INL/MIS-20-59199-Revision-0

Advanced Test Reactor Experiment Safety Analysis

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

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Advanced Test Reactor Experiment Safety Analysis

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July 30, 2020

13:45-14:30 MDT

Summary

- Define Experiment Safety Analysis
- Discuss what we are protecting and the applicable limits
- Show how safety analysis fits into the experiment process
- Explore the scope of experiment activities and associated accidents
- Present how we categorize accidents and establish accident frequencies
- Identify how controls are implemented and process improvements

What is Experiment Safety Analysis?

- Battelle Energy Alliance operates ATR for the Department of Energy (DOE).
- DOE approves activities and consequences of accidents.
- Experiment Safety Analysis shows experiment activities are within what has been authorized by DOE.
- Similar to the Unreviewed Safety Question process for DOE complex

What is Experiment Safety Analysis?

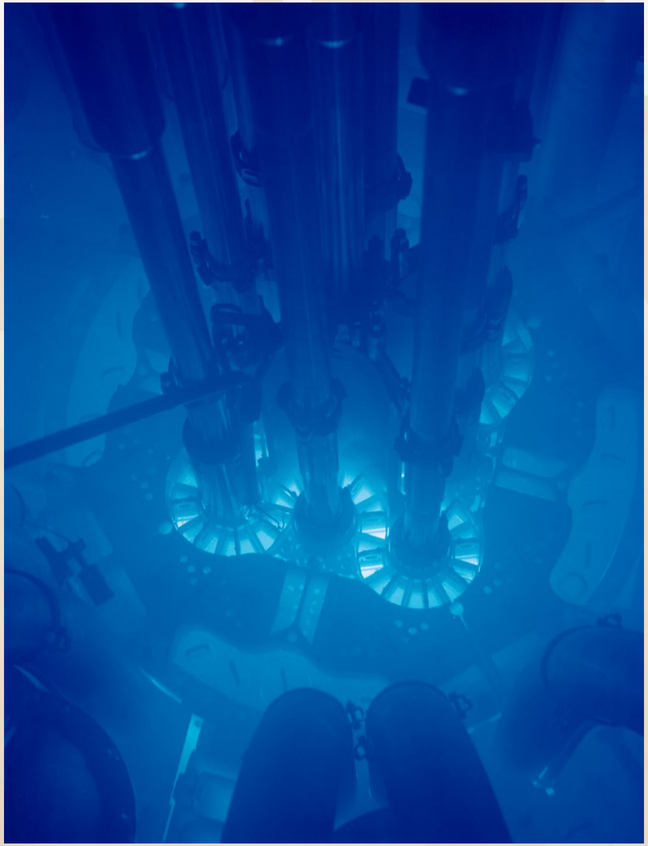
- Experiment Safety Analysis covers all experiment activities at ATR including:
  - Receipt
  - Irradiation
  - Reconfiguration
  - Inspection
  - Shipping

Experiment Safety Analysis Scope

- Aspects of safety: mechanical, chemical, electrical, radiological, etc.
- ATR safety and health programs address industrial type safety concerns
- Documented safety analysis addresses radiological safety
  - Focuses on ATR driver fuel
  - Establishes limits for experiments
  - Experiment safety analysis used for experiments

What is Protected in Experiment Safety Analysis?

- Radioactive material release from experiments
- Damage to the containment boundaries for the ATR diver fuel
  - Fuel plate cladding
  - Primary coolant system
  - Confinement (no Containment)

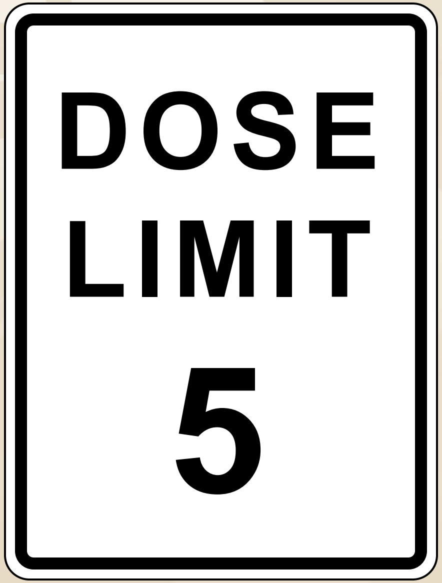


Accident Probabilities

- Department of Energy sets limits based on probability
  - **Condition 2** – Anticipated (once every 100 years)
  - **Condition 3** – Unlikely (once in 10,000 years)
  - **Condition 4** – Highly Unlikely (once in a million years)

Dose Consequence Limits

- **Condition 2**
  - 5 rem on-site / 0.5 rem off-site
  - No rupture of fuel plate cladding
- **Condition 3**
  - 6.25 rem on-site and off-site (facility workers allowed high dose)
  - Primary coolant system must be maintained
- **Condition 4**
  - 25 rem on-site and off-site
  - If Primary coolant system failure then confinement must be maintained



