APPLICATIONS

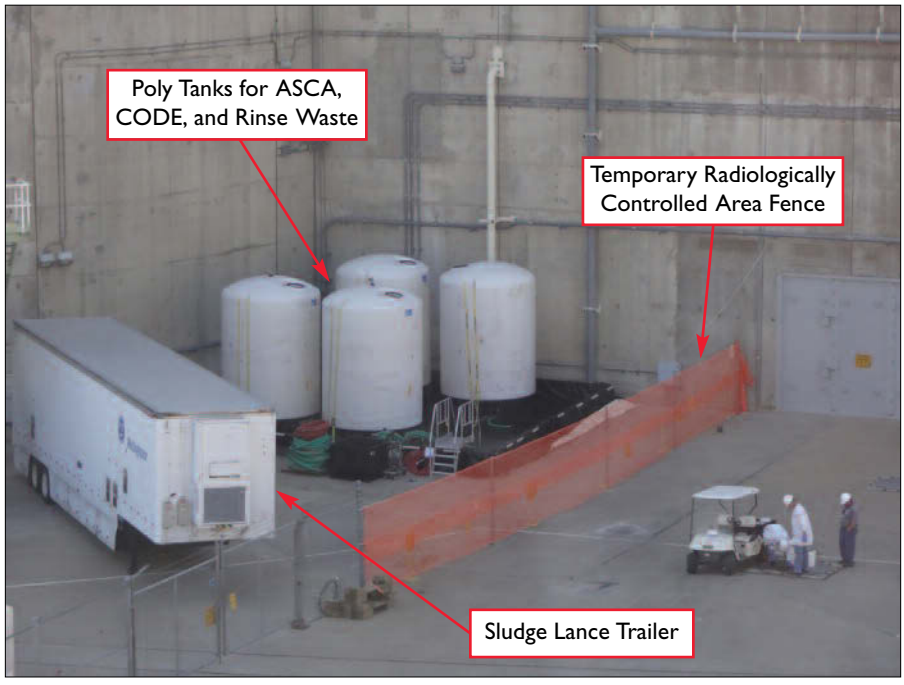
Prolonging steam generator life with improved sludge removal

Luminant teamed with Westinghouse and Dominion Engineering in 2014 for its top-of-tubesheet steam generator cleaning project at Comanche Peak-2.

Nuclear power plant steam generators are vital components. They are also large and expensive and require careful monitoring and maintenance to protect them from corrosion and other damaging impacts of their operating environment.

When the spring 2014 outage for Unit 2 of Luminant Generation Company's Comanche Peak nuclear power plant was being planned, a common maintenance item for steam generators was included: the removal of as much sludge as possible from the top-of-tubesheet (TTS) area of each of the four Unit 2 steam generators. The sludge, or secondary-side deposits, hardens and forms crevices and TTS "collars." Removal is necessary because the sludge provides an environment for corrosive elements to "hide out," and, if left intact, leads to stress corrosion cracking, tube plugging, and a shortened operating life for the affected steam generator. Further, in the absence of proper maintenance, the TTS sludge pile can grow and expand.

Knowing that periodic, thorough TTS cleanings are critical for long-term steam generator health, Luminant decided to work with Westinghouse Electric Company as the lead contractor to apply a first-of-a-kind chemical cleaning combination of inhibited advanced scale conditioning agent (iASCA) and consolidated deposit extraction (CODE) technologies. Westinghouse provided equipment setup and demobilization, as well as operations and project administration, and contracted Dominion Engineering for chemical and process qualification and on-site technical expertise. The teams worked closely with Comanche Peak -2 personnel to coordinate outage and operations planning throughout the project.



