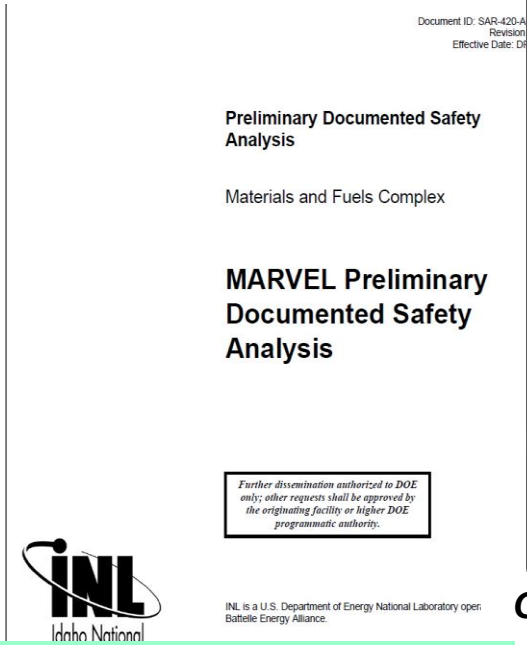
PRESENTATION OVERVIEW

- MARVEL DSA Background
- Interrelationship with TREX-C
- Hazards & Accident Analyses
- Design Features → SR-SSCs
- Status & Path Forward

MARVEL Documented Safety Analysis (DSA) – Background & Overview

MARVEL is a major modification to the TREAT facility

- DOE-STD-1189 (Safety in Design) applies & requires documented safety analyses (DSA)
- TREAT Reactor Experiment Cell (TREX-C) Project also a major modification with same need for DSA
- Safety Design Strategy (SDS) - combines MARVEL & TREX-C designs into one SAR Addendum
  - Safety analyst embedded in design team
  - Safety Design Integration Team (SDIT) – resolves/integrates safety basis issues across design, DSA, and organizations
  - Iterative process of design, hazard evaluation, & accident analysis


Document ID: SAR-420-A
Revision
Effective Date: D

Preliminary Documented Safety Analysis

Materials and Fuels Complex

MARVEL Preliminary Documented Safety Analysis

Further dissemination authorized to DOE only; other requests shall be approved by the originating facility or higher DOE programmatic authority.

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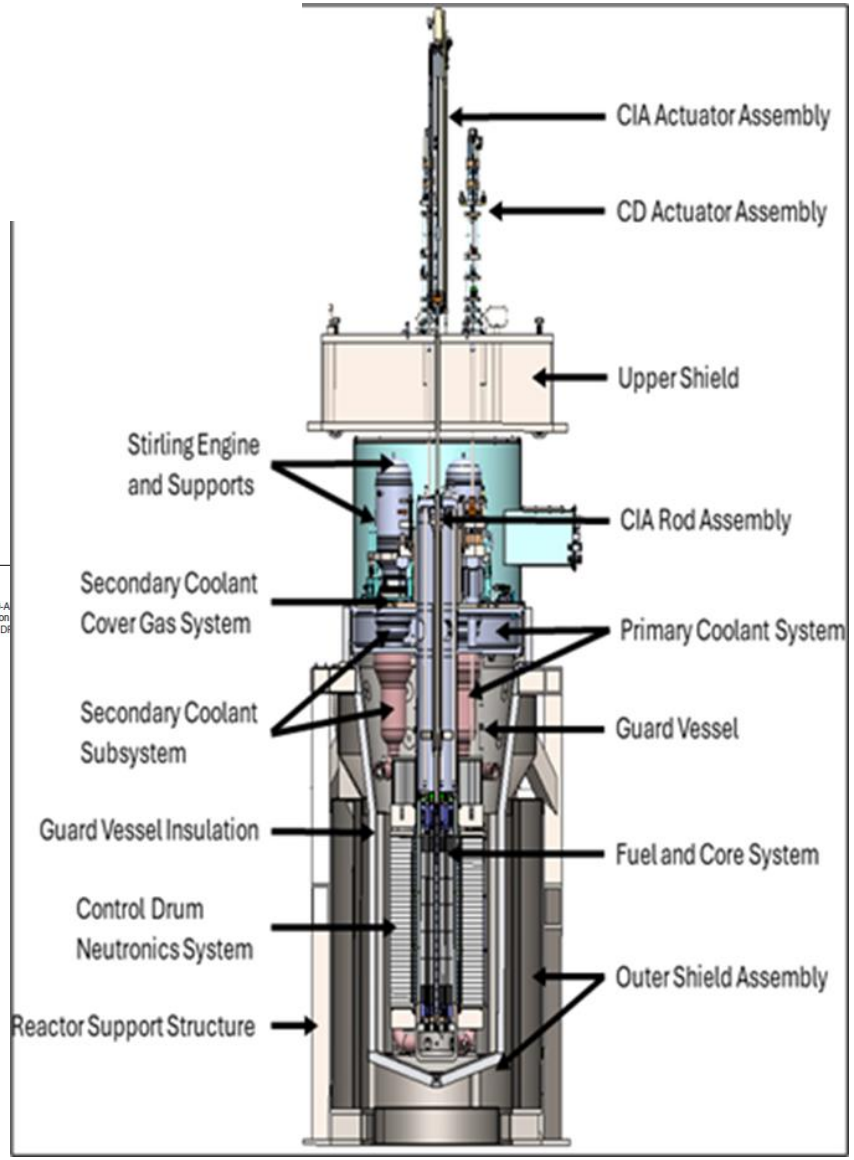


