Regulatory Strategies to Minimize Generation of Regulated Wastes from Cleanup, Continued Use or Decommissioning of Nuclear Facilities Contaminated with Polychlorinated Biphenyls (PCBs) – 11198

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ABSTRACT

Disposal costs for liquid polychlorinated biphenyl (PCB) radioactive waste are among the highest of any category of regulated waste. The Toxic Substances Control Act (TSCA) [1] regulations at 40 CFR 761 [2] require most liquids with PCBs at a concentration of ≥ 50 parts-per-million to be disposed by incineration or equivalent destructive treatment. Few disposal options exist for these wastes. Disposal fees can be as high as $53 per liter ($200 per gallon.) Minimizing the generation of costly liquid radioactive PCB waste is therefore a significant waste management challenge. However, TSCA provisions for cleanup of PCB spills can require the liberal use of industrial solvents and rinse water. In nuclear facilities, cleanups are complicated by technical issues such as radiological hazards and a given facility's unique structural design. At the United States Department of Energy's (DOE) Savannah River Site (SRS), PCB spills may occur, or historic contamination may be discovered, during either normal operations or deactivation and decommissioning activities. In managing these situations, SRS has determined critical factors for developing and implementing effective PCB cleanup strategies that comply with applicable regulations and also minimize the generation of TSCA-regulated waste in general and radioactive liquid PCBs in particular. These factors include evaluation of facility conditions on a case-by-case basis; identification of all potentially applicable TSCA cleanup/decontamination provisions for each facility based on its operational status; determining which potentially compliant cleanup option will generate the least amount of liquid radioactive PCBs; and effectively communicating the technical and regulatory issues and preferred cleanup strategies to facility personnel, regulators, and other stakeholders. In a recent PCB contamination situation involving the one of the site's former production reactors, SRS developed a facility-specific cleanup strategy based on these factors. The strategy was a modified version of a cleanup procedure contained in the TSCA regulations, for which SRS obtained concurrence from the Environmental Protection Agency (EPA). By implementing this strategy, SRS minimized the generation of liquid radioactive PCB waste and reduced the associated disposal fees by over $25,000. The approach has been used again at SRS and also could be used at other sites to minimize the generation of liquid radioactive PCB waste in certain situations.

INTRODUCTION

Toxic Substances Control Act (TSCA) [1] regulations at 40 CFR 761 [2] govern the entire life cycle of polychlorinated biphenyls (PCBs), from manufacturing to active use as well as spill cleanup and the storage and disposal of PCB wastes. The appropriate path for managing PCBs in any given situation must take into account the regulations that are applicable to the life cycle of the PCB material.

PCB spill cleanups often generate large volumes of waste, because the removal of PCBs typically requires the liberal use of industrial solvents followed by a thorough rinsing process. In a nuclear facility, the cleanup process may be complicated by the presence of radiation and other occupational hazards. Building design and construction features, e.g., the presence of open grating or trenches, may also complicate cleanup. If PCBs have contaminated porous materials such as concrete, cleanup is especially difficult as PCBs tend to penetrate deep into the material. In addition to the technical challenges associated with spill cleanup, selection of the appropriate regulatory requirements and approach may be challenging. PCB waste management and disposal is a significant issue for most nuclear facilities as well. Radioactive PCB waste, particularly in liquid form, is expensive to dispose. Disposal fees for radioactive liquids with PCBs at concentrations ≥ 50 parts-per-million can be as high as $53 per liter ($200 per gallon), exclusive of labor, packaging, storage and transportation costs. The high cost is driven by the limited availability of treatment and disposal facilities that can achieve the TSCA destruction standard of 99.9999% for PCB liquids. Minimizing the generation of liquid radioactive PCB waste is therefore a waste management challenge with major cost implications.

In 2009, the United States Department of Energy (DOE) Savannah River Site (SRS) discovered extensive PCB contamination in four of its five former production reactors. Of particular concern was the impact to the L-Reactor, building 105-L. Of the four facilities in which the PCB contamination was found, 105-L is the only one with ongoing missions. Two of the three other reactors were actively undergoing deactivation and decommissioning (D&D). The third facility was inactive, but not yet scheduled for D&D. Because 105-L is an active facility, there were several concerns related to the PCB contamination. The first was the impact on regulatory compliance and the potential for enforcement action. Another was the impact on worker safety and health. There was also concern about how the facility operations could be impacted during the process of conducting a cleanup. Budget impacts were also a concern; at the time of discovery, there was no funding for conducting a cleanup or managing this expensive waste form. Nor was there confidence that the PCBs could be removed, as it was learned that an unsuccessful attempt was made by a previous management and operations (M&O) contractor to remove the unsightly degraded sealant in the C-Reactor. The attempt was abandoned due to the inability to find solvents that would remove the material without posing unacceptable personnel and/or fire safety risks. This effort occurred before there was information to indicate that the sealant contained PCBs.

In determining a path forward for 105-L, SRS sought to address all of these issues. Due to the budget concerns, it was important to identify solutions that minimized the generation of radioactive PCB waste.

METHODS

In the course of addressing the PCB contamination issues at 105-L, SRS identified four factors that are critical in determining the optimal regulatory strategy and cleanup approach. These include evaluation of facility conditions on a case-by-case basis; identification of all potentially applicable TSCA cleanup/decontamination provisions for each facility based on its operational status; determining which potentially compliant cleanup option would generate the least amount of liquid radioactive PCBs; and effectively communicating the technical and regulatory issues and preferred cleanup strategies to facility personnel, regulators, and other stakeholders.

