Spent Fuel Pool Accident Risk at Decommissioning Plants

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Background

- Permanently shutdown nuclear power plants look for early regulatory relief in three areas:
  - Insurance
  - Security
  - Emergency Preparedness (EP)
- Relief provided by exemption process
- Zirconium fire important consideration
- Several rulemaking attempts initiated
  - Stopped; technical bases inadequate

1) EP and Security relief allow significant man-power reductions at the site. Insurance costs are proprietary but are thought to be less than 500K per year even without exemptions. The industry appears to be more interested in getting out of the Price-Anderson secondary insurance pool so that a decommissioning licensee would not be liable for an operating reactor event.

2) The staff has processed approximately 9 exemptions in each regulatory category (insurance, EP, & safeguards) for decommissioning plants.

3) Consideration of when a zirconium fire is no longer possible evolved into a de facto acceptance criteria for these exemptions after the SRM on SECY-93-127.

4) Insurance rulemaking actually went through the proposed rule stage before it was halted. EP and Safeguards never went any further than rulemaking plans.

Background (cont.)

- Industry challenged zirconium fire criteria
- Commission meeting March 17, 1999
  - SRM sanctioned risk-informed approach
- Staff committed to perform detailed technical study on decommissioning plant spent fuel pool risk
- Risk study now complete

1) In mid 1998, Maine Yankee challenged the staff's use of deterministically assessing for the possibility of a zirconium fire for an EP exemption at their site.

The staff conducted a backfit review which was ultimately upheld in favor of the staff's position in mid-1999.

2) At a March 1999 Commission meeting, the staff indicated that resolution of the zirconium fire issue might be achieved using a risk-informed approach. The SRM for the meeting supported the staff's efforts to pursue this approach.

3) The details of the staff's technical risk study and subsequent decommissioning rulemaking plans were contained in SECY-99-168. The SRM for this SECY agreed on going forward with the technical study as outlined in the SECY.

4) The completed risk study was publicly issued on January 17, 2001.

Study Charter

- Provide generic, risk-informed technical study for spent fuel pool accidents that could be used as basis for rulemaking
- Provide guidance that could be used while rulemaking process was ongoing

In March 1999, TWG formed to:

1) to provide a generic technical basis on SFP accident risk to support development of a risk-informed technical basis for integrated rulemaking for decommissioning plants

2) to provide guidance that could be used while rulemaking process was ongoing

As you recall, the staff was undergoing rulemaking to improve regulatory consistency and predictability

- 10 CFR Part 50 directed toward operation of NPPs

- Commission directed the staff to explore improvements in regulations for decommissioning plants.
  SRM dated June 23, 1999 from March 17 Commission briefing

- Commission thought areas of insurance, emergency preparedness, and security were candidates for risk-informing.

- NRC has generally granted exemptions on case-by-case basis using plant specific analysis to show no offsite release over EPA Protective Action Guidelines.
  - most extreme case, demonstrate no zirconium fire with air sufficient cooling.

Stakeholder Interactions

- 2 draft reports issued for public comment
- 15 different organizations or individuals provided comments
- 14 open meetings held with stakeholders
- 5 open agency meetings (Commission and ACRS)

Throughout project, the staff has worked extensively with the stakeholders

1) Issued draft reports in June 1999 and February 2000 for public comment

2) Received comments from 15 different organizations or individuals
e.g., - Organizations: NEI, WOG, UCS, Friends of the Coast (in Maine)
- Individuals: James Atherton, Paul Blanch, Michele Kiddell

- 110 comments were responded to in the latest report

3) Held 14 open meetings with the stakeholders directly

- including public meeting on 2/6 regarding NEI's presentation material from the last ACRS meeting

4) and, in addition, had 5 agency meetings
(Commission and ACRS) to which the public could attend and, many times, participate in.

- Commission mtgs: March 1999; November 1999
- ACRS full committee: November 1999; November 2000
- ACRS subcommittee: October 2000

- Staff received favorable letter from ACRS from Nov 2000 meeting. Additionally, ACRS had seen info from NEI January 10 letter report from NEI presentation in ACRS Nov 2000 mtg.

Analysis Approach

- Used "generic" decommissioning plant and spent fuel pool
- Estimated likelihood of fuel uncovery
- Performed numerous sensitivity studies
  - Consequence analyses
  - Thermal-Hydraulic analyses

Analysis Approach

1) Used "generic" decommissioning plant and spent fuel pool

- defined level and temperature instrumentation; staffing; procedures; cooling and makeup systems
- important parameters defined in the Staff Decommissioning Assumptions and Industry Decommissioning Commitments

2) Estimated likelihood of fuel uncovery

- spectrum of initiating events (seismic , cask drop, loss of power, loss of cooling, tornado)

- did not perform accident progression analysis (PRA ended 3 feet above top of fuel and T/H analysis started with a drained pool (complete or partial))

3) Performed numerous consequence sensitivity studies

- varied decay time; evacuation time; plume parameters; ruthenium release

Analysis Approach (cont.)

