SAFETY ANALYSIS OF THE ARC-100 SODIUM-COOLED FAST REACTOR

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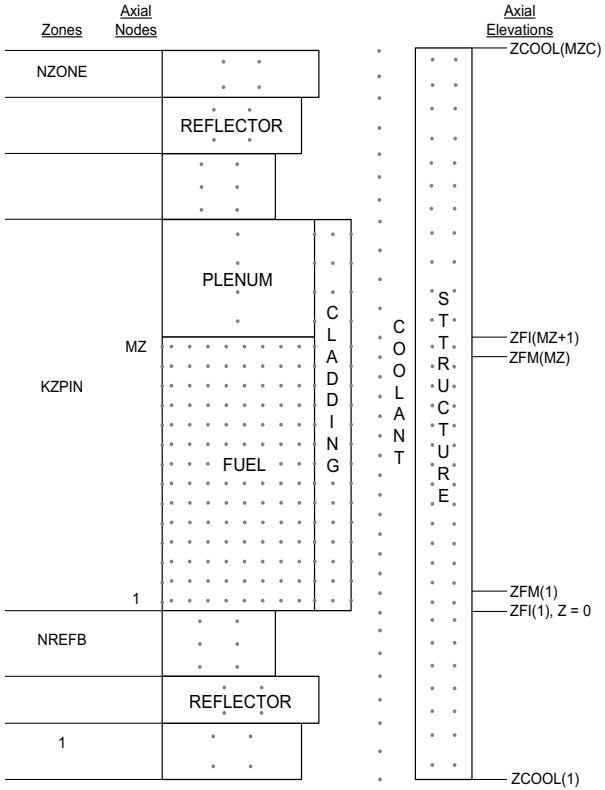
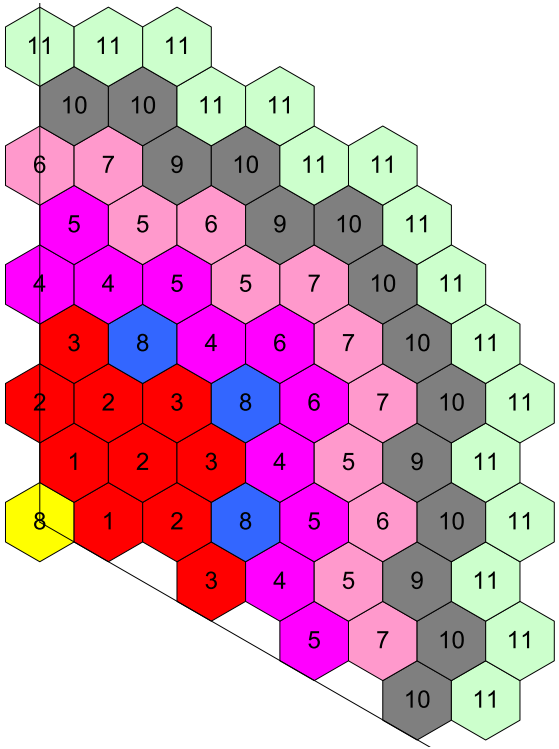
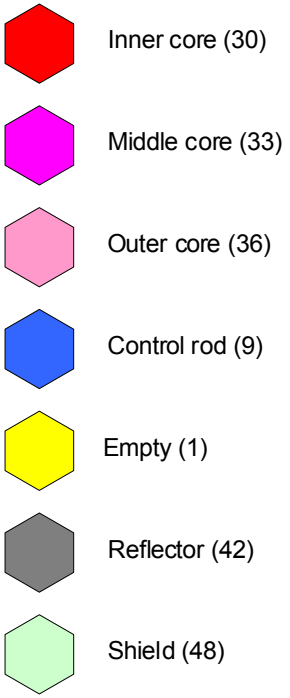
OVERVIEW

- ARC-100:
  - 100 MWe fast reactor
  - Long-lived core with low burnup reactivity swing
  - Sodium coolant
  - Metallic fuel
  - Pool type
- SAS4A/SASSYS-1 model represents:
  - Core
  - Primary heat transport system
  - Secondary heat transport system
  - RVACS
  - DRACS
- Safety Design Philosophy:
  - Relies on passive safety
  - Leveraging safety characteristics of key design features
- Unprotected transients analyzed:
  - Station blackout
  - Loss of heat sink
  - Transient overpower
  - BOL, MOL, and EOL

