San Onofre Unit 1 Decommissioning

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Introduction

Nuclear plant decommissioning presents several challenges in radiation protection. The plant demolition must consider radiation protection for workers, protection of the public, and careful material management. Decommissioning of the San Onofre Nuclear Generating Station (SONGS) Unit 1 presented some additional challenges.

SONGS 1 History

SONGS 1 was a first generation Westinghouse 3-loop pressurized water reactor (PWR) originally rated at 450 MWe. The unit operated from January 1968 to November 1992 when it was permanently retired from service. Containment consisted of a 2.5 cm thick steel sphere. In 1976, a 1 m thick steel-reinforced concrete Sphere Enclosure Building was constructed around the sphere for post-accident radiation shielding. One of the more unique aspects of SONGS 1 is that it is collocated with SONGS Units 2 and 3 that are newer 1100 MWe Combustion Engineering reactors. They were declared commercial in 1983 and 1984 respectively.

The unit was permanently retired after 25 years of service due to financial considerations. To bring the plant up to the more strict safety standards of the more modern nuclear plants, a number of plant modifications were still required. Rather than invest that capital in the plant, the regulators and company agreed to shut the unit down. At the time, it had 15 years left on the operating license.

Once shut down, the US Nuclear Regulatory Commission (USNRC) requires that plants either begin immediate dismantlement, known as DECON, or be placed in a condition known as SAFSTOR. In SAFSTOR, fuel is removed from the reactor and systems are retired that are no longer needed to maintain safe cooling of the irradiated fuel. SONGS 1 was placed in SAFSTOR in 1993. The operating license was converted to a Possession-Only License. Systems were categorized into those Required for Operation (RO) such as spent fuel cooling and those Not Required for Operation (NRO). The intention was that the unit would remain in a SAFSTOR configuration until the permanent retirement of Units 2 and 3, projected for many years in the future.

In the late 1990's the decision was made to begin active dismantlement of the plant. Decommissioning will result in reduced customer costs through lower fuel storage costs. The spent fuel will be placed into dry cask storage, an Independent Spent Fuel Storage Installation or ISFSI. At the time, low-level radioactive waste (LLRW) disposal costs were also known whereas LLRW disposal in the future was uncertain. Dismantlement could also be accomplished safely using proven technologies. Moreover, there are personnel still working at the site who are familiar with SONGS construction, design, and operation. And finally, there are sufficient funds available in the decommissioning trust.

Project Priorities

The primary goals of the project included:

- Protection of the spent fuel throughout the decommissioning process until the US Federal Government (Department of Energy) accepted the fuel for disposal
- Industrial health and safety
- Disposal of radioactive and hazardous wastes according to the highest standards practical to ensure long term public health and safety
- Compliance with all applicable state and federal requirements; recognition by the public of that compliance
- Perform the work in a reasonable and prudent manner

Major Activities

In addition to the complication of having two large operating units on the same site, the SONGS 1 decommissioning project was also constrained due to the very small site. There is little room for laydown space for staging equipment, waste containers, rubble, offices, etc. Very careful planning was required for that reason in addition to the normal demolition planning. Moreover, with little space, radiation levels around the work area varied depending on the location of materials being removed. These varying levels had to be considered when conducting radioactive contamination surveys of nearby materials.

One of the early projects was the separation of Unit 1 from the security area for Units 2 and 3. Since Unit 1 was built first, a number of systems had to be separated from the plant since they supported the operation of the two larger units. These included the meteorological tower, some electrical supplies, and fire protection.

The unit was provided with independent monitoring and isolated electrical and water supplies. This allowed the majority of the existing plant to be declared "cold and dark." That meant that demolition crews could cut into piping and electrical systems without worrying if the systems were still in service. Active systems were identified with bright orange paint.

Some of the first buildings demolished included the Emergency Diesel Generator Building (the Diesel Generators had been removed and sold) and the Control Building (a new independent Control Room was constructed). The sequence of major building removal was developed to make room for the ISFSI.

License termination would normally take place after complete dismantlement of buildings and structures and restoration of the property. However, that will probably not occur until many years into the future simply due to the existence of the ISFSI and the adjacent operating units.