- Compared results to agency quantitative health objectives
- Assessed Emergency Preparedness (EP) relaxation consistent with RG 1.174

Analysis Approach (cont.)

4) Compared results to agency quantiative health objectives

- the risk to an average individual in vicinity of NPP of prompt fatality should not exceed one-tenth of 1% from all other accidents that the US population is exposed to

- the risk to the population in area of NPP of cancer fatalities should not exceed one-tenth of 1% from sum of all other cancer fatality risks from all other causes

5) Assessed EP relaxation consistent with RG 1.174

The risk assessment is consistent with all PRAs in that security events were not included.

Examples of Stakeholder Comment Response

- Need to consider criticality
  - Included a criticality assessment
- Too conservative in our seismic assessments
  - Included EPRI and LLNL hazard curves
- Need to consider recent events
  - Included Browns Ferry and Duane Arnold SFP temperature increase

Examples of Stakeholder Comment Response

1) Commenters stated that we needed to consider criticality
so we included a criticality assessment writeup in the report

- staff had considered criticality but since there was no effect, we did not include a write up in June draft

2) Some commenters thought we were too conservative in our seismic assessments
Added both EPRI and LLNL curves

- LLNL used by staff; EPRI curves generally predict lower frequency estimates; particularly when dealing with large earthquakes (larger uncertainity).

- Methodologies for LLNL and EPRI curves were developed by different groups of seismic experts. Both methodologies are valid, so we included both. In this case, the difference in methodologies did not affect our conclusions.

3) Several commenters said we needed to consider recent events - example:

Evaluated Browns Ferry and Duane Arnold SFP temperature increase
- Browns Ferry (Dec 1998) 25 degree increase over 2 days
- Duane Arnold (Jan 2000) 40 - 50 degress increase over 2.5 days
Explicitly mentioned in report when considering loss of cooling events. Staff Decommissioning Assumptions 1) on direct measurement of pool for temperature and level, and 2) walkdowns once per shift

Technical Findings & Conclusions

- Spent fuel pool accident risk is low
- Agency quantitative health objectives are met
- Consistent with RG 1.174
  - EP relaxation after 60 days is consistent with a "small change" in risk

Our findings....

The results of the study are based on decommissioning plants using our "generic" plant

1) confirmed what was thought all long - that the SFP accident risk is low and the agency quantitative health objectives were met

- QHOs met even with most unfavorable parameters from the study's sensitivity studies, including the highest ruthenium release fraction of 75%

2) EP relaxation after 60 days cooling time is consistent with a "small change" in risk from RG1.174

- modeled EP relaxation by varying the evacuation time (before release or after release)
- Impact of EP is "small change" because
  - for seismic events, the infrastructure is destroyed
  - for cask drop, planned evacuation does help but there is a low probability of occurrance
  - slow boil off events are easily mitigated, low probability events, or requires the very low probability of a complete organizational breakdown that fails to stop the event and therefore would fail to execute a preplanned evacuation.

Technical Findings & Conclusions (cont.)

- Cannot define a generic decay heat time beyond which a zirconium fire is not physically possible
  - Fuel geometry following very low frequency events indeterminate
- Research on source term generation in air environment would be useful in reducing uncertainties

Technical Findings & Conclusions (cont.)

3) Criterion of sufficent air cooling to preclude a significant release cannot be satisfied on a generic basis

- study did not conclude that the fire was likely; rather the study concluded that the possibility of a fire could not be precluded because the decay heat source remains nonnegligible for many years and since configurations that ensure sufficient air flow for cooling cannot be assured

4) Research on source term generation in air environment would be useful in reducing uncertainties

However, because the events that we are most concerned with are catastrophic events, the benefits of further research must be considered in comparison to the gains in reducing uncertainties

Regulatory Implications

- No immediate safety concerns
  - Immediate regulatory action not needed
  - Low likelihood of fuel uncovery event resulting in significant off-site radiological release
- Staff granted exemptions based on sufficient cooling for reasonably conceivable situations

A significant finding of report is that it is not feasible to define a generic decay heat level and time beyond which a zirconium fire is not physically possible.