The first critical factor is the performance of a thorough evaluation of facility conditions. The initial step in the evaluation process is a walk-down inspection of the facility to establish the potential extent of contamination. If the PCB source is not known, potential PCB sources should be noted during the inspection. During the facility walk-down, evaluators should also identify any aspects of a facility's construction that may complicate the cleanup process, such as the presence of open grating, trenches or other features that could cause the PCB contamination to be spread further during the process of spill cleanup. The types of materials that are contaminated should also be noted, e.g., porous surfaces or non-porous surfaces, so that the applicable TSCA cleanup standard may be identified. The second step of the evaluation is to confirm the source or sources of the PCBs. Candidate source materials may be identified through review of facility records and publicly available information about PCB products as well as through consultation with personnel who are knowledgeable about PCB uses. Facility records that may contain relevant information include engineering drawings; specifications for construction materials; maintenance procedures; product specifications; and records containing analytical results from previous PCB sampling of similar materials. Sampling is needed to confirm the PCB source and the associated PCB concentration. Sampling may also be needed to delineate spill boundaries if they cannot reliably be determined through visual inspection. To limit the amount of cleanup effort and resulting waste generation, only the materials/surfaces that are actually contaminated with PCBs should be included in the spill area.

The second critical factor is the identification of all potentially applicable TSCA cleanup/decontamination provisions for each facility. Once the PCB spill area is delineated, the potentially applicable regulatory provisions must be identified based on the age of the spill, the extent and type of PCB contamination and the operational status of the facility. Four options are provided via promulgated Environmental Protection Agency (EPA) guidance and TSCA regulations. The Subpart G PCB Spill Cleanup Policy [3, 4] is a promulgated EPA guidance document initially issued in 1987. The policy subsequently was published with the PCB regulations as Subpart G of 40 CFR 761, although it is not an actual regulation. The policy provides protection from enforcement for improper PCB disposal, but only for spills less than 72 hours old. For spills that are more than 72 hours old, there are three sets of potentially applicable provisions that are contained in the actual TSCA regulations. The PCB Remediation Waste section at 40 CFR 761.61 includes several approaches that can be used remediate contaminated environmental media and/or structures. The 40 CFR 761.79 Decontamination provisions establish authorized cleanup methods and set cleanup standards for materials, equipment and surfaces. This section emphasizes complete removal of PCBs so that previously contaminated items are re-usable without conditions and/or unregulated by TSCA for disposal purposes. The 40 CFR 761.30 Authorizations section, which sets forth the only remaining legal uses of PCBs, contains another potentially applicable option. Specifically, 40 CFR 761.30(p) authorizes the continued use, under certain conditions, of porous surfaces such as concrete, that are contaminated by spills of liquid PCBs. Such surfaces generally are not amenable to cleanup once the PCBs have absorbed into the material. The use authorization contains cleanup/contamination control procedures and conditions under which these contaminated surfaces may remain in service.

Each of the four potential cleanup options under TSCA has its own specific criteria related to allowable cleanup methods/procedures, cleanup standards by type of material, cleanup verification requirements, and regulatory approvals. These provisions must be evaluated to determine which may be suitable in a given situation. This determination considers both regulatory compliance and technical efficacy. It should be done on a case-by-case, facility-specific basis. Facility personnel must evaluate whether it is technically feasible to meet all required cleanup standards and/or perform the required decontamination procedures. Evaluators must identify any risks associated with particular cleanup methods. For example, the use of large volumes of cleaning or rinse liquids near open grating could actual cause the original contamination to be spread farther.

The candidate options may differ even for nearly identical facilities, depending on whether or not the facility is in active use. For example, in a facility that is scheduled for or undergoing closure, a cleanup using the TSCA risk-based provisions for PCB Remediation Waste at 40 CFR 761.61(c) may allow some or all of the PCB contamination to be disposed in place during closure if it can be demonstrated that no unreasonable risk to health or the environment would result. Leaving the PCBs in place during closure may result in an outcome in which no PCB wastes are generated outside of the facility. For an active facility with frequent personnel access to the PCB-contaminated areas, an extensive cleanup could be required. The candidate options then must be evaluated in terms of their impact upon facility operations, the associated amount of occupational exposure, the amount of PCB waste that would be generated, and any additional regulatory compliance issues.

In addition to TSCA, other potentially applicable laws and regulations must be identified and addressed. For sites that are subject to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) [5], the CERCLA administrative process may be applicable to facilities undergoing decommissioning. CERCLA may impose additional requirements. However, CERCLA may also allow for enhanced flexibility in addressing PCB contamination in facilities, to include the disposal-in-place of PCBs in certain situations. Applicable safety regulations also must be considered. DOE sites must meet the requirements of the 10 CFR 851 Worker Safety and Health Program regulations [6] and the 10 CFR 835 Occupational Radiation Protection regulations [7]. Wastes generated during cleanup must be characterized in accordance with the Resource Conservation and Recovery Act (RCRA) [8] regulations [9] as well as the TSCA regulations.

