Legacy Hazards

One Organization's Assessment of Occupational Exposures

By Robert C. Adams and Michael W. Holton

IN BRIEF
- **As a result of a compliance audit, a large municipal wastewater treatment facility needed to develop a strategy to address in-place legacy hazardous materials including asbestos, lead, mercury and polychlorinated biphenyls.**
- **Initially proposed approaches called for extensive bulk sampling campaigns and would have been unreasonably expensive with little risk reduction benefit.**
- **A modified approach was developed that reduced the volume of samples needed and provided a risk-based in-place management strategy which focused on the activity to be performed instead of the bulk content of the material.**

Building materials that contain asbestos, lead, mercury and polychlorinated biphenyls (PCBs) are generally believed to have been phased out and banned, and often are not considered when analyzing potential occupational exposures. Some of these materials have not actually been banned, and even those that have may still be present in existing building materials and equipment. Occupational exposures related to the presence of and contact with these materials during repair, renovation and routine operations are often poorly characterized and misunderstood. Furthermore, governmental agencies involved in regulating these materials may apply rules and regulations that vary based on the material, its condition or specific activity being performed.

Between 2009 and 2010, work was conducted with a large municipal wastewater treatment bureau to develop a strategy to characterize and manage exposures to these "legacy" materials. The bureau operates more than 20 wastewater treatment plants ranging in age from 25 to 100 years. Each treatment plant consists of multiple buildings, miles of pipe and an array of mechanical equipment. The bureau began the project after an initial exposure assessment and sampling strategy it developed was deemed to be too costly to implement.

A compliance audit raised a concern about the presence of in-place legacy hazardous materials. To address that concern, an initial assessment strategy was proposed; it consisted of extensive bulk sampling in an effort to identify and document the location of all materials containing asbestos, lead, mercury or PCBs (collectively, the contaminants of concern or COCs) in the facilities.

The initial plan called for the sampling of virtually all painted surfaces and suspect asbestos-containing materials regardless of condition or likelihood of contact or disturbance. This plan was based on the assumption that the presence of these materials alone presents unacceptable risk to workers; however, the strategy did not address the condition of materials and the activities performed on them, which are much more accurate indicators of exposure risk. In addition, the strategy did not acknowledge that new products could contain the targeted COCs or how to address any new COCs that the new products might contain.

A proposed exposure management strategy based on the risk posed by work on or around these materials, using various exposure factors, not merely on their presence in any given facility, was developed. This approach to an exposure management strategy included these steps:

- Conduct walkthrough surveys and meetings with management at a sample of the plants to determine the types of materials present, their condition and the activities that might affect the materials.
- Analyze regulatory guidance and scientific literature to determine when testing is required and which activities pose risk of exposure.
- Identify similar exposure groups (SEGs) and exposure activities to characterize exposure.
- Develop a strategy for the coordinated collection of a limited number of bulk samples and industrial

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hygiene exposure measurements that can be used to accurately quantify exposure and subsequent risk.

•Communicate risks to employees through continued awareness programs. These programs also address issues related to labeling and identification of in-place materials presumed to contain COCs.

According to this strategy, most materials potentially containing the COCs were assumed to contain these contaminants and will be managed in-place until such time as they are to be disturbed. Managing materials in-place allows sampling and abatement cost to be deferred over time without increasing risks.

Assessment Methods

To develop the sampling strategy, an approach based on AIHA's *Strategy for Assessing and Managing Occupational Exposures* as well as other published literature (e.g., Ahrens & Stewart, 2003; Ignacio & Bullock, 2006; Keil, Simmons & Anthony, 2009; Paustenbach, 2000; Viet, Stenzel, Rennix, et al., 2008) was developed. Figure 1 summarizes the general process for assessing and managing exposures. This process involves several steps:

•Gather available information on potential exposures including the specific occupational environment; employees handling the material and their level of expertise; task that involves that material; expected time of exposure; and exposure pathway.

•Examine potential exposures for similarities in the above-mentioned factors and create SEGs.

•Priority rank SEGs by examining past exposure assessments and by gathering information from related organizations that have conducted monitoring. This information can be used to determine the need for future exposure assessments, fill data gaps and assess the exposures of less-frequent activities.

•Strategically perform exposure assessments where it is determined that a potential exposure exists, data are insufficient or no longer applicable.

•Group results into three basic categories: 1) acceptable exposure; 2) uncertain; and 3) unacceptable exposure. Acceptable exposures require no additional action until processes change significantly; however, these exposures should be routinely revisited to identify any variations since the initial assessment.

Unacceptable exposures require control implementation; the type of control varies based on task frequency and nature. Uncertain exposures require additional information gathering, such as information on the task or the material behavior during that task, to determine the exposure.

•Document and distribute information in an accessible format to affected employees.

•Repeat the process for all new exposure activities as well as those processes that experience a significant change in nature. Exposure assessment strategy is a never-ending path that continues to allow refinement of exposure understanding and more effective control implementation overall.

