Guidance for Decommissioning Plants Entering Safe Storage – 15280

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ABSTRACT

Although a number of plants worldwide have been placed into safe storage after permanent shutdown, there is no generic guidance for establishment of safe storage conditions. To address this need, EPRI is conducting a project to document the best practices to reduce risk, maintenance and monitoring requirements during safe storage, as well as practices that optimize decommissioning following the safe storage period. This project additionally evaluates potential options for establishment of safe storage conditions, such as performance of chemical decontamination, completion of environmental remediation activities, early removal of highly activated components, dismantlement of non-power block structures and partial site release in advance of completion of decommissioning of the nuclear island.

INTRODUCTION

An available option for permanently shut down nuclear power plants is to place the plant in a stable condition after defueling and then to complete decommissioning at a later date. This safe storage option is primarily available to allow for decay of shorter-lived radionuclides. This option also enhances efficiency at multi-plant sites where other units will remain in operation for an extended period by allowing decommissioning of all plants on the site at one time.

The decision of whether to proceed into active dismantlement as soon as practicable after plant shutdown or enter into safe storage is influenced by many factors. The more critical factors are listed below:

- Radiation exposure during dismantlement: favors safe storage to allow for radioactive decay (primarily cobalt-60);
- Decommissioning trust fund: favors safe storage if not fully funded;
- Plant material condition: favors prompt dismantlement to allow plant equipment to be used to support dismantlement;
- Waste disposal capability:
  - favors safe storage if disposal is not available for all or most of the expected waste
  - if waste disposal capability is available, prompt dismantlement could be the favored strategy to avoid future waste disposal cost increases and/or waste disposal site closure
- Utility staff: favors prompt dismantlement if knowledgeable staff will be supporting dismantlement;
- Land/facility value: favors prompt dismantlement if the plant is on high value land or the site will be immediately re-purposed; and
- Public policy: favors prompt dismantlement if the public wants all perceived nuclear risk eliminated as soon as practicable.

SELECT EXPERIENCE WITH SAFE STORAGE

Recently, Kewanee, Crystal River and Vermont Yankee have ceased operations and have elected to place their plants into safe storage. Additional plants worldwide are currently in safe storage such as Indian Point 1, Peach Bottom 1, Dresden 1, TMI 2, Millstone 1, Douglas Point, Gentilly 2 and Pickering 2 and 3. Further, plants such as Rancho Seco, Humboldt Bay and Zion 1 and 2 in the US and Garigliano, Caorso, Trino and Latina in Italy were initially placed into safe storage after shut down and then subsequently began active decommissioning. Finally, a number of sites in the UK and Japan intend to perform substantial dismantlement of non-power block systems, structures and components, and then to place just the most highly active portions of the plants (the nuclear island) into a safe storage condition.

Indian Point 1:

Indian Point Nuclear Station Unit 1 is a medium-sized pressurized PWR in the US. The plant ceased operations in 1974 and the US NRC formally approved safe storage in 1996. The plant will be maintained in this condition until Indian Point 2 is permanently shut down.

The most notable event that has occurred during the safe storage period is detection of groundwater contamination at the site due to leakage from the spent fuel pool (primarily strontium-90 and tritium contamination). All fuel has been removed from the spent fuel pool and the fuel pool has been drained. A robust groundwater monitoring program has been established at the site in response to this event.

Similar examples of plants that have been in long-term safe storage (greater than 20 years) include Fermi 1, Dresden 1, TMI 2, Douglas Point and Peach Bottom 1.

Humboldt Bay:

Humboldt Bay Nuclear Plant is a small BWR in the US. The plant ceased operations in 1976 and was declared permanently shut down in 1985, at which time the plant entered safe storage. Under US regulations, completion of plant decommissioning could have been delayed until 2045 (60 years from permanent shutdown). However, the utility owner identified a need to construct a new combined cycle plant on the site and began dismantlement of the nuclear plant in 2008 to support repurposing the site. Completion of decommissioning of the Humboldt Bay plant, through license termination is scheduled for 2019.

Humboldt Bay experienced multiple fuel failures during its short operation, resulting in relatively high levels of alpha contamination throughout the plant. This combined with radioactive decay of shorter-lived gamma emitters such as cobalt-60 during the 30-year safe storage period has led to low gamma/beta to alpha ratios within the plant, which has led to challenges with radiation protection measures during plant dismantlement.

Similar examples of plants that originally planned on extended safe storage but opted for earlier completion of decommissioning for economic reasons include Rancho Seco, Zion 1 and 2, and San Onofre 1 in the U.S. Additionally several plants in Italy have begun dismantlement activities after a shortened safe storage period primarily due to public policy changes, including the plants at the Caorso, Trino, Garigliano and Latina sites.

Hamaoka 1 and 2:

Hamaoka Nuclear Power Station Units 1 and 2 are medium-sized boiling water reactors in Japan. These two units permanently shut down in 2008. Three operational units (Hamaoka 3, 4 and 5) occupy the same site. In contrast to pursuing either a prompt dismantlement or safe storage approach, the Hamaoka units will be decommissioned using a hybrid approach in which all facilities except for the reactor building will be promptly dismantled and the reactor building will be prepared for a modest 10-year period of safe storage. This approach will allow for radioactive decay in higher activity components and allow for construction of storage facilities for higher activity wastes.