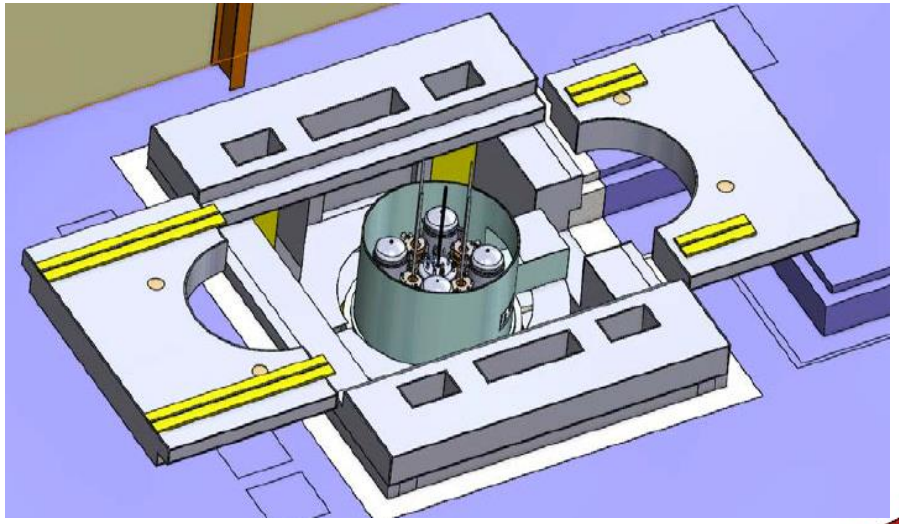
Cut-away view of MARVEL systems/subsystems