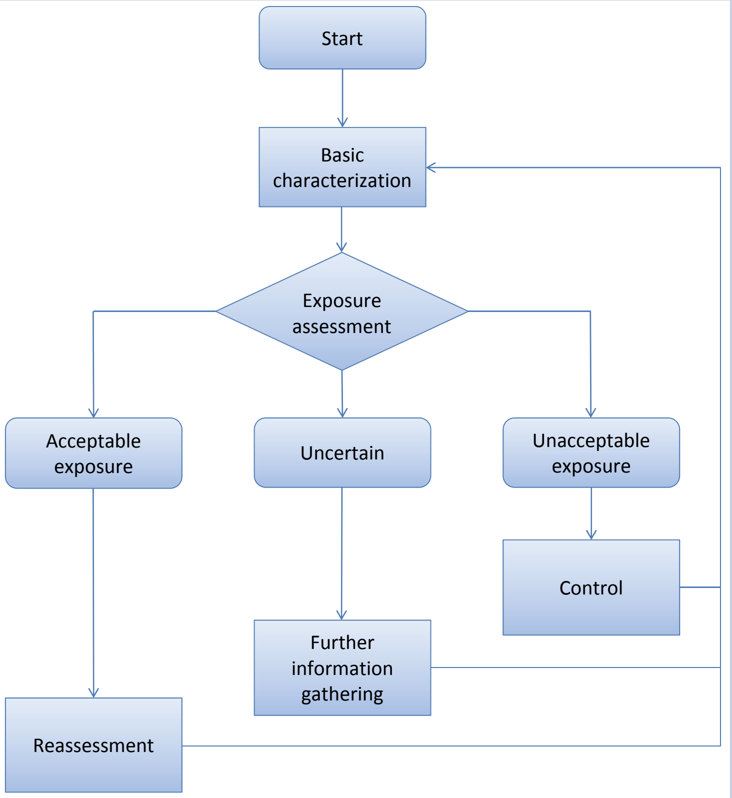
To gather the information required to develop the exposure assessment strategy, a sample (approximately 50%) of the bureau's wastewater treatment plants were visited. Staff representative of various levels and job titles were interviewed about work activities; how often they performed those activities with the possibility of encountering COC-containing materials; and what methodology they used when performing this work. Existing bureau documentation, including standard operating procedures, policy documents, existing sampling results and abatement reports also were reviewed.

Two primary exposure groups were identified, both with limited potential for occupational exposures during typical work tasks. The first group included electricians, machinists, sewage treatment workers and senior sewage treatment workers with minor exposure potential. The second group had no or extremely limited exposure potential; it included instrument specialists, oilers, engineers and senior engineers. It was believed that office and administrative workers had no significant exposure potential to any COC-containing materials.

Existing sample results and a review of the available literature on the handling of COC-containing materials were utilized to characterize the expected

Figure 1

General Methodology for Assessing Occupational Exposures



Note. *Adapted from* A Strategy for Assessing and Managing Occupational Exposures *(3rd ed.), by J. Ignacio and W. Bullock, 2006, Fairfax, VA: AIHA Press.*

exposure levels associated with the work activities identified. Additionally, activities were identified and characterized for situations that workers may encounter in the future, but are currently prohibited due to internal policies or training and regulatory requirements.

Table 1

Asbestos Exposures Associated With Gasket Removal Activities

Author	Reported exposures	Notes
U.S. Navy (1978) *unpublished cited in Madl, et al.	Reported average levels ranging from < 0.05 to 0.13 f/cc. Reported range of < 0.03 to 0.39 f/cc.	Short duration samples. Sample times not specified. Work performed aboard a naval vessel.
Cheng & McDermott (1991)	Reported range of 0.11 to 1.4 f/cc.	Short duration samples. Sample times not specified.
McKinney & Moore (1991)	Average levels of 0.24 f/cc with a reported range of 0.05 to 0.44 f/cc.	Short duration samples. Sample times not specified.
Spence & Rocchi (1996)	Reported a maximum TWA level of 0.005 f/cc.	Exposures reported as 8-hour TWA exposures. Used a wet method not typical in the U.S.
Spencer & Balzer (1998) *summary of three unpublished studies from Madl, et al.	Reported TWA exposures with a range of < 0.045 to 0.008 f/cc.	Exposures reported as 8-hour TWA exposures.
Longo, et al. (2002)	Reported an average task based exposure of 21.8 f/cc with a range of 9.3 to 31 f/cc. Reported TWA exposures of 2.3 to 3.6 f/cc.	Reported both task based and TWA exposure measurements.
Boelter, et al. (2002)	Reported average TWA exposures of 0.014 f/cc with a range of 0.00 to 0.035 f/cc.	Exposures reported as 8-hour TWA exposures.
Mangold (2006)	Reported average TWA exposures of 0.03 f/cc with a range of 0.01 to 0.08 f/cc.	Exposures reported as 8-hour TWA exposures.

Table 2

Asbestos Exposures Associated With Electrical Maintenance Activities

Activity	Exposure level	Sample type	Reference
Wire stripping	One detection at 0.11 f/cc, the remaining samples were below the detection limits; however, detection limits were above the PEL.	Short-term (30-minute) samples	Millette, 1999
Cutting and stripping wire	0.006 f/cc	Short-term, 2-hour samples	Maxim Engineers, 1990[a]
Cutting and stripping electrical cable	< 0.007 to 0.073 f/cc	8-hour TWA samples	Clayton, 1994 [a]
Cable splicing	< 0.011 to 0.073 f/cc	Short-term 20- to 30-minute samples	Soule & Masaitis, 1997 [a]
Electrical repairs	0.0034 to 0.052 f/cc	8- hour TWA samples	Mlynarek, et al., 1996

Note. *[a]Unpublished study. Results are as presented in Williams, Phelka and Paustenbach, 2007.*

Assessment Results

Asbestos

Asbestos was determined to be potentially associated with plant equipment in the form of gaskets, packing, pipe insulation, electrical wire insulation, electrical panels and other materials. Asbestos also may be present in building materials such as floor tile, window caulk, wall mastic, fireproofing and roofing materials. Asbestos-containing material (ACM) had previously been found hidden behind other materials such as walls and floors at the treatment plants. The plants had some records for bulk sampling of ACM; however, the management and organization of the results were not consistent across the facilities. Furthermore, the recordkeeping did not capture samples collected by outside contractors or other governmental agencies.