ALARA Program

Decommissioning presents some unique challenges for an ALARA program. However, the majority of the work may be accomplished using existing ALARA program elements. Therefore at SONGS, the ALARA Program is considered "sitewide," applying to the decommissioning unit as well as the operating units. Those program elements include:

- Job Planning
- Dose Controls, Administrative Limits
- Application of Temporary Shielding if appropriate
- Pre-job Briefings

- Dose Estimates that serve to identify priorities, establish goals and monitor performance
- Use of mockups and training for specific high-dose jobs

There are some specific issues that are important at a decommissioning plant. Foremost is the removal of the high dose components first. For SONGS 1 that included several components at the lowest elevation of the plant such as Residual Heat Removal equipment and removal of the Regenerative Heat Exchanger that presented a high source term in an open area in containment.

Temporary shielding was used when the dose saved exceeded the dose expended to install and remove the shielding. Special instructions were developed for Unit 1 because of the reduced requirements for installing heavy lead blankets on components that were no longer going to be needed for plant operations. Greater loading was available and a much simpler approval process was developed.

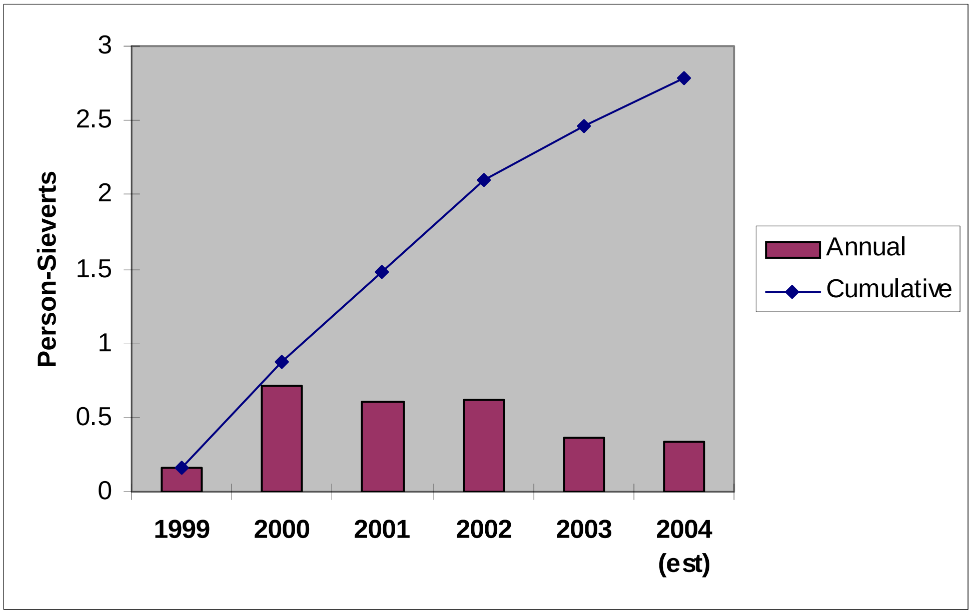
Airborne contamination becomes very different at plants that have been shutdown for at least several years. The decay of most of the shorter-lived beta/gamma emitting radionuclides leaves an increasing contribution from alpha-emitting radionuclides such as the transuranics. For an air sampling program, the reduced contribution of beta/gamma emitters means that more care is required to distinguish between naturally occurring alpha-emitters and plant related contamination. We developed a protocol to facilitate prompt identification of airborne contamination with followup counts to distinguish natural radioactivity.

Major Projects Completed to Date

The table below presents cumulative radiation exposure in Person-Sieverts. "HP" indicates radiation protection activities that includes job coverage, surveys, waste packaging, etc.