SAS4A/SASSYS-1 CORE MODEL

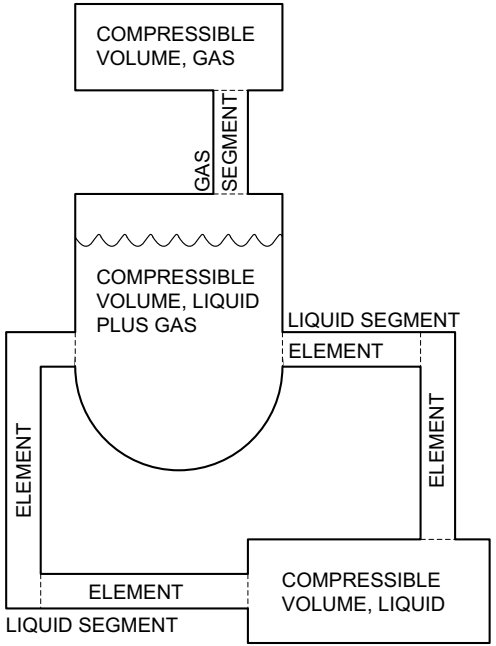


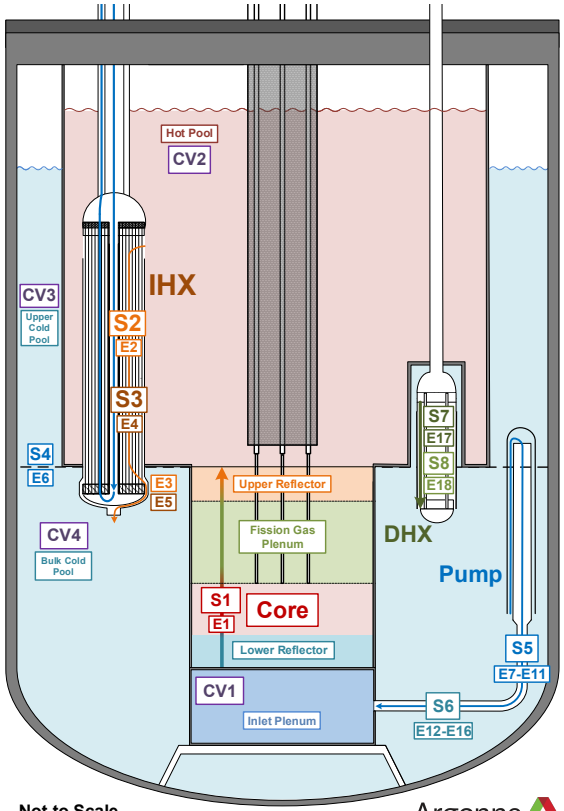




SAS4A/SASSYS-1 HEAT REJECTION SYSTEM MODEL

- PRIMAR-4 module used to model ARC-100 heat transport systems
  - Primary
  - Intermediate
  - DRACS
  - RVACS





METRICS & CRITERIA

Metrics

- Maintain coolable fuel pin geometry
- UTOP, USBO, ULOHS
- Expected to have frequencies of occurrence below 10^{-6} per reactor-year
- Conservatively evaluated against criteria for beyond design basis events
- Note: These metrics are preliminary and will depend on results of PRA