Also, the reports contained no tracking information to confirm that ACMs had been removed. Generally, it was reported that workers and contractors did not intentionally disturb any suspect materials until the materials had been tested and confirmed to be non-ACM. Local regulations require that anyone who handles ACM be appropriately trained. At the time of this work, the bureau employed three electricians who held proper credentials to handle ACM; however, those workers reported that they did not disturb ACM as part of their work, but were on site to provide electrical assistance during the sampling or abatement of suspect ACM associated with electrical equipment.

Although ACM was not intentionally disturbed, many sites indicated that workers may inadvertently contact ACM in the form of gaskets during equipment and pipe maintenance and repair. Also, ACM may inadvertently be contacted during preventive maintenance and repair of electrical systems. It was reported that operators may open electrical cabinets, visually inspect for damage and change fuses. During this work, they will not disturb any ACM that may be present in electrical cabinets. Historically, operators may have blown out the interior of electrical cabinets with compressed air, vacuumed and/or wiped settled dust.

Electricians may perform more disruptive work inside electrical cabinets, such as tightening contacts, removing components, stripping and cutting wire, as well as vacuuming, wiping or blowing out settled dusts. At the time of this assessment, electricians did not perform any activities inside cabinets that may involve presumed ACM (PACM) without prior sampling and abatement if necessary.

Table 3

Presumed 8-Hour TWA Exposure Levels for Lead-Related Construction Tasks

Exposure range		
> 50 to 500 μg/m³	> 500 to 2,500 μg/m³	> 2,500 μg/m³
• Manual demolition • Dry manual scraping • Dry manual sanding • Heat gun use • Power tool cleaning with dust collection systems • Spray painting with lead paint	• Using lead-containing mortar • Lead burning • Rivet busting • Power tool cleaning without dust collection systems • Cleanup of dry expendable abrasive blasting jobs • Abrasive blasting enclosure movement and removal	• Abrasive blasting • Welding • Torch cutting • Torch burning

Asbestos exposure in the workplace is regulated by OSHA (29 CFR 1910.1001 and 29 CFR 1926.1101). OSHA has established a permissible exposure limit (PEL) of 0.1 fibers per cubic centimeter of air (f/cc) and an excursion limit of 1.0 f/cc over a 30-minute period. Both the general industry and construction standards require that an initial exposure determination be performed for any activities with potential exposure to asbestos (OSHA, 1994a, b).

OSHA regulations identify specific classes of work activities and the level of training required to perform those activities:

•Class I: Activities that involve the removal of thermal systems insulation (TSI) and surfacing ACM and PACM.

•Class II: Activities that involve the removal of materials which are not TSI or surfacing materials.

•Class III: Activities that involve repair or maintenance where there is a potential for some disturbance of TSI or surfacing materials.

•Class IV: Activities that are maintenance or custodial in nature, where there may be contact with ACM or PACM, but no disturbance, and activities that involve cleanup of dust, waste or debris created by the first three classes.

The work activities identified in the plants nearly all fit into either class III or class IV.

OSHA requires building owners or employers to identify installed PACM and/or ACM, and to use labels or signs to alert workers to the presence of these materials. The regulations at 1910.1001(j)(4) and 1926.1101(k)(8) provide specific language requirements that any building owner or employer is expected to follow to ensure that employees who are likely to be exposed will notice the signs. The regulations also require the employer to ensure that employees who may observe these signs or labels in the course of their work understand the meaning. The bureau has addressed these requirements via annual hazard awareness training, and labeling and signage programs.

Although bureau workers do not routinely or intentionally disturb ACM, they may unknowingly disturb asbestos-containing gasket material during repairs, maintenance or emergency response. Generally, gaskets are not accessible until a flange is broken and the material is disturbed; thus, bulk sampling prior to replacement is not typically feasible. Table 1 presents exposures associated with the removal of gasket material as reported in the literature (Boelter, Crawford & Podraza, 2002; Cheng & McDermott, 1991; Longo, Egeland & Hatfield, 2002; Madl, Clark & Paustenbach, 2007; Mangold, Clark, Madl, et al., 2006; McKinnery & Moore, 1992; Spence & Rocchi, 1996).

The bureau's existing policy is that if workers encounter gaskets that were previously inaccessible and that after exposing the material are believed to contain asbestos, workers should stop work and

Potential asbestos-containing gasket that would not be accessible until the pipe flange had been opened.

wait for testing before performing any additional work. In assessing this limited-duration exposure scenario, reported exposure magnitudes from the literature were considered, as were the short time associated with any exposure associated with opening a flange initially; the assessment indicated that it would be highly unlikely to create exposure above any regulatory guidance.