The third critical factor in selecting a regulatory strategy to minimize the generation of regulated PCB waste is determining which potentially compliant, technically feasible cleanup option will generate the least amount of waste. In a nuclear facility, it is particularly important to avoid the generation of radioactive PCB waste liquids due to the high cost of disposing them. Each candidate cleanup option must be reviewed in terms of the physical task of removing or controlling the PCBs to the required extent. Physical removal of contaminated surfaces, if feasible, may generate large volumes of PCB waste solids, but low volumes of liquid PCBs. In contrast, most TSCA provisions for cleaning intact surfaces to allow their continued use require the liberal application of industrial solvents and an extensive rinsing procedure. Both the EPA Spill Cleanup Policy and the authorization for continued use of porous surfaces at 40 CFR 761.30(p) may require the performance of a "double wash/rinse method" per 40 CFR 761 Subpart S. That method requires that each 0.09 square meter (one square foot) of contaminated surface area must be wetted thoroughly with solvent and scrubbed for one full minute, then rinsed with 3.8 liters (one gallon) of clean water for one full minute. The procedure must be performed twice. The procedure provides that the wash and rinse fluids may be mopped up or absorbed. However, even if the liquids are safely absorbed, the waste must be disposed at a TSCA incinerator or by equivalent destructive treatment. If the wastes are hazardous per RCRA regulations, the disposal method and facility must also comply with RCRA.

The fourth critical factor in selecting and successfully implementing a regulatory strategy that minimizes the generation of PCB waste is communication. A large cleanup typically involves multiple stakeholders, including facility management, workers, regulators and potentially, the public. The stakeholders may share many of the same interests and concerns, but there may be significant differences. Preparation and delivery of concise yet descriptive information geared to the interest of each audience facilitates the selection of an optimal cleanup approach. Effective communication will describe the extent of contamination; the associated regulatory compliance issues;

worker safety and health concerns; the impact to operations; cleanup requirements for the candidate approaches; and costs of implementing the cleanup including waste disposal. Photographs of the contaminated areas can be used to effectively communicate unusual technical challenges, particularly when the audience is not familiar with the spill site or facility.

RESULTS

SRS has used the identified critical factors to address the presence of PCB contamination inside its nuclear facilities. In 2009, PCB contamination that met the TSCA definition of a "spill" was discovered in one of five former production reactors at SRS. That reactor is designated as the L-Reactor, building 105-L. PCBs were detected at a concentration of 330 parts-per-million (ppm) [10] in a sample of degraded sealant that had seeped onto the floor on the -20 elevation of the facility. The degraded sealant is a polyurethane product that was used to seal around numerous piping penetrations in the biological shield wall of the reactor. The biological shield wall surrounds the reactor tank in which fuel rods were irradiated during the process of manufacturing nuclear materials for the national defense. During the intense neutron bombardment that occurred during reactor operation, the sealant broke down into a thick, viscous material that seeped out of the piping penetrations over adjacent equipment and walls. The PCB contamination in 105-L also implicated the other four former production reactors, since the same sealant had been used in the biological shield walls in those facilities.

To determine the extent of the PCB "spill area," the associated regulatory requirements, and the best cleanup strategies, SRS initiated an in-depth evaluation that included all five reactors. A core "working group" was established to identify and evaluate applicable requirements and options. The working group was comprised of facility environmental compliance staff, an industrial hygienist, facility waste management personnel, and the SRS PCB subject matter expert. As needed, they obtained assistance from radiological control and operations personnel. The core group was responsible for identifying all of the applicable regulatory requirements and options, evaluating them to select the most beneficial cleanup approach, and communicating relevant information to on-site stakeholders.

To evaluate facility conditions in 105-L, SRS M&O contractor, Savannah River Nuclear Solutions (SRNS), first conducted a "walk down" inspection. Participants included the core working group personnel as well as managers in facility operations and the Regulatory Integration and Environmental Services (RI&ES) section.

During the walk down inspection, it was observed that the degraded sealant had accumulated on the floor in a number of locations. The sealant was observed as similar in color to molasses, but more viscous than molasses. Deteriorated sealant was present on both the -20 and -40 elevations of building 105-L. The sealant had seeped over equipment and wall surfaces. Inspectors noted that the seepage had traveled over walls that were, in part, covered with paint. The sealant also had accumulated on the floor near open grating in several locations, which provided a direct pathway for liquids to migrate downward to successive lower levels of the facility. In a few locations, the sealant had in fact traveled through the grating onto surfaces below. No sealant had migrated to building sumps or the environment. Photographs were taken of the affected areas to document the situation and facilitate communication and evaluation. Photographs of the seepage are shown in figures 1 and 2. Based on the inspection, it was determined that a full cleanup of accessible areas would require an extraordinary amount of time and personnel radiation exposure. A high potential for significantly spreading the radioactive and PCB contamination also was noted.

Figure 1. This photograph was taken in building 105-L at the -20 elevation. It shows degraded polyurethane sealant leaking from piping penetrations in the reactor biological shield wall and the painted surfaces that the sealant contacted.

Figure 2. This photograph was taken in building 105-L at the -40 Elevation adjacent to the Near Side Pin Room Entrance. It shows deteriorated sealant which has seeped to the floor next to open grating. Beneath the grating is a trench that ultimately provides a pathway to building sumps.

Available manufacturer's information on the polyurethane sealant raised doubts as to whether it was the actual source of the PCBs. However, building specifications for the original construction of the reactor facilities called for a special coating/paint system to be used in the affected locations. This coating system had been tested a number of times for PCBs at various locations within SRS, including the reactors. PCBs above the TSCA regulatory threshold ($\geq$ 50 ppm) consistently had been detected. The wall paint thus was identified as the probable source of the PCBs that were detected in the initial 105-L sample. However, sampling was needed to confirm the PCB source and delineate the spill area.