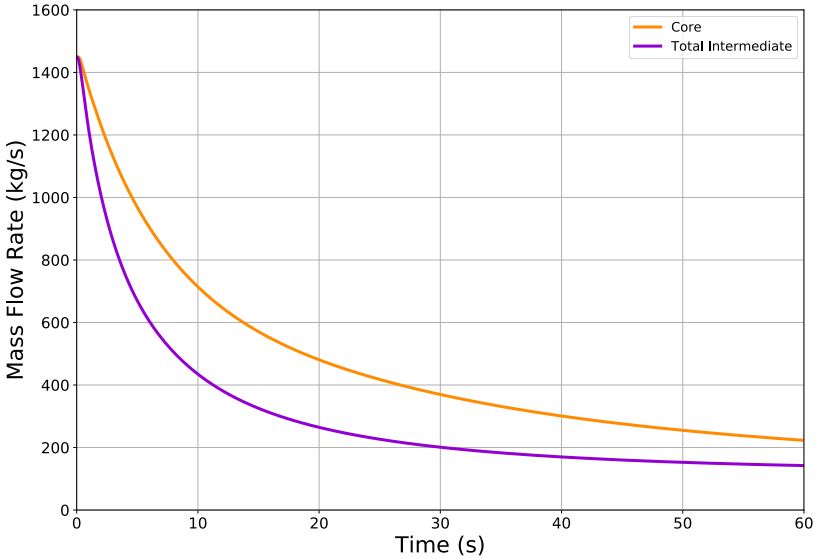
Criteria

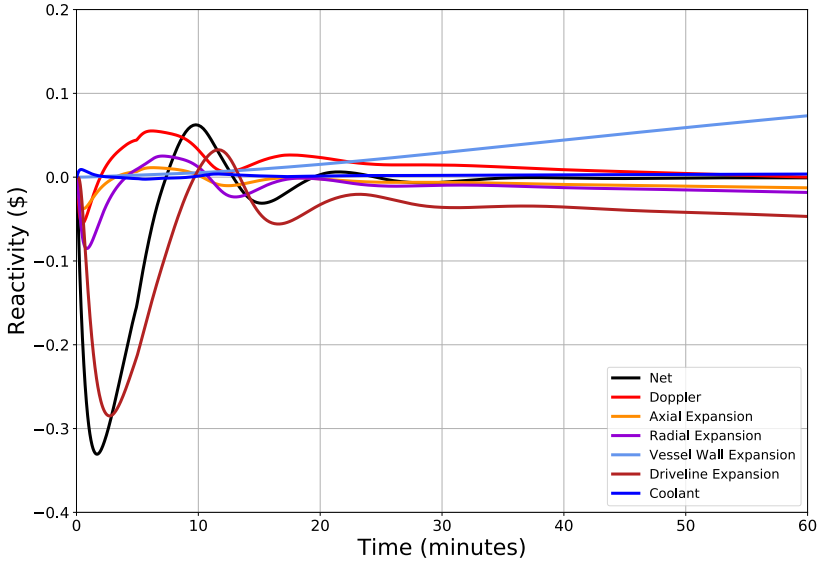
- No sodium boiling
- No fuel melting
- No significant loss of cladding from FCCI
  - Threshold at 715°C
- Maintain reactor vessel integrity
  - Key structures below 704°C