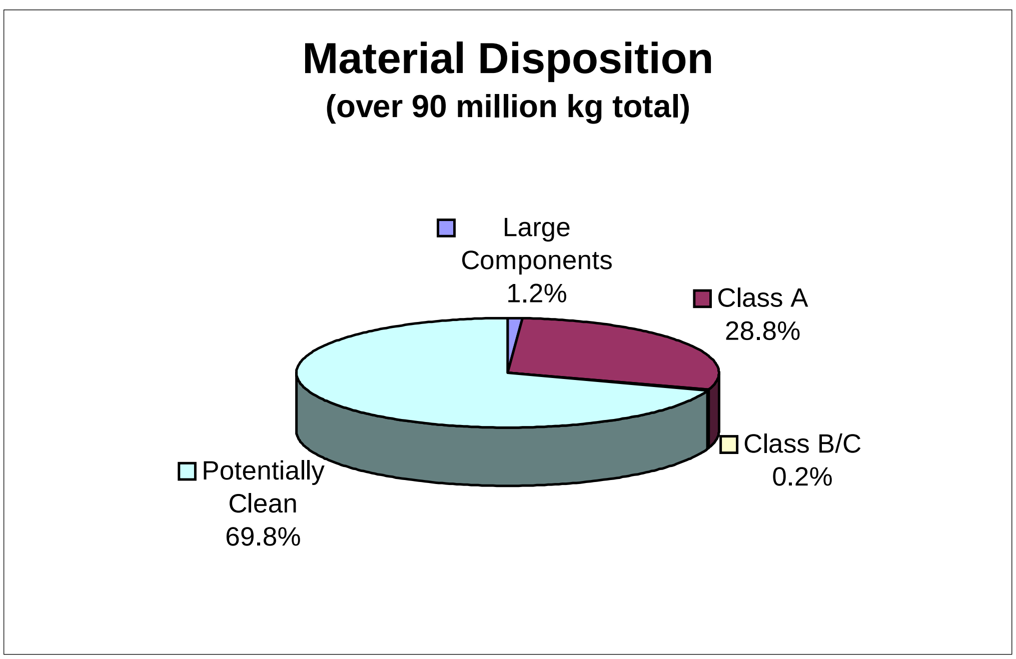
YEAR	PROJECT	Person-Sv
1999	Regenerative Heat Exchanger	0.061
	HP Functions	0.068
2000	Reactor Coolant System Severance	0.158
	Remove Reactor Head Superstructure	0.058
	Remove Interferences and System Equip.	0.069
	Support (scaffolding, temp power)	0.076
	Health Physics (HP) Functions	0.171
	Asbestos Abatement	0.095
2001	Large Component Removal Preps	0.136
	Reactor Vessel Internals (RVI) Segmentation	0.179
	Large Component Removal and RVI support work	0.114
	HP Functions	0.149
2002	Large Component Removal	0.358
	RVI Segmentation	0.049
	Support work	0.080
	HP Functions	0.115
2003	Containment Systems Removal	0.215
	HP Functions	0.060
	Fuel Transfer	0.033
	Containment Decontamination	0.029

The cumulative radiation exposure for the entire decommissioning project will likely total about 4.5 person-Sv. The graph below indicates performance at about half project completion. Note that the annual exposure will continue to decrease as more and more of the sources are removed.