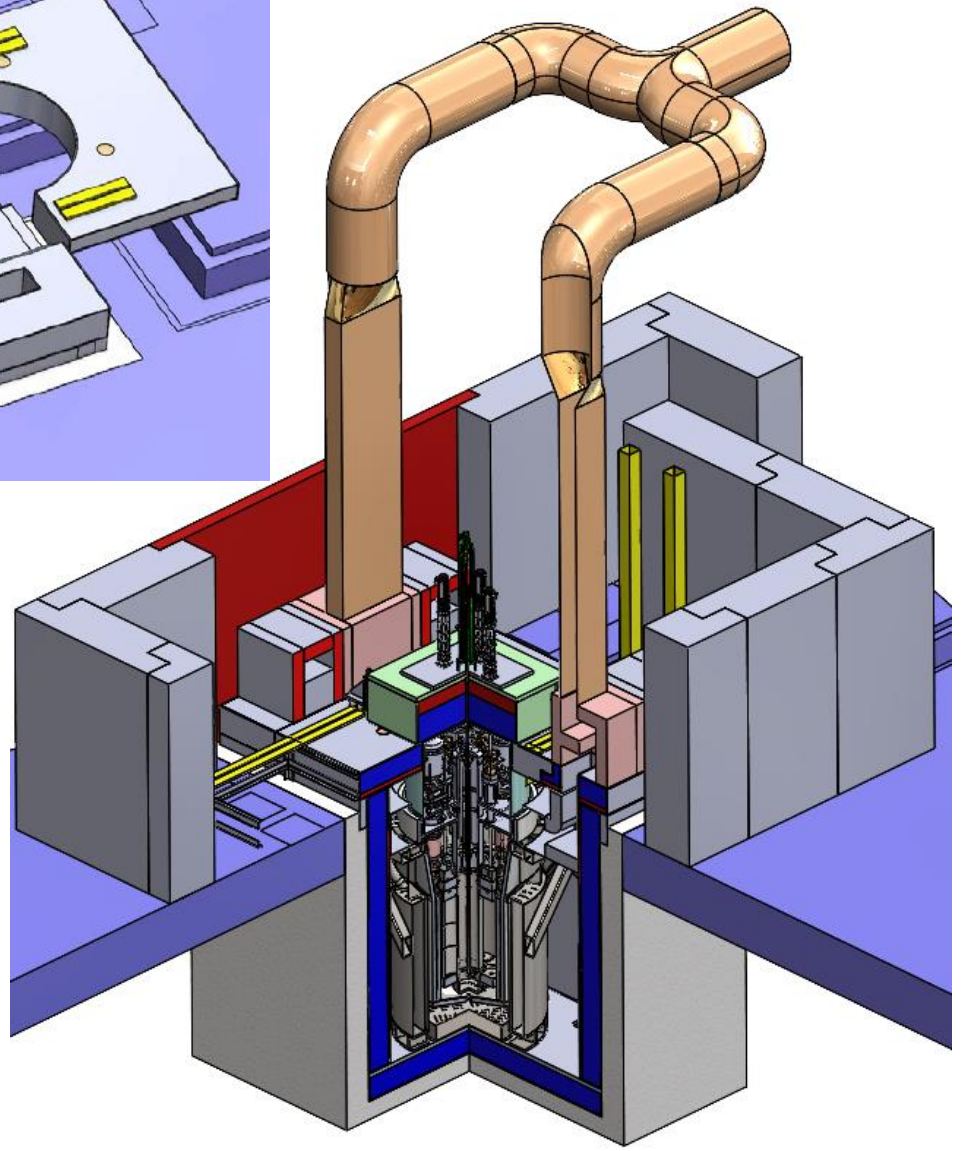
PDSA purpose is to define how a nuclear design & operations are safe for technical review, reference, & compliance.

MRP Microreactor Program

TREX-C Project

Institutionally-funded project to prepare TREAT to host multiple nuclear demonstrations (MARVEL will be the first)