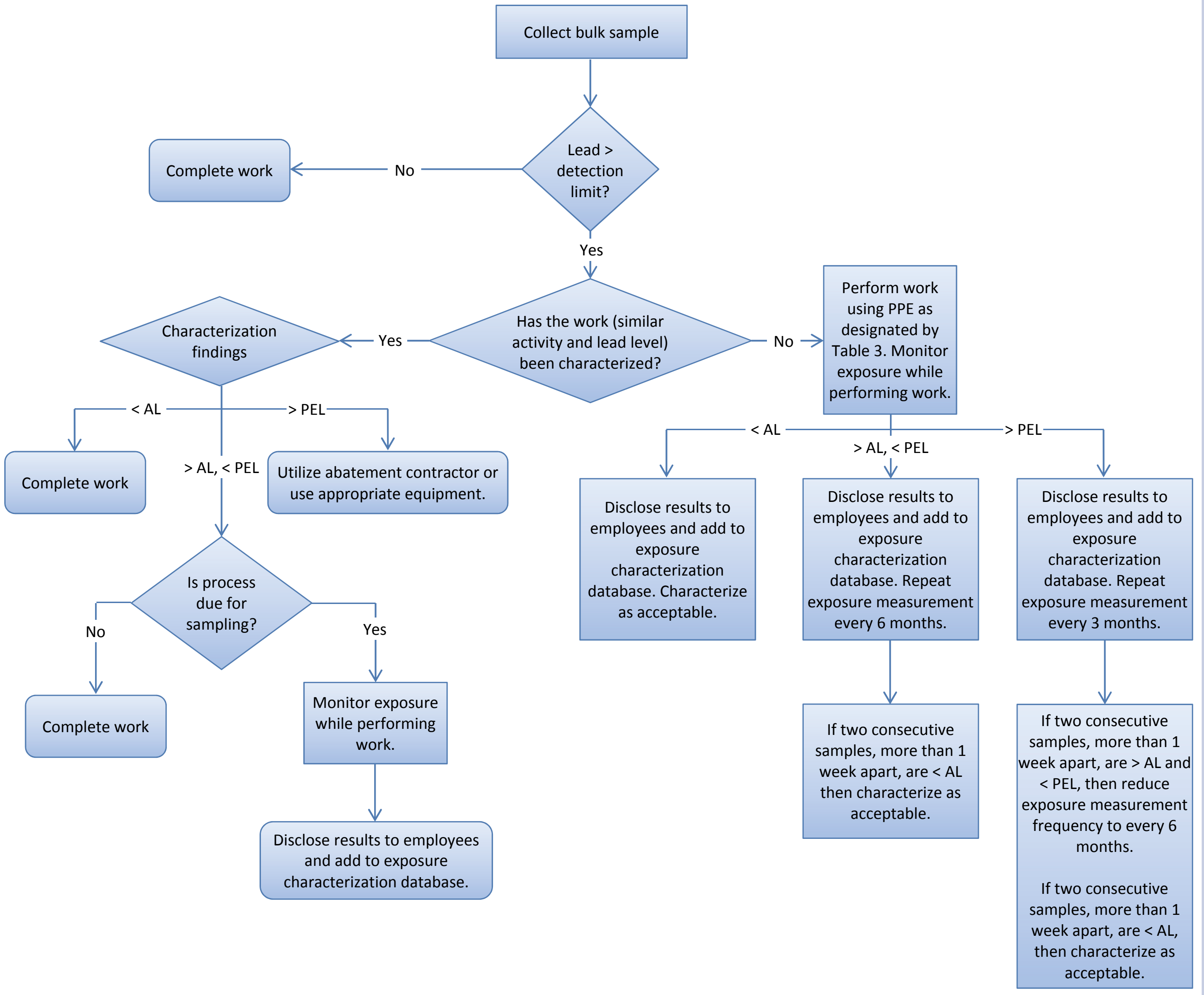
Some limited studies have examined asbestos exposures during electrical maintenance activities (Mlynarek, Corn & Blake, 1996; Millette & Mount, 1999; Williams, Phelka & Paustenbach, 2007). Table 2 (p. 60) presents the exposure ranges reported in these studies. These studies indicate that the potential exposures associated with electrical repair work are below the current OSHA PEL. However, these studies were limited and did not capture all activities that bureau employees may have historically performed. Any future work tasks would require an exposure assessment of the type detailed later.

Lead

Lead was potentially present in paint, solder and electrical equipment. The most likely lead-containing material that employees might encounter was lead-containing paint. However, the assessment team did not use the term *lead-based paint* (LBP) (paint or other surface coatings that contain lead equal to or exceeding 1.0 milligram per square centimeter or 0.5% by weight), as this term does not represent a meaningful threshold when analyzing occupational exposures. OSHA has issued multiple letters of interpretation about bulk sampling and its poor correlation with exposure (e.g., Fairfax, 1999,

Figure 2

Exposure Assessment Process for Lead-Containing Materials



Note. *AL = action limit, 30 µg/m³; PEL = permissible exposure limit, 50 µg/m³.*

2000, 2008; Hillenbrand, 1981; McNully, 2003). Lead-containing paint may be present on building components as well as plant equipment such as pipes, pumps, valves and tanks. Bureau plants had some data on lead concentration in paints obtained by bulk sampling or nondestructive (X-ray fluorescence) methodology. These data were typically collected in relation to a renovation or repair project, and most plants indicated that they tested paint prior to disturbance.

It was reported that some sites used bridge painters during winter months. Although lead was banned in residential paints in 1978, the ban does not apply to nonresidential uses such as wastewater treatment plants (National Cooperative Highway Research Program, 1997). Typical levels of lead in bridge paint range from 10% to 50% lead by weight. It was neither confirmed nor denied that the painters used bridge paints; however, given the nature of the structures that required coatings (e.g., pipes, towers), these industrial coatings may be similar to bridge paints and may have contained lead (National Cooperative Highway Research Program, 1997).

Plant policy allowed for the application of lead-based paints in areas where no feasible alternative exists; it also allowed employees to perform a specific set of activities that pose low risk for lead exposure exceeding the action level (AL). These activities included repainting with no surface preparation, window pane replacement, door repair, electrical fixture repair, activities that disturb less than 2 sq ft of paint (except dry scraping) and chemical paint removal with nonmethylene chloride paint removers. The policy also defined guidelines for lead abatement activities performed by outside contractors. Typical paint-disturbing activities performed by plant personnel include drilling holes to mount equipment; cutting pipe; and removing bolts on painted pipes and equipment.