RESULTS

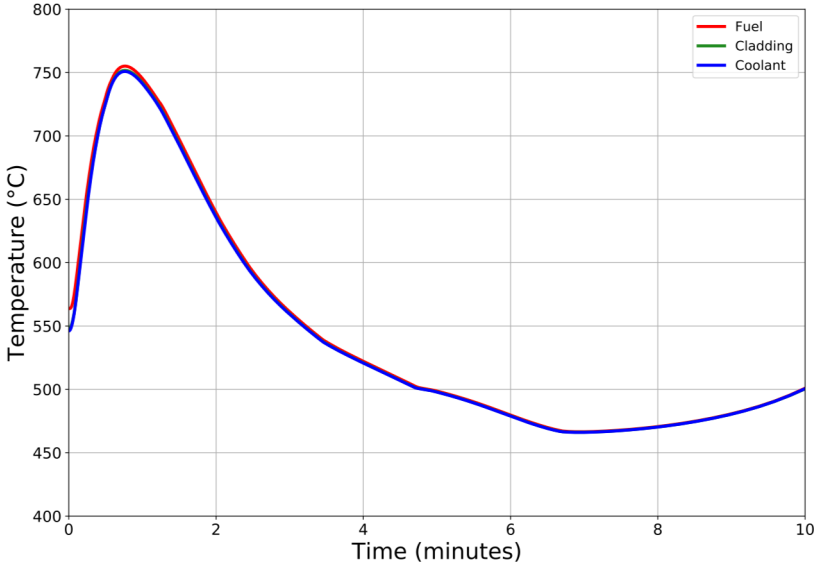
BOL UNPROTECTED STATION BLACKOUT

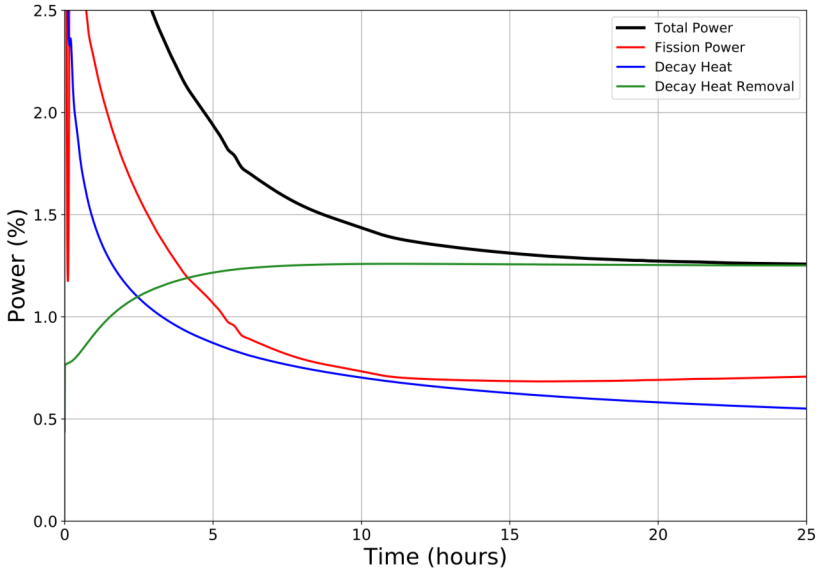
- Loss of electrical power to all plant systems
- Primary pumps trip
- Intermediate pumps trip
- SG heat rejection to zero
- DRACS air baffles open





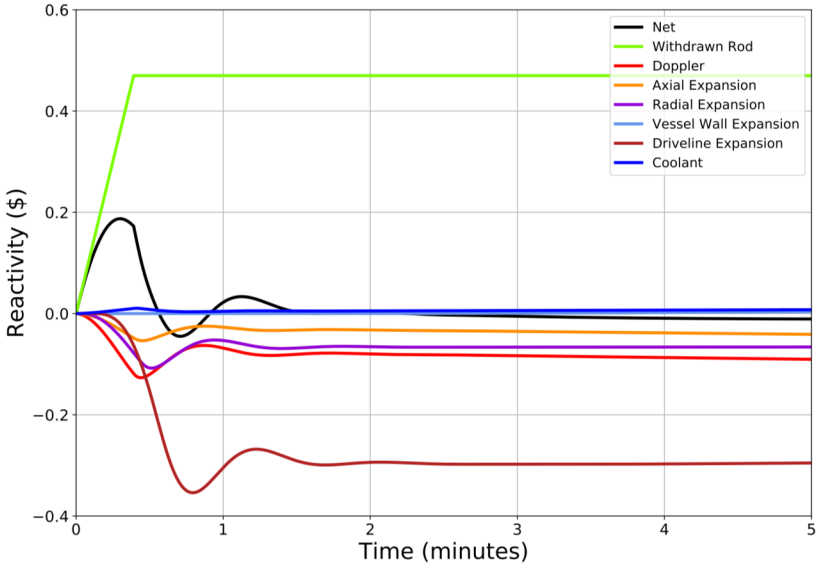
BOL UNPROTECTED STATION BLACKOUT

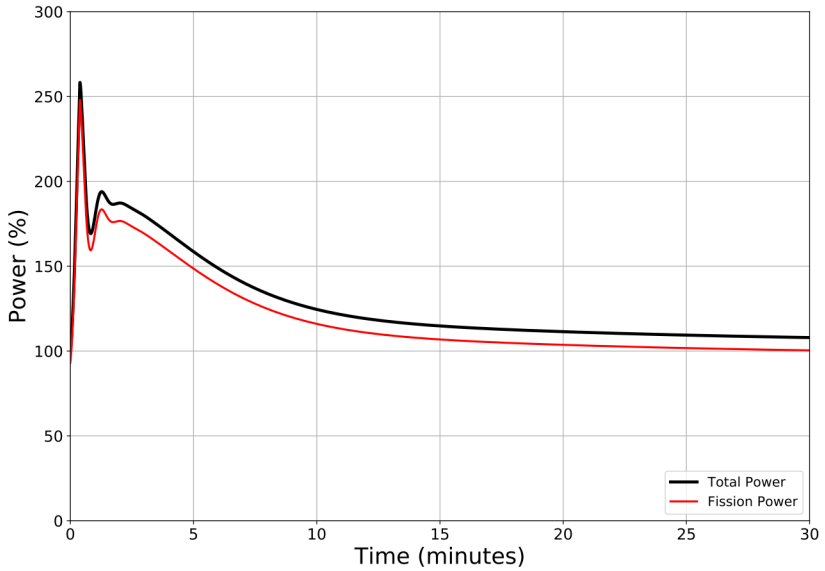




BOL UNPROTECTED TRANSIENT OVERPOWER

- Single most reactivity control rod withdrawn from reactor
- BOL: 47¢ at 2¢/s
- Pumps remain on
- SG conservatively assumed to continue rejecting at 100%