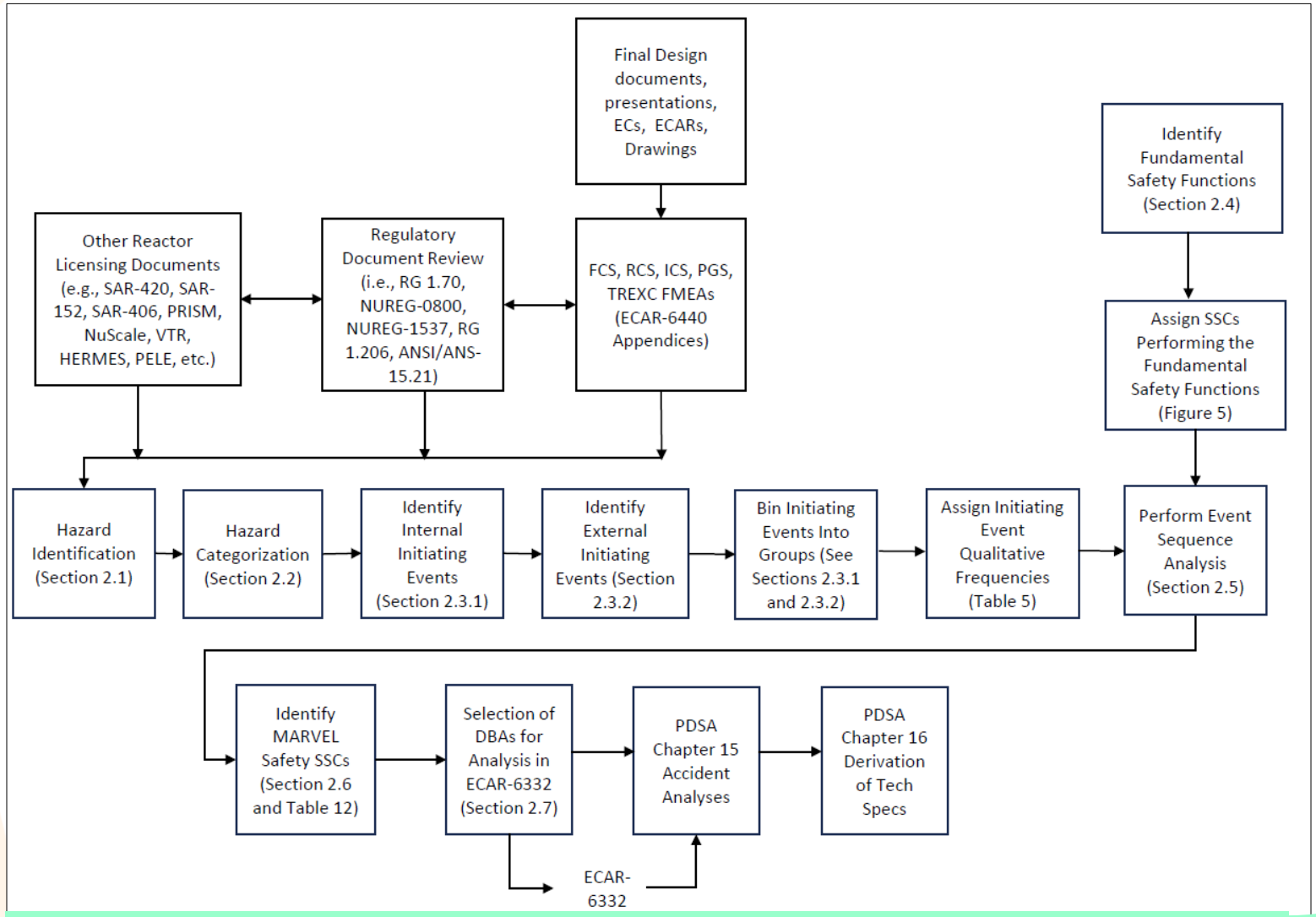
T-REXC Scope: (SPC-70454 T-REXC Interface Specification)

- Pit shield structures (to prevent neutron activation of the concrete)
- Pit lid, with integrated top shielding
- I&C infrastructure facility data and demonstrator data displays)
- Electrical power infrastructure – interface panel, standby generator
- Signal/data transfer between MFC-720 & MFC-724 Control Room
- Ventilation, including HEPA filter and exhaust monitoring
- Fire detection, including Na and NaK fires
- Fire mitigation systems, per TREAT fire hazards analysis
- Neutron source for startup
- Radial static neutron reflectors
- Beryllium oxide (BeO) control drums for neutron population control
- A system to preclude water intrusion into the pit
- Radiation monitoring.

