



# 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 uncovering 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	$2 \times 10^{-2}$	$10^{-3}$
Average using voluntary guidance from GL 88-17 and NUMARC 91-06	$8 \times 10^{-5}$	$10^{-5}$
In-depth using voluntary guidance from GL 88-17 and NUMARC 91-06	$2 \times 10^{-6}$	$6 \times 10^{-7}$
Minimum compliance with proposed rule	$10^{-5}$	$4 \times 10^{-6}$

# 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