In follow-up to the walk down inspections, SRNS conducted an investigative sampling campaign. In order to determine whether the sealant was also a PCB source, it was essential to obtain a sample of sealant that had not been in contact with the paint. Sample collectors were unable to obtain, in building 105-L, a sufficiently large sample of sealant that had not been in contact with paint. A "sealant-only" sample was successfully collected in 105-C, which was simultaneously undergoing evaluation [11]. Samplers were also unsuccessful in obtaining a sufficient "paint-only" sample at the selected location in 105-L. In order to obtain the necessary data, samples were collected from both 105-L and 105-C. The paint and pipe sealant specifications for these facilities were identical; therefore data from either of these facilities was deemed applicable to both facilities. Samples were collected as follows:

- Paint that was not in contact with sealant
- Sealant that was not in contact with paint
- Sealant in contact with paint

Analytical results are summarized in Table I. These demonstrated that TSCA-regulated concentrations of PCBs were present only in samples of paint and in samples of sealant that had contacted the paint. Thus, the PCB source was confirmed to be the wall paint that was applied during the construction of these facilities in the 1950s. The sealant itself does not contain TSCA-regulated concentrations of PCBs. SRS used the sample data to delineate the spill area. Included in the spill area were any surfaces with deteriorated sealant that had contacted the PCB paint. Any areas with deteriorated sealant that had not contacted the PCB paint were excluded from the spill area. The horizontal surfaces where PCB-Contaminated sealant was present were estimated to comprise approximately 28 square meters (300 square feet). The vertical surfaces with degraded sealant were roughly estimated to comprise an additional 28 square meters (300 square feet). Under TSCA regulations, all of the areas with PCB-contaminated sealant fit the definition of a spill. TSCA regulations further require PCB spills to be cleaned up. Evaluators noted that the wall and floor surfaces were concrete, i.e., porous surfaces per TSCA regulations. Cleanup options for the facility were then evaluated in terms of the TSCA options /requirements for porous surfaces.

Table I. PCB Concentrations in Samples of Sealant and Paint Collected from Buildings 105-L and 105-C as Determined by Gas Chromatography [11, 12, 13, 14]. Table continued on following page.

Sample I.D.	Facility/Location	Description	PCB Concentration
L20-1	105-L, -20 level; painted wall for canal across from heat exchangers	Paint only	Not determined; unable to scrape sufficient sample material; see sample C20-1 for similar location in 105-C
L20-2	105-L, -20 level; floor near bulk moderator	Sealant in Contact with Paint	63 ppm
L20-3	105-L, -20 level; floor near junction box	Sealant in Contact with Paint	14.79 ppm
L40-1	105-L, -40 level; floor near confinement heat removal system	Sealant in Contact with Paint	97.4 ppm
L40-2	105-L, -40 level; Floor/wall at Pin Room entrance	Sealant in Contact with Paint	102.4 ppm
C20-1	105-C, -20 level; painted wall for canal across from heat exchangers	Paint only	3400 ppm
C20-2	105-C, -20 level; leak collection berm beneath System 5 process water piping	Sealant only	5.94 ppm

Table I. (Continued.) PCB Concentrations in Samples of Sealant and Paint Collected from Buildings 105-L and 105-C as Determined by Gas Chromatography [11, 12, 13, 14].

Sample I.D.	Facility/Location	Description	PCB Concentration
C20-4	105-C, -20 level; floor near Andale Strainer	Sealant in Contact with Paint	12.73 ppm
C20-5	105-C, -20 level; leak collection berm beneath System 2 process water piping	Sealant only	1.04 ppm
C20-7	105-C, -20 level, floor near Ion Chamber	Sealant in Contact with Paint	150.6 ppm
C40-1	105-C, -40 level; wall & floor below pump 1 suction line	Sealant in Contact with Paint	30.86 ppm

The SRS working group evaluated all of the potentially applicable cleanup options under TSCA as well as the requirements of other applicable regulations and standards. Based on that evaluation the group chose a preferred option for addressing the PCB contamination in the 105-L facility. The preferred option was 40 CFR 761.30(p), which authorizes, under certain conditions, the continued use of porous surfaces contaminated by spills of liquid PCBs. This regulatory provision was considered most appropriate because it specifically addresses situations where PCB liquids have penetrated deep into a porous surface such as concrete. An example of the intended application of this provision is the case of electrical utility companies which need to continue using concrete pads that have been contaminated by leaks of PCB oil from electrical distribution transformers mounted on the pads. The provision recognizes the need to continue using some contaminated surfaces until the end of their useful lives, due to the impracticality of removing the PCBs from the surface and/or removing the contaminated surface from the affected structure. The provision's inherent authorization to continue using an affected surface was particularly relevant to 105-L since the facility is still active. However, the provision requires accessible surfaces to be cleaned via a TSCA double wash/rinse procedure, and then encapsulated. In areas not accessible for cleaning, the entrances to those locations may be barricaded. The TSCA double wash/rinse procedure typically results in the generation of significant volumes of liquid PCB waste. Due to the risks of spreading contamination through the facility's open grating and trenches, the working group believed that the contaminated surfaces were not safely accessible for purposes of the double wash/rinse procedure.