It was generally reported that if paint was found to be lead based, workers used a chemical stripper or contacted an outside contractor to remove the paint in the area that will be disturbed. However, one site indicated that it was unaware of lead paint issues, did not test paint and did not have chemical strippers on site. This site also indicated that it torch cut bolts, which may be coated with paint, on occasion.

OSHA regulates occupational lead exposure in 29 CFR 1910.1025 and 1926.62. These regulations contain no guidance on the collection of bulk samples as they include no threshold for lead content in any material, and the agency has identified no correlation between concentrations in a bulk material and occupational exposures. Rather, the activity must be evaluated. OSHA has established a PEL of 50 micrograms of lead per cubic meter of air (μg/m^3) and an AL of 30 μg/m^3. Both standards require that an initial exposure determination be performed for any activities with potential exposure to lead to determine whether exposures are above AL or PEL. The construction standard defines exposure levels that must be assumed for specific activities until such time as an initial exposure determination has been performed (Table 3, p. 61) (OSHA, 1978a, b).

Based on the nature of the tasks that workers may perform, an initial exposure determination was proposed that involves the collection of industrial hygiene exposure measurement data from a representative group of employees. However, to determine whether any given activity might involve exposure, some level of bulk materials sampling would be performed first to confirm that lead might be present in the material of interest.

If lead is found in detectable amounts, then a quantitative exposure assessment would be performed if no prior characterization of the activity had been performed in the previous 12 months. If the assessment reveals exposures below the AL, no further action is required until a change occurs in the work process. If exposure levels are greater than the AL, but less than the PEL, exposure monitoring must continue every 6 months until two consecutive rounds of sampling, separated by more than 1 week, reveal exposures below the AL.

For exposures greater than the PEL, exposure monitoring must continue every 3 months until two consecutive rounds of sampling, separated by more than 1 week, reveal exposures below the PEL or AL. If exposure measurements are below the PEL but above the AL, monitoring frequency is reduced to every 6 months; if measurements are below the AL, no further action is required until the work process changes. Figure 2 provides a summary of the exposure determination process.

The exposure levels associated with various LBP activities have been reported in multiple sources. Additionally, OSHA provides default exposure as-

Pipe with lead-containing paint removed to facilitate torch cutting.

sumptions for specific activities to be used until an exposure assessment has been established; these are summarized in Table 3 (p. 61). Table 4 provides a summary of reported exposure measurements associated with work that may be performed by employees or contractors operating at plants (National Cooperative Highway Research Program, 1997; NIOSH, 1997). Note that the values presented assume that the work activities occur for a full 8-hour day; tasks are typically small in scale and short in duration, and would result in lower time-weighted average exposures than those presented in the table.

Mercury

Mercury-containing materials at the plants may include paint, pressure switches, thermostats, thermometers, fluorescent lightbulbs and floats. Plants had an inventory of all pressure switches, thermostats, thermometers and floats that contained mercury. However, they had no reports that tracked mercury in paint, but paint was tested before any disturbance similar to the procedure followed for lead. Standard policy was to handle mercury-containing materials other than paint as universal waste.

Plant employees were unlikely to disturb mercury-containing materials in any significant manner. Paint was tested for mercury content prior to disturbance; if mercury was detected, an outside contractor was hired. Mercury-containing devices such as lightbulbs and switches do not represent a potential exposure during normal handling. It was reported that if a mercury-containing device was broken, the area was barricaded, an outside contractor was engaged, and air monitoring for mercury vapors was initiated.

OSHA regulates mercury exposure under 29 CFR 1910.1000, Table Z2. OSHA has established a PEL of 0.01 mg/m^3 for mercury. The standard requires that an initial exposure determination be performed for any activity with potential mercury exposure to determine whether exposures exceed the PEL (OSHA, 2006). Based on the activities performed by plant personnel, the team found no reason to believe that employees would be exposed to mercury above the PEL.

Polychlorinated Biphenyls

PCBs were potentially present in paint, transformer oil, light ballasts, concrete and caulk. Before 1978, PCBs were used often in paints and caulks and other elastic sealant materials because of their plasticizer properties. When PCBs were present in transformer oil, they were labeled accordingly.The bureau sampled PCBs in paint along with metals (including lead and mercury) any time paint was to be disturbed. None of the facilities assessed indicated that they typically sampled caulk for PCBs, although some were aware of asbestos being present in window caulk. PCBs have been discovered in contaminated concrete at some sites.

PCBs are regulated by EPA under the Toxic Substances Control Act, although the agency has no regulatory requirement for bulk sampling of paint and caulk. If caulk is sampled and has PCB content > 50 ppm, it is considered an unauthorized use and must be removed and decontaminated. It is not clear whether "in use" paint requires immediate removal (EPA, 1999). Regulation of PCB-containing materials is an emerging issue, and federal, state and local governments are facing pressure to regulate them when found in building materials. Recently, New York City has instituted a plan to remove PCB-containing light ballasts from public schools (Navarro, 2011).

OSHA (2006) does not have a standard specific to PCBs, but the agency does have a PEL for chlorodiphenyl (42% chlorine PCB) of 1 mg/m^3 (1,000 µg/m^3) and chlorodiphenyl (54% chlorine PCB) of 0.5 mg/m^3 (500 µg/m^3) in CFR 1910.1000, Table Z1. OSHA also issued a letter of interpretation, citing the general duty clause, stating that exposure to other PCB congeners should be addressed consistent with the existing PELs. A PCB congener is any single, unique well-defined chemical compound in the PCB category based on the number of chlorine substituent and the position of each chlorine. American Conference of Governmental Industrial Hygienists' threshold limit values (TLV) for PCB exposure are identical to OHSA PELs.