This was the basis for Price-Anderson exemptions and an important consideration for staff decisions in EP and Safeguards. Other considerations for many of these exemptions was that for reasonably conceivable situations, there would be sufficient air cooling of fuel such that significant release would not occur.

The conclusion that there is no immediate safety concern was primarily based on the low likelihood of a fuel uncovery event resulting in a significant offsite release.

Other reasons for no immediate safety concern include:

- Over 20 hours of heatup time is available to take protective or mitigative actions at all decommissioning plants based on the current level of decay heat at these sites.

- The actual fuel burnup at the decommissioning plants with exemptions is lower than the fuel burnup assumed in the study

- The spent fuel pools are not full, therefore, ventilation will likely be better than assumed in the study

- Staffing at the currently decommissioning plants is still highly qualified

Staff is re-examining
1) Regulations (VBS)
2) Guidance (RG 5.65)
3) Exemptions

Insurance

- SRM for SECY-93-127 directed staff to approve a reduction in insurance requirements after requisite minimum spent fuel cooling period elapsed
- Exemptions based on assessment that air cooling of fuel would not result in zirconium fire
- Exemptions granted relief in primary and secondary insurance protection

Zirc Fire = "Reasonably Conceivable" (DBA --- Reasonably Conceivable --- Hypothetical)

1) Price-Anderson enacted in 1957. It is periodically re-authorized, and currently will expire on August 1, 2002.

Commission is authorized to reduce Price-Anderson coverage based on hazard considerations

2) Two-part insurance system for liability payments:
- Primary Insurance: $200M *per site.*
- Secondary Insurance: $83.9M *per reactor per accident*
  Total Retrospective Pool ($83.9M x 104 reactors = ~$9 Billion)

3) Exemptions after requisite cooling period resulted in the following levels of coverage:
   - Primary Insurance: $100 M per reactor (Commission SRM authorized reduced coverage in SECY-93-127)
   - Total $600 M still available for claims ($100 M Licensee/ $500 M Government Coverage)
   - No participation in Secondary Retrospective Pool

4) Liability of secondary pool appears to be bigger concern to decommissioning plants than cost of primary coverage

SECY-93-127 stated that the requisite cooling period after reactor shutdown was the time when a zirconium fuel cladding fire sequence was no longer a concern since the fuel would air cool sufficiently to avoid zirconium cladding combustion

Air cooling analyses were done assuming unrestricted air flow through fuel assembly cooling channels without blockage or assembly geometry changes. SECY-93-127 stated that zirconium fire sequences that involved blockage of coolant channels approach the "strictly hypothetical."

- 10 insurance exemptions given at 9 decommissioning sites (one issued before SECY-93-127)
- A zirconium fire was considered a "reasonably conceivable" in SECY-93-127

Examples of bases used in exemptions:
Haddem Neck: "...spent fuel is no longer susceptible to rapid zircoloy oxidation...."
Maine Yankee: "...there is reasonable assurance that rapid zirconium oxidation is no longer possible.."

Security

- Exemptions to certain security requirements based on considerations such as:
  - No significant threat to public health and safety
  - No significant offsite consequences
  - Potential release of large radioactive source term no longer exists

Examples of Bases for current security exemptions
San Onofre: "In addition, with more than 90 months of radiological and heat decay since SONGS 1 was shut down in 1992, the radiological hazards associated with the remaining target sets, even to sabotage attack, do not pose a significant threat to the public health and safety."

Zion: "The staff also noted that recent evaluation of the decay heat conditions of the spent fuel in the fuel pool has indicated that even if a sabotage attack were to succeed in draining the spent pool, there would not be any significant offsite consequences."

Big Rock Point: "The potential for a release of a large radioactive source term to the environment from the high pressure and temperature associated with reactor operations no longer exists."

Yankee Rowe: "The status of YNPS provides a significancy reduced risk from a radiological release as a result of sabotage."

Rancho Seco: "The exemption request is based on . . . (4) that an act of sabotage that could result in a dose in excess of these [10 CFR Part 100] limits is not a credible event."

Part 100 limits are 25 Rem Whole Body and 300 Rem Thyroid

General Notes:
- Exemptions to security programs were issued to 9 licensees for 10 decommissioning plants.
- The exemption for San Onofre 1 explicitly states that uncovery of spent fuel will not result in a fuel cladding fire because the fuel has stainless steel cladding.
- The remaining 8 exemptions do not address the probability or likelihood of a zirconium fire.
- In general, the exemptions stated that the potential radioactive source term was reduced and that credible radiological sabotage events do not pose a significant threat to public health and safety.

Other Implications: The bases for previous exemptions for the devitalization of the spent fuel pool at operating reactors and security for dry cask storage may need to be reconsidered.