T-REXC safety-related design & SSCs incorporated in MARVEL PDSA

MRP Microreactor Program

PDSA Development – Hazards Analysis



Started during conceptual design, revised through final design

SAR Addendum TOC

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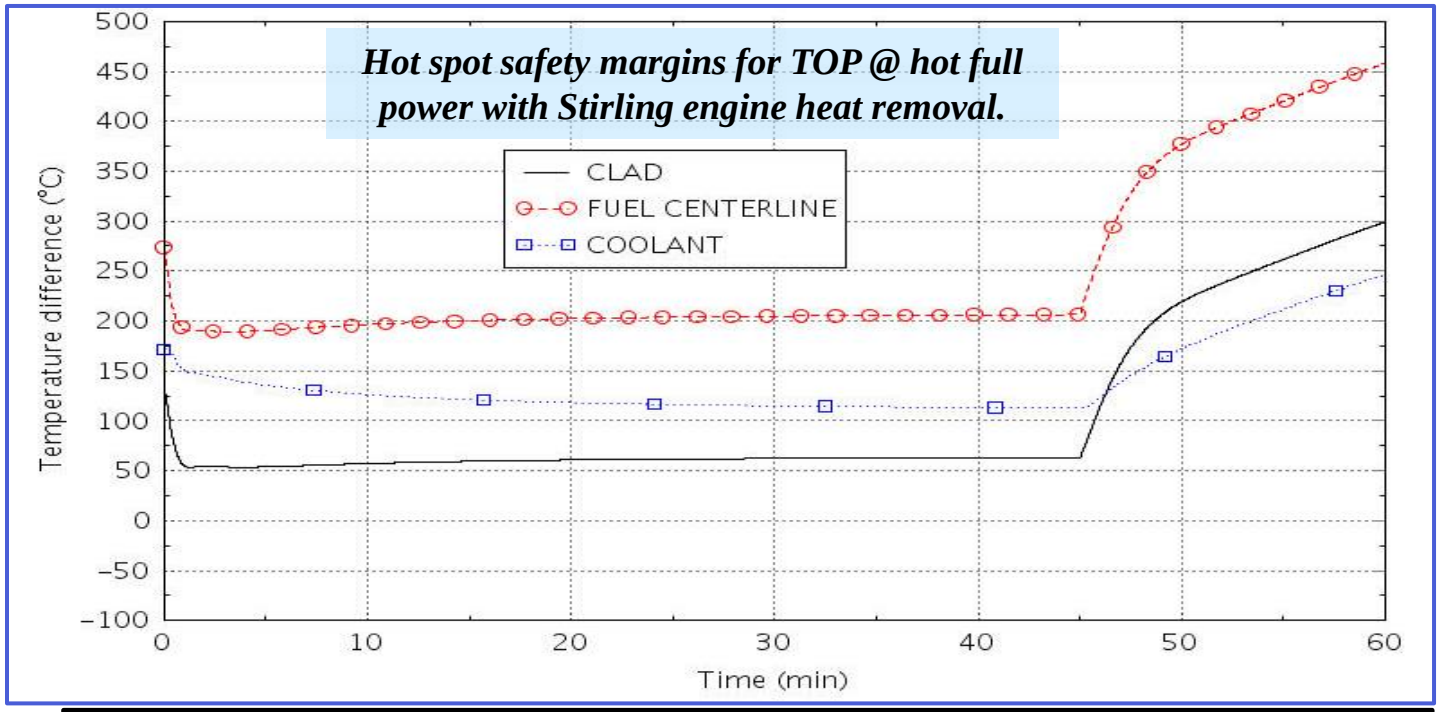
PDSA Development – Accident Analysis

Design Basis Accidents

- Transient Overpower (TOP)
- Loss of Heat Sink (LOHS)
- Loss of Flow (LOF)
- Loss of Offsite Power (LOOP)
- Seismic Event[Design Basis]
- Seismic Event [Beyond Design Basis]
- Loss of Coolant Accident (LOCA)

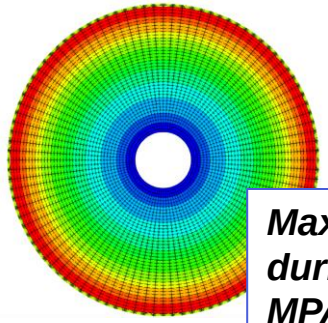
Evaluated for Consequence:

- NaK Spill and Fire
- Radioactive or Hazardous Material Release, or Direct Radiation Exposure, from an SSC failure



Fuel Temperature during Loss of Flow & Coolant Accidents

Fuel Temp (°C)	SS Ops	LOFA	LOCA
$T_{\text{Fuel meat peak}}$	612	718	718
$T_{\text{Fuel meat surface}}$	586	692	692



Max Hoop Stress during LOFA: -1.27 MPA (compressive)

Acceptance Criteria:

- $T_{\text{Fuel meat peak}}$ < 900°C
- $T_{\text{Fuel meat surface}}$ < 764°C
- $T_{\text{Bulk Coolant}}$ < 704°C
- Core remains coolable

No safety concerns identified

MRP Microreactor Program

PDSA Development – Engineered Safety Features (ESF)

Reactivity Control

- Passive inherent reactivity feedback
- Control Drum & Central Insurance Absorber