The working group presented its preferred option to key staff personnel and managers within SRNS and DOE for their approval. The preferred option consisted of a modified approach to the 40 CFR 761.30(p) authorized use provisions. In the modified approach, the accumulated sealant on horizontal surfaces would be scraped up manually. The double wash/rinse procedure would be omitted, and no liquids would be applied to the surfaces. After the sealant was scraped off, the horizontal surfaces would be covered with a physical barrier and labeled with the EPA "Large PCB Mark" (also known as the "PCB Caution Label.") Vertical surfaces would not be cleaned, but collection devices would be installed to control the PCB material. Management staff within SRNS and DOE approved of the modified approach, contingent upon obtaining EPA concurrence. SRS then approached EPA to see if the agency would allow SRS to implement the strategy. SRS provided EPA with photographs depicting the spill areas and the open grating, and explained that the contaminated surfaces were not safely accessible for purposes of conducting a double wash/rinse procedure. SRS personnel explained that the modified approach would minimize the risk of spreading contamination and simultaneously reduce occupational exposures to personnel. EPA agreed to allow SRS to use the modified approach. EPA also determined that this approach would be compliant with the regulations.

The process of cleanup, which included scraping the horizontal surfaces and installing floor coverings and barricades began on October 4, 2010 and was completed on October 14, 2010. Photographs of the completed actions are provided as figures 3 and 4. SRS is not aware of any other DOE facilities using this modified approach prior to the SRS implementation at 105-L.

Figure 3. This photograph was taken in building 105-L at the -20 elevation where the horizontal surfaces have been cleaned by scraping, covered and labeled.

Figure 4. This photograph was taken in building 105-L at the -40 elevation near the Reactor Pin Room where the horizontal surfaces have been cleaned by scraping, covered and labeled.

The selected cleanup approach served to minimize the generation of liquid radioactive PCBs and to reduce costs. Full implementation of the double wash/rinse method on accessible horizontal and vertical surfaces would have generated approximately 528 liters (139 gallons) of liquid radioactive PCB waste in 105-L. At an estimated disposal cost of $53 per liter ($200 per gallon,) the fees for disposing the liquid waste would amount to $27,984. These figures do not include labor costs or transportation costs associated with managing the liquid waste. The volume of liquid waste that actually was generated as a result of the cleanup approach used by SRS totaled 37.85 liters (10 gallons) of radioactive PCB liquids. At a disposal fee of $53 per liter, the disposal fees are estimated to be $2,006. This represents an estimated savings/cost avoidance of $25,978 (92.8%) in disposal fees for liquid PCB waste generated in the L-Reactor cleanup. The waste will be shipped to an off-site vendor for disposal in 2011.

The estimated volumes of PCB liquids and the associated disposal fees and savings were calculated using the following factors:

a: <u>Contaminated vertical & horizontal surface area in 105-L (estimated)</u>: 55.7 square meters (600 square feet)
b: <u>Volume of solvent required to perform the double wash/rinse method (estimated)</u>: 0.47 liters (16 ounces) per 0.09 square meter (one square foot) of contaminated surface area; two applications required
c: <u>Volume of rinse water required to perform the double wash/rinse method as required by the regulatory procedure</u>: 3.79 liters (1 gallon) per 0.09 square meter (1 square foot) of contaminated surface area; two applications required.
d: <u>Total volume in liters of liquid required to perform double/wash rinse procedure</u>

The equation to calculate the volume of liquid (d) needed to clean the all of the L-Reactor's contaminated surfaces using the TSCA double wash/rinse procedure is:

$$2[a (b+c)] = d$$
$$2[55.7 (0.48+ 4.26)] = d$$
$$2[(55.7)(4.74) = d$$
$$2[264.02] = d$$
$$528.04 = d$$

The volume of non-liquid radioactive PCB waste generated from the cleanup of the 105-L facility totaled 0.48 cubic meters (110 gallons). The non-liquid waste is job control waste composed of personal protective clothing and equipment, tools, and old spill containment devices. Had a double wash/rinse cleanup been conducted, the volume of non-liquid waste would have been larger. Although a specific factor for calculating the non-liquid waste cannot be derived from the double wash/rinse procedure, it is noted that the volume of non-liquid waste generated during the 105-L cleanup was eleven times greater than the volume of liquid waste.

When the mission for 105-L is deemed complete, its final decommissioning will be conducted under CERCLA. The residual PCBs will be addressed by the CERCLA process. It is anticipated that the PCB material ultimately will be grouted in place.

DISCUSSION

The cleanup of PCB contamination in a radioactive environment can pose numerous technical, regulatory, safety and financial challenges. SRS had to address all of these challenges in developing a cost-effective path forward to manage extensive PCB contamination in the 105-L facility. SRS found a solution for these issues by developing and using, with EPA concurrence, a modified version of a cleanup procedure contained in the TSCA regulations.

The operational status of a facility plays an important role in assessing viable options and evaluating their impacts on compliance, worker safety, and facility operations. Although 105-L is an active facility, personnel entry into the locations with degraded sealant is infrequent due to changes in mission requirements (no reactor operations) and the radiological conditions. Irradiation of fuel rods has ended, and current missions require minimal access to areas near the biological shield. Routine entries are made only to conduct essential safety inspections such as a monthly inspection of fire extinguishing equipment. These routine entries require only a brief period of time, e.g., approximately 30 minutes per entry. As needed, entries are made for maintenance tasks such as pumping water from sumps. No degraded sealant is present in the locations of 105-L where there are active missions involving routine personnel access.