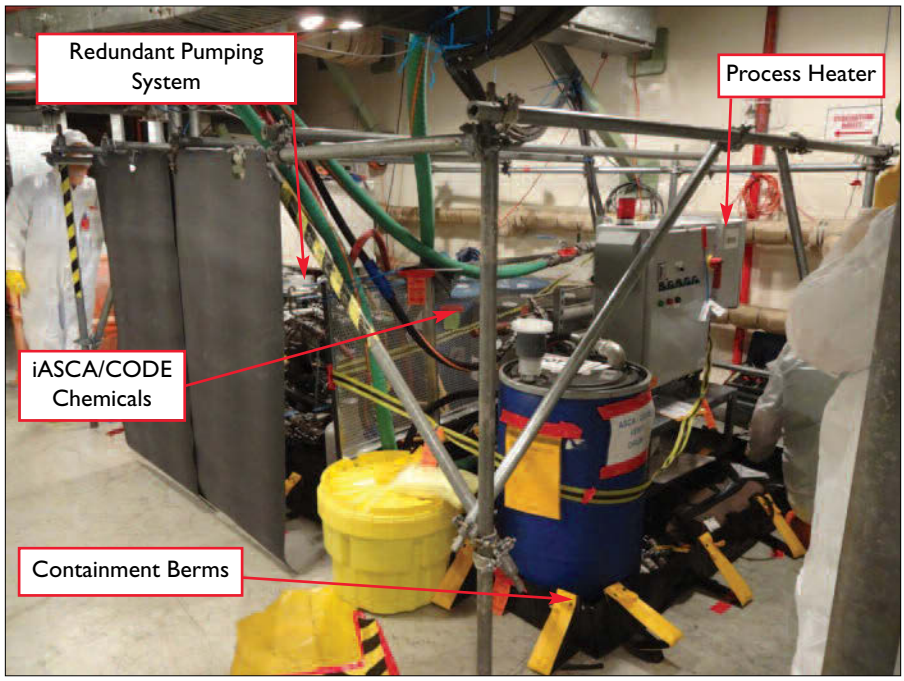
The top-of-tubesheet (TTS) iASCA/CODE waste area at Comanche Peak-2

The iASCA technology increases the deposit removal capacity of ASCA, which has been applied globally at various plants more than 40 times since its inception in 2000. Both iASCA and ASCA are highly effective in removing bulk steam generator secondary-side deposits, such as tube scale, by dissolving magnetite, copper, and other primary deposit constituents. The choice of ASCA or iASCA is dependent on specific plant needs. But no traditional chemical cleaning process can dissolve chemical binding species such as those containing aluminum and silicon. It is these binding species that promote the formation and hardening of TTS collars, making them very difficult to remove using conventional chemical and mechanical cleaning techniques. CODE technology is a new chemical composition designed to address this.

Both iASCA and CODE use simpler equipment than conventional chemical cleaning methods and can be applied with

minimal outage schedule impact. These processes enhance steam generator performance and longevity with minimal corrosion of steam generator materials of construction during the cleaning process. Working together, these chemical agents also increase the effectiveness of mechanical deposit removal methods, such as sludge lancing or ultrasonic energy cleaning. Because of iASCA/CODE liquid chemical composition, the treatment can cover 100 percent of the TTS area for thorough cleaning.

The planning of the iASCA/CODE application process by Comanche Peak-2 and Westinghouse personnel began 18 months before the spring 2014 outage. The planning stage included multiple steps and interfaces to ensure that the planned process application was designed to maximize deposit removal and minimize outage schedule impact. The major activities during this phase were performing qualification testing, conducting a site walkdown, and holding a project kickoff meeting before physical work in the plant began.