Core Flow & Heat Removal

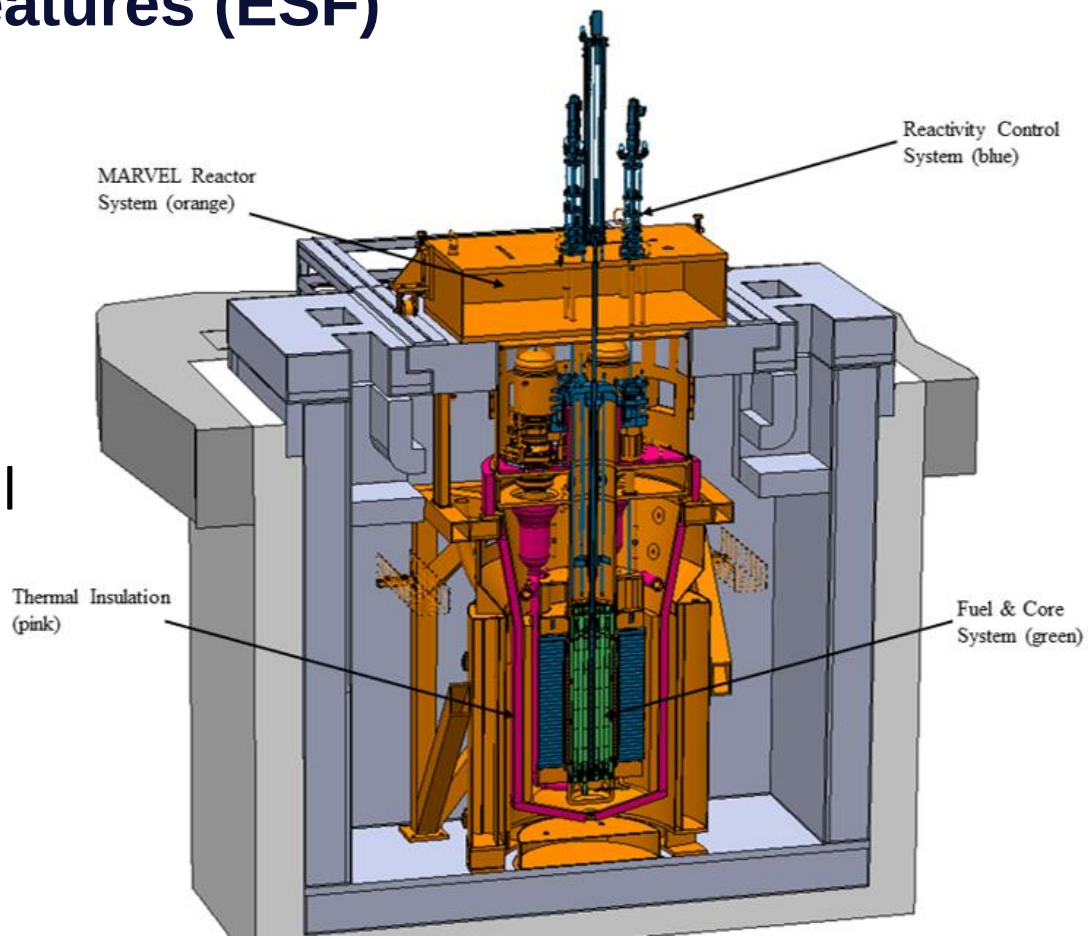
- Natural circulation & decay heat removal
- Fission & decay heat removal

Confinement of Radioactive & Hazardous Material

- Fuel cladding, & primary coolant (NaK),
- Primary Coolant Boundary including reactor barrel & piping (downcomers)
- Guard vessel, upper confinement structure, and
- T-REXC SSCs

Control of Direct Radiation Exposure

- Shielding/containment of radioactivity & radiation sources
- Radiation/radioactivity monitoring instrumentation