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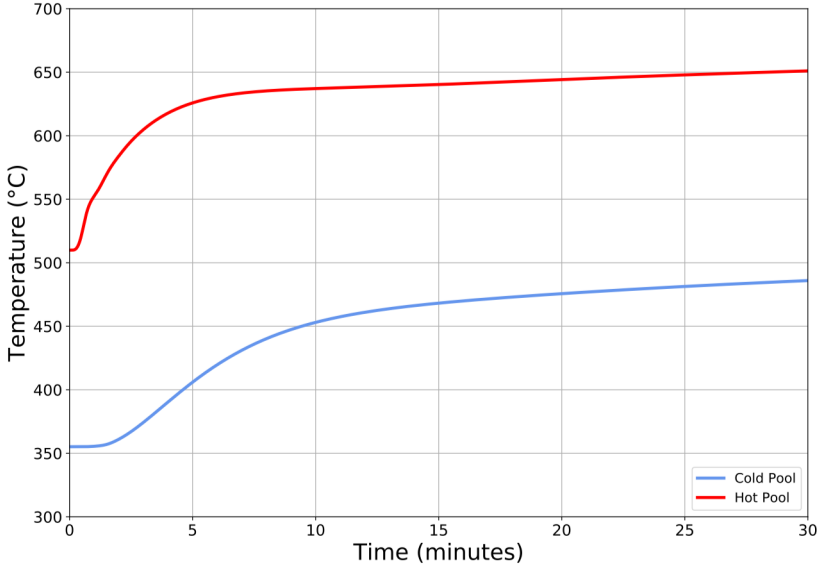
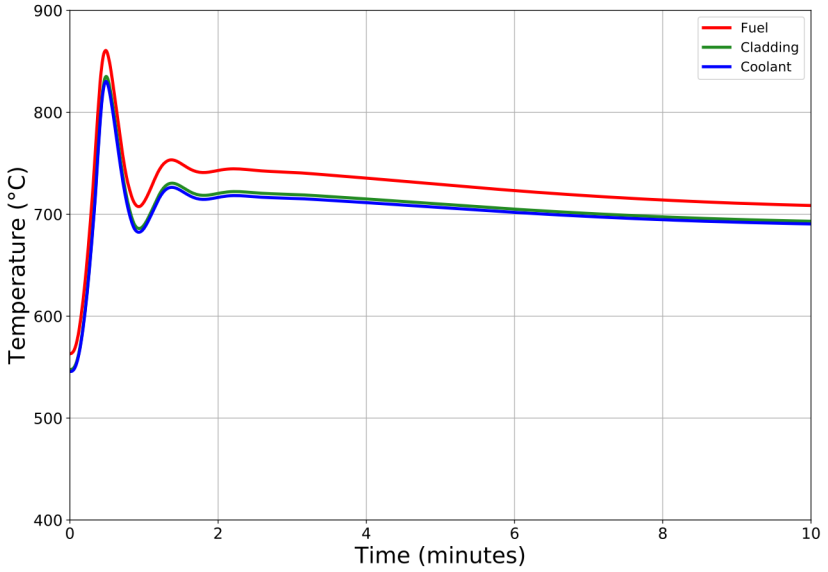
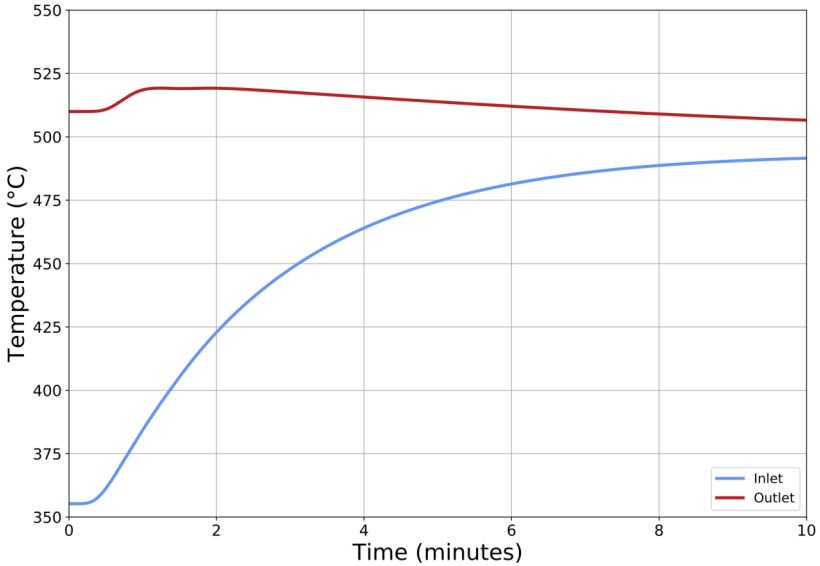
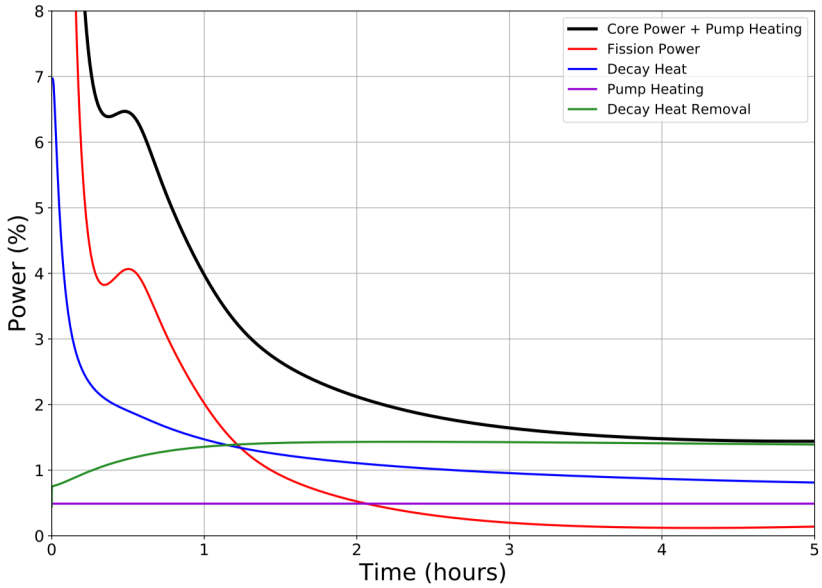