In developing a cleanup strategy, the concerns and programmatic requirements of several organizations had to be addressed. Those organizations included DOE and SRNS management and staff in facility operations, area/facility decommissioning and closure projects, industrial hygiene, environmental compliance, radiological controls and waste management. The various groups shared common concerns, particularly with respect to regulatory compliance and the impact on worker safety and health. However, each group had its own set of issues and programmatic/compliance drivers. Open and frank discussion among these groups was essential to developing a workable path forward. The efforts of the core working group members were critical to the communication process. The group promptly briefed supervision, management and key staff members of the SRNS and DOE on the situation. Photographs of the spill areas were used to convey the complexity of the situation. The photographs were particularly useful, especially in communicating with personnel who do not routinely enter the facilities and/or radioactively contaminated areas. Initial briefings were followed by regular updates in meetings and e-mail as additional information was gathered and evaluated. Once the working group had identified the preferred strategies, they formally presented them to SRNS and DOE management for approval prior to discussing them with the regulatory agency.

The Industrial Hygienist for the reactor facilities performed an occupational exposure evaluation [15] to determine the hazards to personnel of various cleanup options. The assessment was performed in accordance with the DOE Worker Safety and Health Program requirements. The evaluation addressed PCBs, dioxins, heat stress, radiological contamination and noise hazards. The evaluation considered the impact of leaving the materials in place "as-is" as well as the impacts of conducting a cleanup activity. The analysis of available information from peer-reviewed literature, and industrial hygiene calculations, established very low possible airborne concentrations of polychlorinated biphenyls (PCBs) from those materials targeted for remediation. From an integrated risk analysis perspective, the conduct of a comprehensive remedial activity carried greater risk of an adverse occupational health consequence than doing nothing other than maintaining administrative controls.

The provisions of applicable DOE occupational and radiation protection rules were also evaluated. The 10 CFR 835 Occupational Radiation Protection regulations require DOE activities to develop and implement plans and measures to maintain occupational radiation exposures as low as reasonably achievable (ALARA). As applied to occupational radiation exposure, the ALARA process does not require that exposures to radiological hazards be minimized without further consideration, but that such exposures be optimized, taking into account both the benefits arising out of the activity and the detriments arising from the resultant radiation exposures and the controls to be implemented. The DOE Radiological Control Standard, DOE-STD-1098-99 [16], states, "There should not be any occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure." With respect to radioactive waste generation/disposal, the DOE Radiological Control Standard also provides that generation of radioactive waste must be minimized in order to reduce the environmental impact of DOE operations, help reduce personnel exposure, and reduce costs associated with handling, packaging, and disposal. Thus, the applicable DOE regulatory requirements supported the selection of the least intrusive/rigorous cleanup action possible.

Although the occupational exposure analysis and the DOE regulations supported leaving the contaminated sealant "as-is," the "do nothing" approach would not comply with TSCA regulations applicable to active facilities. The findings from the occupational exposure analysis and the review of DOE regulations were discussed with EPA. They were an important factor in securing the EPA approval to utilize a modified cleanup approach.

The TSCA regulations were reviewed to determine applicable provisions and options. The Subpart G Spill Cleanup Policy was ruled out because the contamination was older than 72 hours. In the Decontamination section at 40 CFR 761.79, none of the self-implementing provisions addressed the circumstances, although an "alternate decontamination approval" possibly could have been requested. However, based on previous experience at SRS and other locations, attempts to remove long-standing PCB contamination from porous materials such as concrete are unsuccessful in most cases.

TSCA provisions for remediation waste at 40 CFR 761.61 were then examined. Under TSCA, structures that are contaminated with liquid PCBs are considered PCB remediation waste. Of three remediation waste options, one was identified as inappropriate due to its establishment of rigid "clean" thresholds that site personnel believed would be unattainable in these facilities. A second option addresses only the disposal of wastes generated during cleanup; it provides no actual direction for determining and implementing a cleanup approach that would be deemed compliant with TSCA. The third remediation waste option, "Risk-Based Disposal" at 40 CFR 761.61(c) was considered a potentially viable approach, particularly for facilities undergoing closure. This provision allows the regulated party to propose, for EPA approval, a customized cleanup or disposal approach tailored to the unique circumstances of a given contamination area.