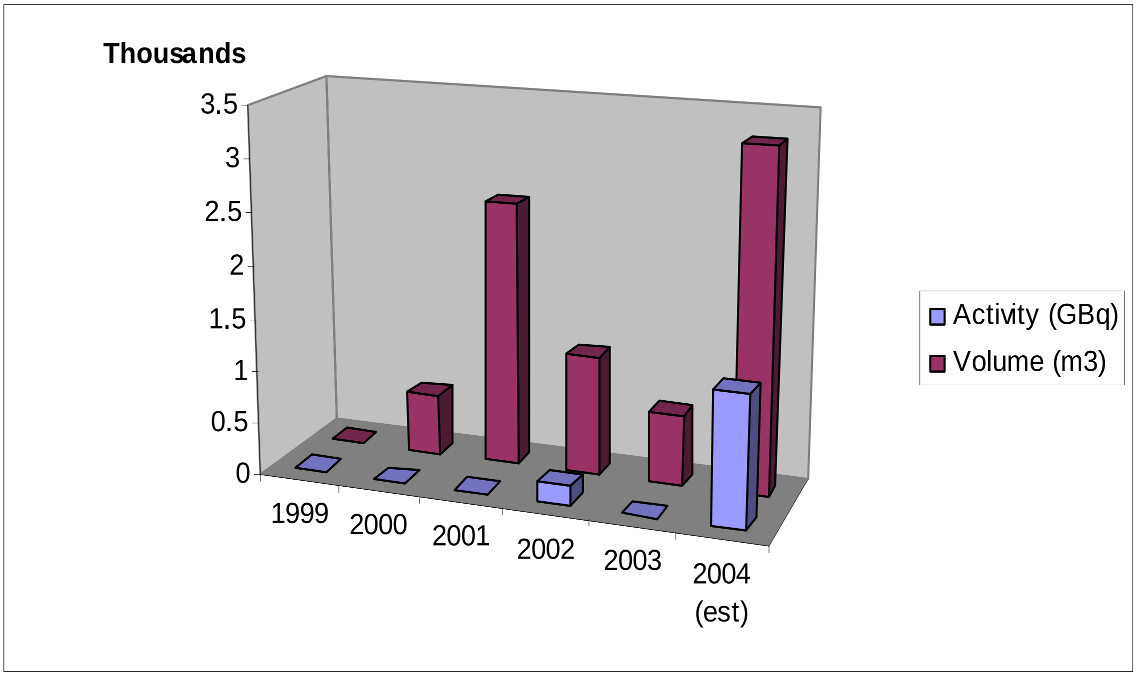
Materials Management

One of the larger focuses of the project is the efficient disposal of waste materials. This includes the very careful distinction between what is radioactively contaminated and what is not. Early in the project planning phase, estimates were made for the total quantities of materials including estimates of the various low-level waste classifications and the relative amounts of clean materials. The pie-chart below depicts the estimated quantities.



Waste Disposal

Radioactive waste shipments to date are shown in the following bar chart. Note that the dominant contribution to the total radioactivity is the reactor pressure vessel and internal components that were anticipated for disposal in 2004 (but won't be). Also in 2004, a large volume of contaminated rubble from inside containment is expected.



Large Component Removal

From a radiological perspective, an early goal was to remove the large components – the reactor pressure vessel, the three steam generators, and the pressurizer. A first step in large component removal was the segmentation of the reactor internals. Due to limitations of the total radioactivity quantity acceptable by the disposal facility, those internals had to be sectioned so that some parts could be placed in the reactor vessel for ultimate disposal and the higher activity parts were removed for long-term storage in the ISFSI. This particular job had the potential for significant radiation exposure based on experiences at other plants. Therefore, considerable effort was expended to ensure best practices, use of reliable equipment, and mockup training when appropriate.

The large components were lifted out of the containment sphere after the SEB roof was removed and holes were cut into the sphere. Restrictions were placed on work inside containment during the large component lifts to ensure that contamination wasn't stirred up to present potential airborne releases out the openings. After the large components were removed, covers were placed over the openings to prevent rain intrusion and to minimize release paths for contamination.

The three steam generators and the pressurizer were shipped for disposal by rail. Due to size limitations, the reactor head was shipped using an oversized truck. The reactor pressure vessel was packaged with some of the internals within a steel canister. Low-density grout was placed for stability both inside the vessel and between the vessel and the canister. Other components that presented shipping challenges due simply to size and weight included the three reactor coolant pumps. Once all those components were removed along with a few smaller components inside containment, the radiation levels to workers were greatly reduced.

CONCLUSIONS

Decommissioning including complete removal of above ground structures can be accomplished safely and efficiently. None of the low-level radioactive waste is unique to decommissioning although transportation of large components can be a significant challenge. Proven techniques are available to handle Greater than Class C waste (highly activated reactor internals) and spent fuel.

A considerable challenge is the dispositioning of the very large volume of potentially clean material. There is a high cost to survey and decontaminate materials. Moreover, in the US today there are no standards for the clearance of potentially contaminated volumetric materials. Careful planning is necessary to determine the most cost-effective means for waste management, whether it includes decontamination and surveys or simple disposal.

Lastly, existing ALARA programs with some minor modifications provide sufficient worker and public protection from radiation.