A similar hybrid approach is being taken at all commercial power reactor sites in the UK, although the planned safe storage periods for the reactors are much longer (greater than 50 years in most cases).

Barseback 1 and 2:

Barseback Nuclear Power Station Units 1 and 2 are medium-sized boiling water reactors in Sweden. The plants permanently shut down 1999 and 2005, respectively. After completion of transition period activities, including coolant system chemical decontamination and spent fuel transfer, the plants have been maintained in safe storage. However, rather than maintaining the plants in safe storage for an extended period as discussed above, dismantlement activities are planned to commence within the next several years (2016-2018), with the timing tied to the planned commissioning date of the national decommissioning waste disposal facility in Sweden.

Crystal River 3:

Crystal River Nuclear Power plant is a large pressurized water reactor in the US The plant ceased operations in 2009 and permanent shutdown was announced in 2013. The utility owner has announced that the plant will be placed in safe storage with a dormancy period of approximately 50 years[1]. This approach will allow completion of decommissioning activities through license termination within the 60-year period prescribed in US regulations. The recently shutdown Gentilly 2 plant in Canada is also preparing to enter an extended safe storage period. These plants will join a number of plants in the U.S., Spain and Canada that are already in extended safe storage periods, notably including Indian Point 1 and Peach Bottom 1 in the US that have been in safe storage for 40 years.

CONSIDERATIONS FOR ESTABLISHMENT OF SAFE STORAGE CONDITIONS

Although there are no formal requirements for what constitutes safe storage, the following generic activities should be considered:

- Remove all spent fuel from the plant and transfer to either dry storage or to a central wet spent storage location. This key activity is not required, but has been taken at most, but not all, shut down sites. This is desirable to reduce overall radiological and industrial safety risk, and to reduce staffing, monitoring and reporting requirements. The key limitation to this goal is the availability of alternative spent fuel storage.

- Drain all contaminated water from plant systems and tanks to the extent practicable. This is desirable to minimize movement of contamination both within and external to the plant during the safe storage period and to reduce monitoring requirements. Key limitations to this goal are availability of alternatives to spent fuel storage in the plant spent fuel pool (e.g., dry cask storage or transfer to a central wet fuel storage facility); and the ability to process and discharge water from the site immediately after plant shut down.

- Dismantle non-radiological systems, structures and components. This relatively low-cost activity is desirable to free up space on the site for future dismantlement activities, to reduce potential for contamination of non-impacted areas, and to minimize monitoring requirements during the safe storage period. Since such systems, structures and components are not contaminated, there is no radioactive decay driver for delaying dismantlement.

- Perform a comprehensive historical site assessment to ensure all areas of potential radiological and non-radiological hazards have been identified. This is desirable to accurately define the scope of future dismantlement activities and to identify actions that may be required immediately to manage existing contamination (see bullet item below). Additionally, personnel knowledgeable with the detailed operations of the site will likely not be available when dismantlement commences.

- Manage known radiological and non-radiological environmental contamination. This may include prompt remediation, isolation of the contaminant or development of a monitoring program. This is desirable to minimize the spread of such contamination during the safe storage period. The primary limitation to this goal is early use of decommissioning funds.

- Disconnect all plant utilities and re-power using external sources (that is, establish "cold and dark" conditions). This is desirable to minimize personnel risks and to minimize monitoring requirements during the safe storage period, and to reduce risks to workers unfamiliar with plant systems during early dismantlement activities that may be conducted 40 or more years in the future.

In addition to the general considerations discussed above, it is worthwhile to evaluate the following activities that have not routinely been performed:

- Consider chemical decontamination of the reactor coolant system. This may be particularly desirable for plants with higher levels of alpha emitters or other longer-lived contamination for which little to no decay will occur during the safe storage period. It should be noted that the levels of transuranics may increase over time due to production of decay products that are also radioactive, peaking 50 or more years after shut down.

- Consider early removal of activated components such as reactor internals and bioshield concrete. This may be desirable since such components are contain the highest activity levels of non-fuel materials and there may be marginal benefit from radioactive decay during storage with respect to waste classification. Early removal of these components may reduce overall risk during the safe storage and early dismantlement periods, and reduce monitoring requirements. In making such an evaluation, worker exposure during dismantlement activities should be considered. It is likely that the optimum time for removal may be after some period of safe storage to allow for decay of short-lived activity, but prior to extended storage.

- Consider release of non-impacted portions of the site. Similar to dismantlement of non-radiological systems, structures and components, this is a low-cost activity that does not benefit from radioactive decay during the safe storage period. This is desirable to make the land available for beneficial use sooner and to minimize liability and monitoring requirements during the safe storage period.

SUMMARY

The conditions, drivers and approach for safe storage of shut down nuclear power plants vary widely. Thus, other than the general requirement to "maintain the plant in a stable condition," there are no strict requirements for activities that constitute safe storage conditions. However, establishment of optimum safe storage conditions will reduce risks and the costs associated with maintenance and monitoring during the safe storage period. Additionally, key activities may be completed when safe storage conditions are established that will optimize decommissioning activities in the future. Evaluation of the experiences of plants that have been placed into safe storage after shut down has provided an opportunity to identify key areas for consideration for plants entering safe storage in the near future.

REFERENCES

Crystal River Unit 3 Post-Shutdown Decommissioning Activity Report, DOCKET NUMBER 50-302 / LICENSE NUMBER DPR-72, December 2013.