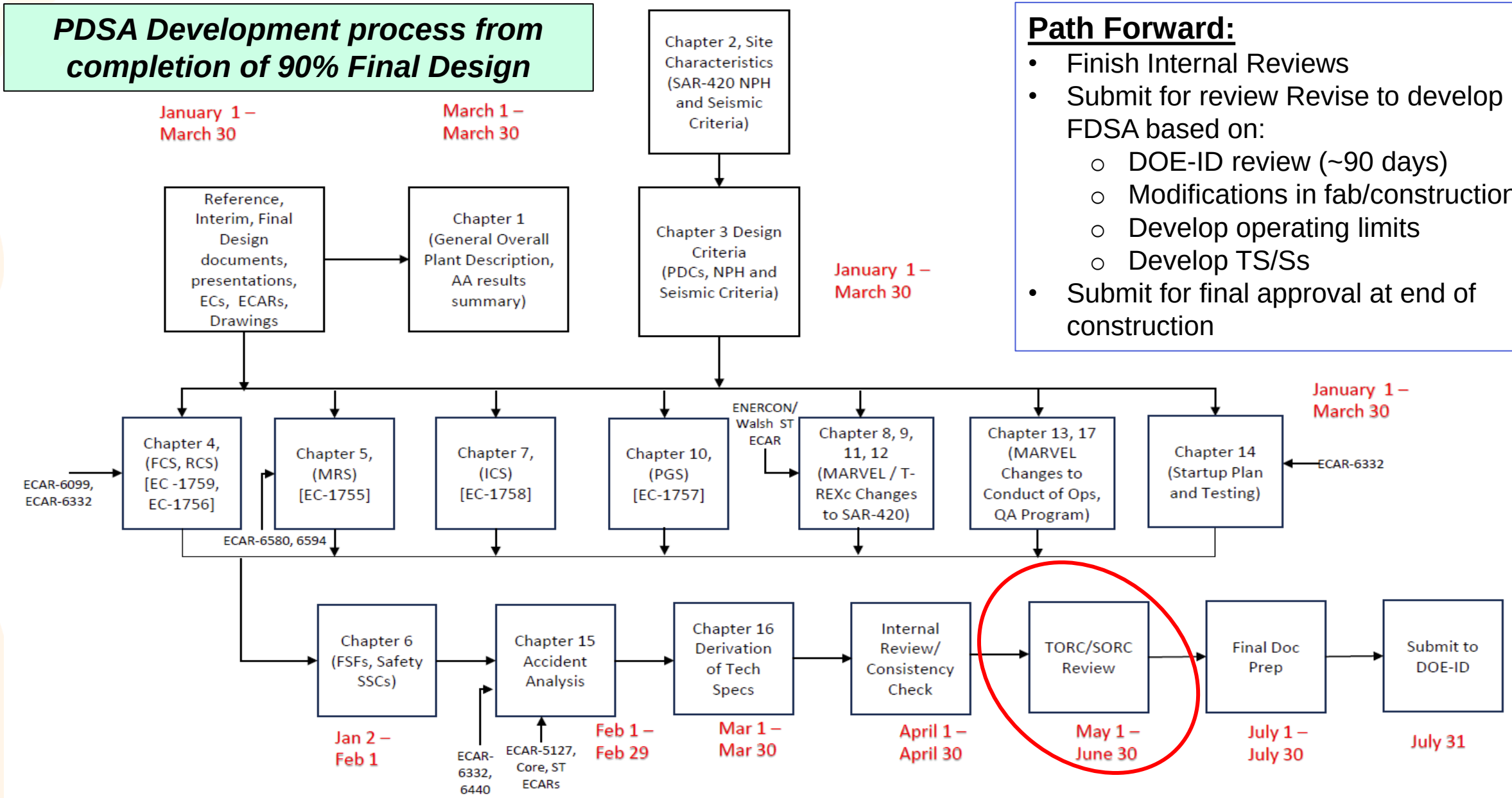


- ***ESFs mitigate the consequences of DBAs to maintain consequences with Evaluation Guidelines (RG 1.206)***
- ***SSCs needed to meet ESFs for reactor safety, protection of the public, collocated/facility workers, & the environment are safety-related.***

MRP Microreactor Program

PDSA Development – Process-to-date, Status, and Path Forward

PDSA Development process from completion of 90% Final Design



Path Forward:

- Finish Internal Reviews
- Submit for review Revise to develop FDSA based on:
  - DOE-ID review (~90 days)
  - Modifications in fab/construction
  - Develop operating limits
  - Develop TS/Ss
- Submit for final approval at end of construction

Thank-you

Questions?