There were no existing industrial hygiene sampling results for PCBs specific to any of the treatment plants. The exposures associated with the presence of PCBs in building materials is an emerging issue and there is limited data available about potential exposures in the scientific literature.

The potential for exposure associated with PCB-containing caulk has been measured in some studies. Most of these studies looked at biomarkers of exposures, but a few measured the concentration of PCBs in air. These studies reported air concentrations ranging from 111 to 393 ng/m^3 (0.111 to 0.393 µg/m^3) associated with the presence of PCB-containing caulk (some of which was dried and cracked), and up to 120 µg/m^3 associated with the removal of caulk (Herrick, McClean, Meeker, et al., 2004; Kontsas, Pekari, Riala, et al., 2004; Sundahl, Sikander, Ek-Olausson, et al., 1999). The results of these studies indicate that the presence and removal of caulk would be unlikely to result in exposures greater than the PEL or TLV; however, based on the limited data, it was recommended that samples be collected at a minimum during removal activities to better characterize the range of expected exposures.

The team was unable to identify any measurements of exposure to occupants of buildings with PCB-containing paint or among workers removing PCB-containing paint. Washington State Department of Health (2010) has used an emissions model to estimate PCB concentrations in air associated with PCB-containing paint and paint debris on a building's exterior. This model is not generally applicable to indoor or occupational settings; however, it suggests that exposures would be below the PEL.

It is generally recognized that the standard handling of PCB light ballasts and the presence of PCB contamination in transformer oil does not present a significant exposure hazard. NIOSH (2009) performed a health hazard analysis in a school building with burned out PCB light ballasts and did not find any unacceptable exposures.

Discussion

Although in-place materials have some potential for exposure during disturbance, they generally did not or were not expected to result in significant exposures when undisturbed in this case; that is, the mere presence of these materials will not trigger occupational exposures of concern to workers or occupants. Large-scale bulk sampling and surveying of materials for contaminants were found to be extremely costly and a dubious strategy to reduce any de minimis risk of exposure. Dependent on local regulatory handling requirements and waste disposal regulations for the specific materials, broad-based bulk sampling was found to be unwarranted.

Although the analysis indicates that widespread bulk sampling of materials is unnecessary for estimating and understanding risks, an employer must still communicate all risks to employees in conformance with regulatory requirements and best management practices, which the bureau did through an annual awareness training campaign, labeling and signage programs.

Overall, a strategy that uses a combination of targeted bulk sampling and task-based exposure monitoring was determined to be the most efficient method of reducing risk to workers.

Asbestos

Intact ACM presents no exposure hazard until such time as it is intentionally disturbed, it degrades or becomes damaged, or it is subjected to conditions that could lead to fiber release. The following recommendations were developed to assess and document potential exposures to ACM:

•ACM and PACM should be appropriately labeled for easy identification by employees. Suspect materials should be visually assessed regularly to ensure that they are not damaged or degraded, consistent with in-place management practices recommended by EPA.

•Materials tested and confirmed to not contain asbestos should be labeled as non-ACM and catalogued in a database as sampled with a negative outcome. Further, a system should be developed to label or otherwise identify where new non-ACM have been installed in a system. Such systems must be constantly maintained and updated to ensure that information is current and useful to decision makers and workers.

•Although employees did not intentionally disturb any ACM, if such work were to begin, it was recommended that an exposure assessment be performed for each material/activity combination to determine the level of protection required or the need for outside contractor assistance.

Lead Paint

•U.S. EPA has defined lead-based paint as any coating containing greater than 0.5% or 1 mg/cm^2 of lead.

•U.S. Consumer Product Safety Commission has defined lead-based paint as any coating containing greater than 0.06% lead by weight.

•OSHA has ruled that the presence of lead in paint at any concentration, even concentrations less than 0.06%, can pose exposure risks under specific work conditions.

Table 4

Reported Exposures Associated With Lead-Based Paint Removal Activities

Activity	Range of exposure (µg/m^3) Typical (median)	Maximum
Open abrasive blasting	17,300	59,000
Contained blasting	25,700	59,000
Welding/cutting/burning	600	28,000
Hand scraping	45	167
Chemical stripping	11	476
Power tool use	735	20,066
Enclosure movement	500	2,100
Miscellaneous rehabilitation	45	41,000

