



SHUTDOWN OPERATION – A HISTORICAL PERSPECTIVE

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The purpose of this presentation is to provide a historical perspective of shutdown operation as an introduction to Jeff Mittman's presentation that addresses recent trends in shutdown events.



Historical Events

- 4/80 - Davis Besse lost residual heat removal (RHR) for 2 ½ hrs
- 3/86 - San Onofre 2 lost RHR for ¾ hrs, boiling in reactor coolant system (RCS)
- 7/86 – Waterford 3 lost RHR for 3 ¾ hrs, boiling in RCS with reflux cooling – boiling in core with condensation in steam generators (SGs)
- 4/87 - Diablo Canyon 2 lost RHR for 1 ½ hrs, boiling in RCS with reflux cooling. Augmented Inspection Team (AIT).

Diablo Canyon Configuration at Time of Event Initiation

- Containment equipment hatch cover removed, personnel airlock open, no plan for closure
- Bolts in RCS-side SG manways loosened
- SG secondaries open to atmosphere
- SGs in wet layup (73% wide range)
- RCS water level below mid-elevation of hot leg at RCS connection

Diablo Canyon Conditions After Boiling Initiated

- Plant in unanalyzed condition
- Steam and water leaking into containment
- Containment radiation alarms activated
- Hand-held radiation monitors climbing
- Some operators exhausting Scott Air Packs in 10 minutes
- Core cooled via unrecognized reflux boiling
- SG manway would have been removed if event initiated about ½ hr later

Shutdown Precursors

- Few associated NRC regulations and plant technical specifications; limited attention in exams and evaluations
- Inadequate outage planning
 - Little to no plans for makeup capability, control of inventory, training, criticality control, containment
 - Little to no instrumentation depending on parameter measured; instruments often incorrect or indications not understood

Shutdown Precursors (cont'd)

- Phenomena and operational implications not understood
- Reflux boiling not recognized
- Minimum time to core uncover believed to be about 4 hrs - Actually 10 min
- Shutdown operation believed generally safe compared to power; actually risk is comparable to significantly higher

Response following Diablo Canyon Event

- GL 87-12 illustrated that shutdown problems were continuing and not being addressed
- GL 88-17 provided in-depth insights, addressed many items identified in the last 2 slides
- 3/90 - Vogtle 1 lost RHR for ½ hr. Initially AIT, changed to Incident Inspection Team (IIT)
- Vogtle event, many AITs, and plant visits showed improvement but many issues were inadequately addressed
- Industry more actively involved via such means as NUMARC 91-06 and owners group activities
- NRC staff developed proposed rule and probabilistic risk assessment (PRA)

1995 Prediction of Core Damage Frequency per Reactor Year

Item	PWR	BWR
Legally enforceable requirements with no credit for additional operator actions	2×10^{-2}	10^{-3}
Average using voluntary guidance from GL 88-17 and NUMARC 91-06	8×10^{-5}	10^{-5}
In-depth using voluntary guidance from GL 88-17 and NUMARC 91-06	2×10^{-6}	6×10^{-7}
Minimum compliance with proposed rule	10^{-5}	4×10^{-6}



NRC Post-PRA Response

- Commission did not authorize rule - unnecessary given staff estimate of current industry performance.
- Some shutdown aspects introduced into 10 CFR 50.65 Maintenance Rule
- Commission instructed staff to monitor licensee performance and "commission ... may take further action if any adverse trends are identified" (February 4, 1999, Federal Register).
- Jeff Mittman's presentation will cover the response to the Commission's instructions.



References for Additional Info

- NUREG-1269 – Diablo Canyon
- NUREG-1410 – Vogtle
- NUREG-1449 – Shutdown Coverage
- 59 Federal Register (FR) 52707-52714, 10/19/94 – Proposed Rule
- 64 FR 5623, 2/4/99 – Proposed Rule Withdrawn
- 64 FR 38551-38557 – Maintenance Rule