Approved Accidents and Consequences

- Documented safety analysis (SAR-153) evaluates a broad set of accidents
- SAR-153 shows these accidents are below DOE limits
- Must show that accidents occurring for specific experiments remain within the accident set and consequences presented in SAR-153

Integration with Experiment Design

- Up-front integration with experiment design
- Analysis guides provide best-practice for compliance with standard safety requirements
- Experiment safety analysis requirements are incorporated in final design and analyses

Experiment Safety Analysis Process

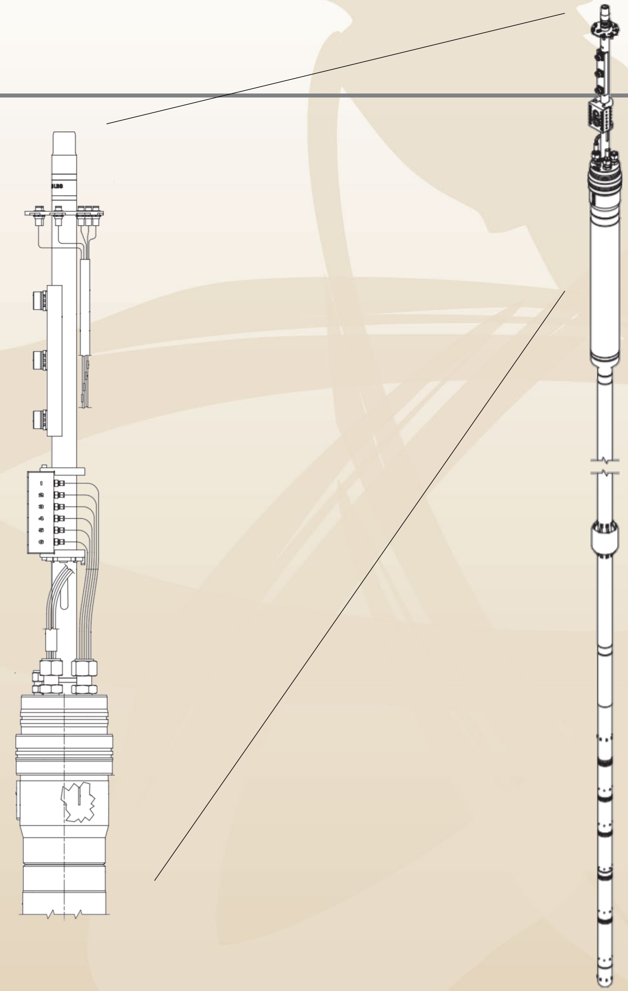
- Understand and capture full scope of experiment activities
  - Review written procedures
  - Draw on system knowledge and operating experience
- Ensure specific requirements from SAR-153 are met
  - Departure from nucleate boiling ratio
  - Reactivity insertion
  - Fission power
- Review potential accidents
  - Evaluate experiment specific accident to ensure no new accidents are introduced
  - Ensure dose consequence is within SAR-153 accident analysis

In-Pile Tube (IPT) Experiments

- Located in flux traps – have greater potential for reactivity insertion
- Combined, IPT experiments represent significant fission product inventory
- Established analysis in SAR-153 protects driver fuel and the IPT facility, includes:
  - Blowdown analysis
  - IPT structural limits
- Assumptions in these analyses are protected
  - Temperatures
  - Stress Cycles
  - Power
  - Experiment construction

Lead-Out Experiments

- Include support systems
- Have the potential to release outside the reactor
- Typically have a more robust experiment containment
- Installation and removal from reactor are more complicated



Drop-In Experiments

- Directly cooled by the primary coolant system
- Experiment release occurs directly into the primary coolant system
- Typically small, but can include full-size fuel plate designs

Experiment Transfer, Reconfiguration, and Storage

- Large transfer cask
- Drop-chute
- Manual handling tools
- Specialty fixtures

Experiment Sizing

- Dry Transfer Cubicle
  - Ventilation
  - Manipulators
  - Saws
  - Combustible Loading
- Canal Sizing
  - Guillotine Cutter
  - Bandsaw
  - Changes in center of mass

Experiment Shipping

- Cask/container loading
- Cask/container movement and storage
- Vacuum drying

Establishing Accident Frequencies

- Probability of accidents is based on qualitative guidance and precedent established by accident scenarios evaluated in SAR-153
- All experiments fail
  - One-of-a-kind tooling
  - Novel fuel and cladding concepts
  - New procedures and processes
- Area of improvement
- More robust designs fail less frequently

Protecting Analysis Assumptions/Inputs

- Analysis is only valid if the assumptions/inputs are maintained
- Examples include:
  - Lobe power
  - Decay time
  - Experiment Configuration
- Use of procedure tags

Process Improvement Initiatives

- Development of generic experiment safety analyses
- Move to decouple programmatic and safety requirements
- Assume all experiments fail at Condition 2
- Establish bounding dose consequence analyses
- Derive programmatic requirements for experiment failure

Conclusions

- Experiment Safety Analysis limits radiological dose consequences from experiments
- All experiment activities at ATR are considered and shown to be within DOE authorization basis
- Constantly working to improve the process