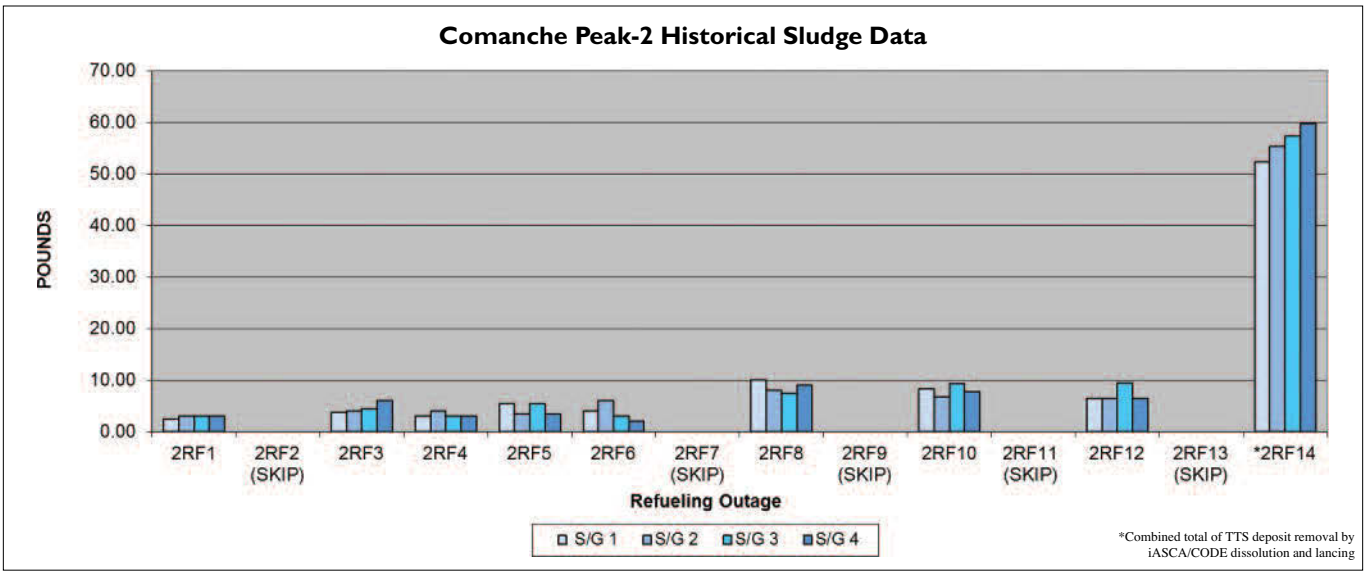


TTS iASCA/CODE process equipment in the in-containment laydown area at Unit 2 of the Comanche Peak station

Qualification testing

The qualification testing was plant-specific to help determine the chemical formulation and treatment method that could best address the steam generator deposit structure and morphology at Comanche Peak-2. The steam generator deposit samples were collected, prepared, inspected, and separated by type (tube scale, collar, and bulk-powered sludge) prior to the performance of an analysis of the chemical and physical properties of the deposits.

Based on the sludge deposit characterization results and sludge loading estimates, several candidate iASCA/CODE formulations and processes were designed. These process options were then evaluated in eight preliminary tests conducted on the Unit 2 steam generator deposits and representative



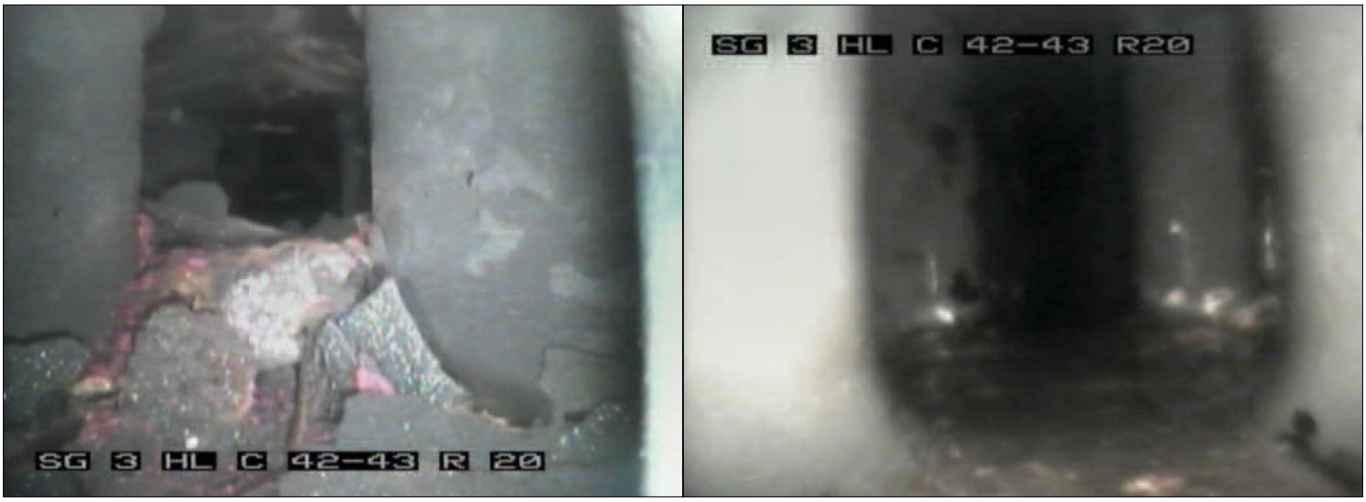
Use of the iASCA/CODE chemical formulation significantly increased the amount of sludge removal from the TTS area of the steam generators as shown in the graph above.

steam generator construction materials. The results of these preliminary tests provided the data on cleaning effectiveness and corrosion that were needed to determine the best formulation and process, which was then further investigated in a final, formal qualification test.

This final qualification test was conducted in a larger vessel that provided a more realistic simulation of the effectiveness of the planned treatment formulation and process and facilitated the consideration of a larger number of steam generator materials of construction. The plant's cleaning objectives, impacts on the outage schedule, process time required, and temperature obtainable in the field were all taken into account in this final qualification test. From this test, recommendations for the actual application were made.