In 40 CFR 761.30(p), TSCA offers an option specifically intended for use in active facilities. This provision is entitled "Continued use of porous surfaces contaminated with spills of liquid PCBs." The provision is particularly useful in situations where PCBs have migrated deep into surface materials such as concrete. The regulation requires the owner or operator of the facility to take several actions including: removing or containing the source of the PCBs; performing a "double wash/rinse" procedure; and barricading entrances to locations that are not accessible for surface cleaning. These steps must be followed by encapsulating the cleaned areas by applying two layers of solvent- and water-resistant paint in contrasting colors, or placing solid barriers on accessible parts of the contaminated area. Once these actions have been taken, the contaminated surfaces are authorized for continued use. No formal EPA approval is required. However, use of the EPA's "double wash/rinse procedure" was problematic with respect to both safety and waste minimization. The procedure requires the liberal use of industrial solvents for cleaning. Each 0.09 square meter (one square foot) of contaminated surface area would have to be wetted thoroughly with solvent and scrubbed for one full minute, then rinsed with 3.8 liters (one gallon) of clean water for one full minute. The procedure provides that the wash and rinse fluids may be mopped up or absorbed, but clearly assumes that there is no open grating or other path for the liquids to escape during the process. The procedure must be performed twice. In the SRS case, most of the PCB-contaminated sealant was adjacent to open grating that provided a direct and immediate path for the contaminated liquids to spill downward to successive lower levels of the facility. In addition, the procedure would generate large volumes of liquid radioactive PCB waste. This regulatory option was determined to be viable for 105-L, but only if SRS could successfully demonstrate to EPA that reliance on barriers and minimal surface cleaning, in lieu of the double wash/rinse procedure, would be an acceptable implementation of the regulation. This modified approach was deemed to be contingent upon EPA concurrence, so SRS arranged a conference call with the EPA Region 4 PCB Coordinator. The objective was both to inform EPA of the situation and to verify that SRS had made a valid interpretation of the regulation. Prior to the call, SRS transmitted several photographs of the contamination to EPA. During the call, SRS discussed its proposed path forward for the facility. The EPA official concurred that SRS had correctly interpreted the regulation and was authorized under the TSCA regulations to proceed with the proposed path forward for 105-L. SRS followed up the conversation with a letter to EPA [17] to ensure that both the SRS and agency files were properly documented.

The compliance challenges associated with the PCB-contaminated sealant were not limited to the issue of how to address the spill. Another significant challenge relates to the PCB source material, i.e., the paint. The presence and use of PCBs in paint and most other non-liquid materials conflicts with TSCA regulations. Even though the spill containment and facility closure activities could be done in accordance with TSCA provisions, the facilities could not achieve full compliance with TSCA due to the underlying paint.

As background, the use of most PCBs at concentrations of ≥ 50 ppm was banned as of July 2, 1979. The only PCB uses that could remain in use after that date, were those specifically authorized by the TSCA regulations. The pre-TSCA application of PCBs in paints, coatings and caulking was never authorized by EPA for continued use after the 1979 ban. The rulemaking record indicates that EPA was unaware of the widespread use of PCBs in paint and other non-liquid products during the development of the PCB regulations. As a result, their continued presence and use is not compliant with TSCA. However, removing these materials is impractical, if not impossible, in most cases.

In recognition of the many compliance issues associated with paint that contains PCBs, SRS began a dialogue with EPA on this subject in 1996. That is the year when SRS first discovered that PCB paints had been applied in certain site facilities prior to the passage of TSCA. Apart from complete removal of the PCB materials, the TSCA regulations did not then, and do not now, provide procedures or methods through which compliance can be achieved for these materials that remain in use. From a practical standpoint, removal is usually not feasible. As SRS developed a program to manage these materials, it shared information concerning that program with the EPA Region and with EPA Headquarters. The regulations do not provide a basis for EPA to formally approve the SRS program.

However, the SRS approach was to make disclosure and to provide EPA the opportunity to comment on and/or object to the SRS approach. The agency has offered no objection to the SRS approach.

To date, EPA generally has refrained from taking enforcement action against facilities where non-liquid PCB products such as dried paints are present, provided such materials are intact and do not pose an exposure hazard to personnel. For facilities with these materials, establishing, communicating and maintaining a prudent PCB management program serves to reduce the risk of EPA enforcement action. SRS has continued its practice of informing EPA of significant developments concerning those materials. The situation involving the SRS reactors is the most recent example of regulatory issues that directly relate to and/or evolve from, the historical presence of non-liquid PCB materials in SRS facilities that were constructed prior to the TSCA regulations. This ongoing dialogue between SRS and EPA has been a vital part of developing reasonable approaches for managing these PCBs where the current regulation does not provide a realistic means of achieving compliance.

With respect to the communication with EPA concerning the PCB-contaminated sealant, the history of good communication provided a positive foundation. Several other factors contributed to the successful discussion with EPA about the sealant. SRS personnel made a conscious effort to anticipate the questions that the regulator would ask and to have the answers ready. Both environmental compliance staff and operations personnel participated in the preparation for and the conversation with EPA. The photographs that SRS provided to EPA for reference during the phone conversation proved to be particularly helpful. A verbal description of the situation could not have conveyed adequately the extent of the technical and logistical issues involved with any effort to remediate the PCB-contaminated sealant.

Immediately following the cleanup in the 105-L facility, SRS used the same cleanup approach to address PCB-contaminated sealant in the C-Reactor, building 105-C. In 105-C, an 85.7% reduction in liquid radioactive PCB wastes was achieved. In the future, SRS may again employ the modified cleanup approach used in 105-L to manage liquid PCB contamination that has been present for longer than 72 hours. For small, fresh spills, i.e., the contamination is less than 72 hours old, the EPA Spill Cleanup Policy may be a better choice because it affords protection from enforcement. It should be noted that under the Spill Cleanup Policy, cleanup must begin within 24-48 hours of the spill discovery time, which may not always be feasible in a radioactive environment. If the spill is relatively large or it occurs in a location where the use of liquids is risky, then the modified approach used in 105-L may be appropriate. For facilities that are undergoing D&D, a better option may be the risk-based disposal provisions for PCB Remediation Waste, as it may be possible to dispose the PCBs in place and completely avoid the generation of radioactive PCB waste liquids. For facilities undergoing D&D under CERCLA, it also may be possible to dispose the PCBs in place without generating PCB liquids.