Lead

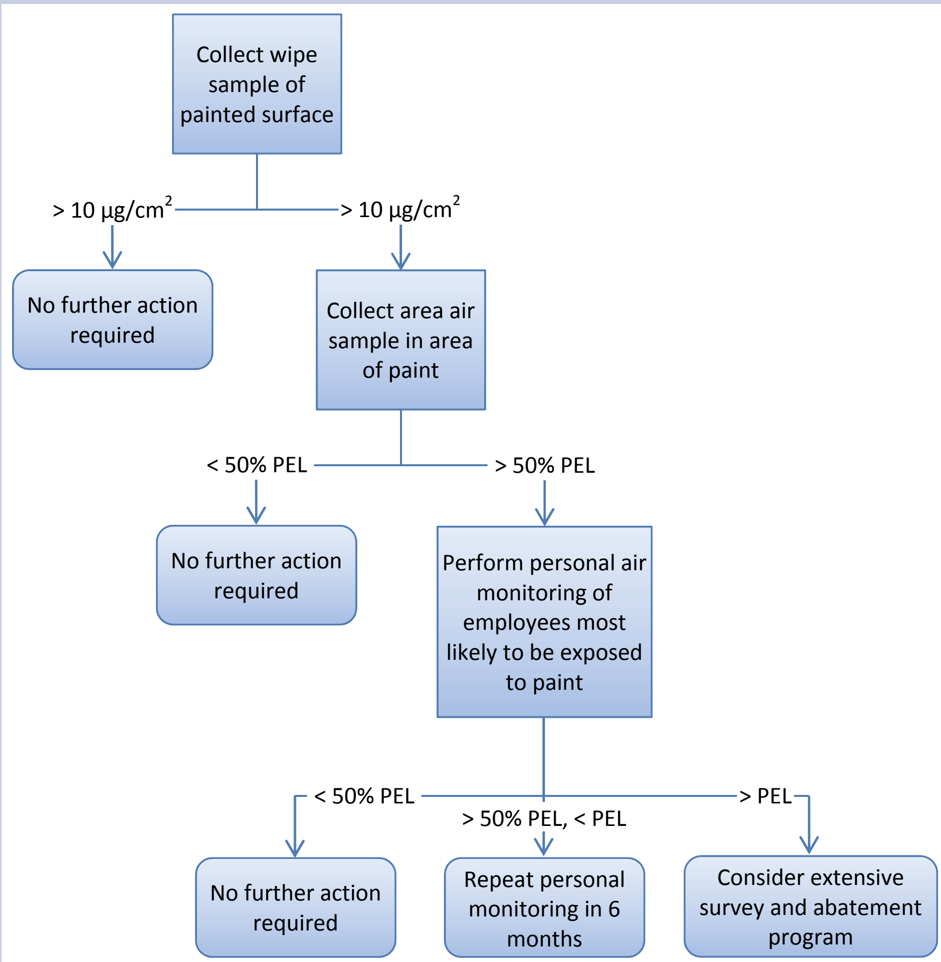
Intact lead-containing materials present no exposure hazard until such time as they are disturbed. In the absence of contrary information, intact coatings should be presumed to contain lead and should be managed in-place until such time as they will be disturbed. The following recommendations should be considered to assess and document potential exposures to lead-containing materials:

•Chipping, peeling and cracking paint presents minimal exposure potential in the absence of an activity that will potentially result in dust generation (e.g., wind erosion, vibration, friction). For areas with damaged paint and potential for dust generation, it was recommended that the paint be tested to determine lead content; if the paint is found to contain lead, then it was recommended that industrial hygiene air samples be collected either in the area or of employees who work in the area to establish a baseline exposure.

•For any activities involving the disturbance of paint known to contain lead, initial exposure determinations consistent with the OSHA lead standards should be established. These determinations should be stored in a central location and consulted for future activities.

•Further, it should be required that contractors provide MSDS for all new coatings being applied to ensure that new lead-containing material is not being applied. No new LBP should be used unless there is no feasible alternative.

Figure 3
Exposure Assessment Process for PCB-Containing Paint



Mercury

Mercury contained within devices or in undamaged paint presents no exposure hazard until containment is breached or paint is intentionally disturbed, degrades or is damaged. The following recommendations should be considered to control and document potential exposures to mercury-containing materials:

•Materials that are tested and confirmed to not contain mercury should be catalogued in the database as sampled with negative outcome.

•Damaged mercury-containing paint presents minimal exposure hazard, but it should be managed in-place, as recommended for lead-containing paints.

•Until such time as mercury-containing devices are eliminated from the workplace, employees should be trained each year (minimally) in the mercury spill procedure.

Polychlorinated Biphenyls

Based on the lack of reliable data, it was recommended that an exposure measurement process be conducted to determine the potential exposure associated with the presence of PCB-containing paints. The recommended approach would be to collect wipe samples. EPA (1999) has stated that if PCBs have not significantly migrated to the surface of paint it is assumed that they will not be present in the air. The analytical methodology for wipe samples can be found in 40 CFR Part 721 from up to 10 locations in each plant where deteriorated paint is present.

If results indicate the presence of PCBs above 10 µg/100 cm², then area exposure monitoring air samples would be collected for comparison to occupational exposure standards. Air samples should be collected in accordance with NIOSH method 5503. If sample results indicate exposures greater than the PEL, then personal sampling should be performed.

If personal samples are found to be above the PEL, a more extensive survey and abatement program should be considered. Figure 3 presents the process of estimating exposures associated with the presence of PCB-containing paints. It is believed that exposures in areas with deteriorated paint will not exceed exposure guidelines; however, based on the lack of quantitative data on exposure, the prudent action is to measure exposure before deciding on appropriate action.

The existing literature does not indicate that the presence of PCB-containing caulk, even when in compromised condition, leads to airborne concentrations above occupational exposure limits. Anytime paint or caulk is to be removed, it should be tested for the presence of PCBs. Although there is no regulatory driver for the bulk sampling of PCBs, the use of dust-generating work practices could result in exposure to employees.

The potential for exposure associated with materials contaminated with PCBs due to historical spills should be evaluated on a case-by-case basis. The size of the spill, likelihood of contact and activities occurring on or around the material should be taken into account when considering potential exposures.

Conclusion

Based on this assessment process, it was determined that the potential risks associated with in-place materials containing asbestos, lead, mercury and PCBs presented little risk to occupants and workers when not disturbed. Wide-scale bulk testing of such materials would provide little risk reduction. Instead, the most effective method to handle these materials would be an in-place management protocol that would involve bulk sampling and air monitoring only when activities would affect these materials. Although this may not be the most efficient method for every workplace (such as small individual locations), this process would nonetheless be effective in controlling exposure. This process also highlighted the difficulties in tracking bulk sample results and linking them to specific locations in large, multisite work environments. **PS**

References

Ahrens, W. & Stewart, P. (2003). Retrospective exposure assessment. In M. Nieuwenhuijs (Ed.), *Exposure assessment in occupational and environmental epidemiology* (pp. 103-113). New York, NY: Oxford University Press.