BOL UNPROTECTED LOSS OF HEAT SINK

- Simultaneous trip of intermediate sodium pumps
- All heat rejection through the balance of plant is conservatively assumed lost





SUMMARY AND CONCLUSIONS

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Beginning of Life	Steady-State	USBO	UTOP	ULOHS
Peak Fuel Temp.	564°C	755°C	861°C	568°C
Fuel Melting Margin	659°C	468°C	362°C	655°C
Peak Cladding Temp.	548°C	752°C	836°C	554°C
Max. Clad Penetration	0%	0.1%	0.5%	0%
Peak Sodium Temp.	547°C	751°C	833°C	553°C
Sodium Boiling Margin	396°C	193°C	122°C	388°C
Peak Hot Pool Temp.	510°C	560°C	651°C	516°C
Reactor Vessel Margin	194°C	144°C	53°C	188°C

- Severe unprotected transient scenarios analyzed with SAS4A/SASSYS-1 to assess ARC-100 safety characteristics
  - Very unlikely double-fault events with an assumed failure of the highly reliable reactor protection system
- ARC-100 maintains large safety margins
  - Due to design features that utilize inherent passive responses to unanticipated conditions and equipment failures
  - Sodium coolant provides superior heat removal at near atmospheric pressures with large margins to boiling
  - Metallic fuel operates at relatively low temperatures due to its high thermal conductivity.
  - Pool-type primary system provides a large thermal capacity
    - Allows for shutdown heat removal through the RVACS and DRACS systems via natural circulation
  - Inherent reactivity feedbacks responsible for reducing power to match the total available heat rejection
- These results demonstrate the capability of the ARC-100 design to provide protection against reactor damage during low probability accident sequences resulting from multiple equipment failures

THANK YOU FOR YOUR ATTENTION