Site walkdown, kickoff meeting

The site walkdown was conducted after the qualification testing so that the walkdown team could consider the expectations for equipment and time needed for the iASCA/CODE process. The overall process included pre-application sludge lancing, application of the iASCA/CODE process, and post-application sludge lancing. The team was able to plan for the spatial laydown ar-



Comanche Peak-2 steam generator 3, Column 42/43, Row 20, pre-sludge lance (left) and post-sludge lance (right)

Comanche Peak-2 steam generator 4, Column 46/47, Row 20, pre-sludge lance (left) and post-sludge lance (right). The overall process for all the steam generators removed 85 percent of the sludge estimated to be in the TTS area of the steam generators. (Due to schedule considerations, photos were not taken of steam generators 1 and 2.)

eas required both inside and outside containment to avoid space and schedule conflicts with other outage activities, and also to identify optimum points for connecting the process equipment.

The team used a detailed walkdown checklist that was developed and is maintained using field experience and lessons learned from steam generator cleaning projects using ASCA. For TTS ASCA and iASCA, the equipment for the application process is located in containment. Since the TTS area of the steam generators was the focus of this project at Comanche Peak, the equipment footprint was smaller than it would be for a full-bundle ASCA or iASCA steam generator cleaning. The waste tanks for the TTS iASCA/CODE process were staged in the protected area immediately outside of containment.

"The culmination of the initial planning phases really started to come to fruition at the kickoff meeting," said Chung Tran, Luminant's engineering program manager. "We had all of the plant area personnel needing to be represented along with the vendor personnel, and the knowledge gained at this stage already had me feeling confident about the success we could have without impacting the outage schedule."

Sludge Removal Results Using iASCA/CODE Process

Steam Generator	Pre-application Sludge Lance (lb.)	iASCA/CODE Fe/Al/Si (lb.)	Post-application Sludge Lance (lb.)	Totals
1	2.8	36.6	13.0	52.4
2	2.8	36.6	16.0	55.4
3	2.8	36.6	18.0	57.4
4	2.8	36.6	20.5	59.9
Total	**11.2**	**146.4**	**67.5**	**225.1**

The project kickoff meeting was conducted 15 months prior to the scheduled outage to allow time to manufacture/acquire the appropriate chemical products, to plan for the necessary equipment inside containment and in the protected area immediately outside of containment, and to carefully plan how the work would be conducted so that it could be completed within the outage schedule with minimal impact on other outage activities.

Implementation

Comanche Peak and Westinghouse personnel worked together to set up the equipment. The major equipment outside containment included waste poly tanks, water pumps, and shipping containers, and was contained within a 30- by 30-foot area.

The major equipment inside containment included iASCA/CODE chemical injection equipment, heater skid, hoses, and chemical totes. The in-containment equipment laydown area measured 8 by 10 feet.

Prior to applying the iASCA/CODE formulation, the primary steam generator side

was completely drained and pre-application sludge lancing was performed to remove loose scale from the tubesheet. (These steps permit the iASCA/CODE chemicals to act directly on hardened deposits that are not effectively removed with traditional lancing.) Once the first two steam generators were pre-lanced, the sludge lancing crew moved to the second pair of steam generators for pre-lancing while the iASCA/CODE was applied to the first pair of steam generators. After the iASCA/CODE cleaning process was completed on the first pair of steam generators, the lancing crew then began a post-lancing cycle, which continued until all four generators were fully cleaned and lanced.

Results

Although Comanche Peak is very proactive in the maintenance of its steam generators, localized areas of hardened TTS collars had begun to accumulate, and this had an impact on the effectiveness of sludge lancing. The accompanying table shows the amount of sludge removed during the pre-application sludge lancing, iASCA/CODE application, and post-application sludge lancing processes. As indicated by the results, much more sludge was removed with the chemical cleaning process, and more sludge was removed with the post-application lancing process as a result of the loosening effects of the chemical application than could be removed during pre-application lancing. The iASCA/CODE cleaning process has enabled Comanche Peak to continue its program of skipping sludge-lancing cycles without the continued buildup of hardened collars.

Jim Stevens, Luminant's consulting nuclear technologist, said, "Using our historical sludge data, we estimate that we've removed approximately 171 pounds of sludge over the life of these four steam generators prior to this cleaning. We found that more than that total was removed in just this one application. Those results and the visual appearance of the tubesheet indicate that we made the right decision."

According to Tran, "The dose from the entire process was less than 1 rem, saving 1 rem from prior lancing without the chemical application, and at all times, personnel and equipment safety were considered.

"The application of the plant-specific iASCA/CODE chemical formulation combined with pre- and post-sludge lancing removed 85 percent of the TTS sludge estimated to be on Comanche Peak's four steam generators," Tran added. "The work was completed on schedule and off critical path, and the successful removal of the sludge will improve the efficiency of this process further in future outages, since the environment that supports corrosive species growth on the TTS area of the steam generators has been eliminated." NN