In an effort to improve the decision-making process for addressing future PCB spills, SRS augmented its environmental training program by adding a short case study on the reactor PCB contamination, including the 105-L cleanup, to one of its existing environmental training courses. The course is required for SRS environmental compliance staff and is optional for waste management staff. The study summarizes the process of selecting an optimal cleanup approach that addresses compliance and waste management issues. The session highlights the lessons learned during the development of the path forward for each reactor. The primary "lesson learned" was the importance of conducting a facility-specific evaluation to determine the best regulatory option based on the life cycle of the contaminated facility or materials. The case study also highlights the importance of open and positive communications with regulatory personnel. The first presentation of the case study was in November 2010. SRS may include and expand the case study as part of an advanced-level workshop on compliance with the TSCA PCB regulations that is expected to be developed in 2011. As with a current 2-day SRS PCB training course on management of PCBs, an advanced level workshop would be available to other DOE sites upon their request.

SUMMARY

PCB spill cleanups in a radioactive facility pose significant challenges with respect to regulatory compliance and waste management. PCBs are difficult to remove from porous materials such as concrete. Regulatory provisions governing cleanup typically result in the generation of large volumes of liquid PCB wastes. When these wastes are also radioactive, the associated disposal costs have a major, negative impact on facilities' operating budgets. Disposal costs for liquid PCB radioactive wastes are among the highest of any category of regulated waste. Few disposal options exist for these wastes, and disposal fees can be as high as $53 per liter ($200 per gallon), not including other costs associated with waste storage and transport.

Minimizing the generation of liquid radioactive PCB waste is a major factor in selecting a cleanup approach that complies with applicable regulations. However, TSCA provisions for cleanup of PCB spills usually require use of a double wash/rinse procedure that generates large volumes of PCB liquid waste. In nuclear facilities, cleanups are complicated by technical issues such as radiological hazards and a given facility's unique structural design.

SRS has identified four critical factors for developing and implementing effective PCB cleanup strategies that comply with applicable regulations and also minimize the generation of TSCA-regulated waste in general and radioactive liquid PCBs in particular. These factors include evaluation of facility conditions on a case-by-case basis; identification of all potentially applicable TSCA cleanup/decontamination provisions for each facility based on its operational status; determining which potentially compliant cleanup option will generate the least amount of liquid radioactive PCBs; and effectively communicating the technical and regulatory issues and preferred cleanup strategies to facility personnel, regulators, and other stakeholders.

SRS used these steps to develop a facility-specific PCB cleanup for building 105-L. The SRS strategy omitted the use of a standard cleanup procedure, the "double wash/rinse" method, prescribed by the selected section of the TSCA regulation. SRS was able to obtain EPA concurrence because the revised cleanup strategy reduced (1) the risk of spreading additional PCB liquids throughout the facility, and (2) the occupational exposure hazards related to radioactivity, heat stress and PCBs. After obtaining EPA concurrence, SRS implemented the strategy and reduced the volume of liquid radioactive PCB waste by 92.8%. The associated disposal fees were reduced by an estimated $25,978.

Immediately following the cleanup in the 105-L facility, the same cleanup strategy was used for a similar cleanup at the 105-C Reactor, and an 85.7% reduction in liquid radioactive PCB wastes was achieved. For active facilities, the modified cleanup approach may again be utilized to manage liquid PCB contamination to porous surfaces if the PCB contamination has been present for longer than 72 hours. For small, fresh spills, the EPA Spill Cleanup Policy may be a better choice because it affords protection from enforcement. It should be noted that under the Spill Cleanup Policy, cleanup must begin within 24-48 hours of the spill discovery time, which may not always be feasible in a radioactive environment. If the spill is relatively large or it occurs in a location where the use of liquids is risky, then the modified approach used in 105-L may suit those circumstances. For facilities that are undergoing D&D, a better option may the risk-based disposal provisions for PCB Remediation Waste, as it may be possible to dispose the PCBs in place and completely avoid the generation of radioactive PCB waste liquids.

In any situation involving PCB contamination, the four critical factors may be used to develop an appropriate cleanup strategy. It is possible that the SRS modified cleanup approach may be used at other nuclear facilities within the United States, depending on the conditions that are present. Elements of the SRS modified cleanup approach have been discussed with environmental compliance staff at DOE facilities located with the EPA Region 4, e.g., the Oak Ridge National Laboratory and the Y-12 National Security Site.

A short case study on the reactor PCB contamination, including the 105-L cleanup, was added to one of the training courses for SRS environmental and waste management staff. The study summarizes the process of selecting an optimal cleanup approach. The training session highlights the lessons learned during the development of the path forward for each reactor. The primary "lesson learned" was the importance of conducting a facility-specific evaluation to determine the best option based on the operational status of the contaminated facility or materials. The case study also highlights the importance of open and positive communications with regulatory personnel. SRS may include and expand the case study as part of an advanced-level workshop on compliance with the TSCA PCB regulations that is expect to be developed in 2011. As with a current 2-day SRS PCB training course on management of PCBs, an advanced level workshop would be available for presentation at other DOE sites upon their request.

Positive outcomes at SRS were achieved by selecting a TSCA-compliant cleanup approach based on facility status, facility conditions, worker safety and health impacts, and waste management efficiencies. Collaboration and effective communication among affected on-site groups and EPA were critical to this process. An established history of forthright communication with the regulatory agency was an especially important element in finding a compliant solution for managing the PCB-contaminated material in 105-L that also minimized the generation of liquid radioactive PCB wastes.

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