Boelter, F.W., Crawford, G.N. & Podraza, D.M. (2002). Airborne fiber exposure assessment of dry asbestos-containing gaskets and packings found in intact industrial and maritime fittings. *AIHA Journal, 63*, 732-740.

Cheng, R.T. & McDermott, H.J. (1991). Exposure to asbestos from asbestos gaskets. *Applied Occupational and Environmental Hygiene, 6*, 588-591.

EPA. (1999). Use authorization for, and distribution in commerce of, non-liquid polychlorinated biphenyls; notice of availability; partial reopening of comment period (40 CFR Part 761). Washington, DC: Author.

Fairfax, R. (1999). Letter of interpretation. Washington, DC: U.S. Department of Labor (DOL), OSHA.

Fairfax, R. (2000). Letter of interpretation. Washington, DC: U.S. DOL, OSHA.

Fairfax, R. (2008). Letter of interpretation. Washington, DC: U.S. DOL, OSHA.

Herrick, R.F., McClean, M.D., Meeker, J.D., et al. (2004). An unrecognized source of PCB exposure in school and other buildings. *Environmental Health Perspectives, 112*(10), 1051-1053.

Hillenbrand, B. (1981). Letter of interpretation. Washington, DC: U.S. DOL, OSHA.

Ignacio, J. & Bullock, W. (2006). *A strategy for assessing and managing occupational exposures* (3rd ed.). Fairfax, VA: AIHA Press.

Keil, C., Simmons, C. & Anthony, T. (2009). *Mathematical models for estimating occupational exposures to chemicals* (2nd ed.). Fairfax, VA: AIHA Press.

Kontsas, H., Pekari, K., Riala, R., et. al. (2004). Worker exposure to polychlorinated biphenyls in elastic polysulphide sealant renovation. *Annals of Occupational Hygiene, 48*(1), 51-55.

Longo, W.E., Egeland, W.B., Hatfield, R.L., et al. (2002). Fiber release during the removal of asbestos-containing gaskets: A work practice simulation. *Applied Occupational and Environmental Hygiene, 17*, 55-62.

Madl, A.K., Clark, K. & Paustenbach, D.J. (2007). Exposure to airborne asbestos during removal and installation of gaskets and packings: A review of published and unpublished studies. *Journal of Toxicology and Environmental Health, Part B Critical Reviews, 10*, 259-286.

Mangold, C., Clark, K., Madl, A., et al. (2006). An exposure study of bystanders and workers during the installation and removal of asbestos gaskets and packing. *Journal of Occupational and Environmental Hygiene, 3*, 87-98.

McKinnery, W.N. & Moore, R.W. (1992). Evaluation of airborne asbestos fiber levels during removal and installation of valve gaskets and packing. *AIHA Journal, 53*, 531-532.

McNully, R. (2003). Letter of interpretation. Washington, DC: U.S. DOL, OSHA.

Millette, J. & Mount, M. (1999). Microscopical studies of asbestos fiber release during cutting and stripping of wire cables. *Microscope, 47*, 159-161.

Mlynarek, S., Corn, M. & Blake, C. (1996). Asbestos exposure of building maintenance personnel. *Regulatory Toxicology and Pharmacology, 23*, 213-224.

National Cooperative Highway Research Program. (1997). Lead-based paint removal for steel highway bridges. Washington, DC: Author.

Navarro, M. (2011, Feb. 3). City to replace school lighting tainted by PCBs. *New York Times.*

NIOSH. (1997). Protecting workers exposed to lead-based paint hazards. Washington, DC: U.S. Department of Health and Human Services (DHHS), CDC, Author.

NIOSH. (2009). HETA 2008-0176: Heath Hazard Evaluation, New York Schools. Washington, DC: U.S. DHHS, CDC, Author.

OSHA. (1978a). Occupational exposure to lead (29 CFR 1910.1025). Washington, DC: U.S. DOL, Author.

OSHA. (1978b). Occupational exposure to lead (29 CFR 1926.62). Washington, DC: U.S. DOL, Author.

OSHA. (1994a). Occupational exposure to asbestos (29 CFR 1910.1001). Washington, DC: U.S. DOL, Author.

OSHA. (1994b). Occupational exposure to asbestos (29 CFR 1926.1101). Washington, DC: U.S. DOL, Author.

OSHA. (2006). Limits of air contaminants (Table Z2, 29 CFR 1910.1000). Washington, DC: U.S. DOL Author.

Paustenbach, D.J. (2000). The practice of exposure assessment: A state-of-the-art review. *Journal of Toxicology and Environmental Health, Part B Critical Reviews, 3*, 179-291.

Spence, S.K. & Rocchi, P.S. (1996). Exposure to asbestos fibres during gasket removal. *Annals of Occupational Hygiene, 40*, 583-588.

Sundahl, M., Sikander, E., Ek-Olausson, B., et al. (1999). Determinations of PCB within a project to develop cleanup methods for PCB-containing elastic sealant used in outdoor joints between concrete blocks in buildings. *Journal of Environmental Monitoring, 1*, 383-387.

Viet, S., Stenzel, M., Rennix, C., et al. (2008). *Guideline on occupational exposure reconstruction.* Fairfax, VA: AIHA Press.

Washington State Department of Health. (2010). Letter of health consultation: Rainier Commons LLC PCB paint contamination. Olympia, WA: Author.

Williams, P.R., Phelka, A.D. & Paustenbach, D.J. (2007). A review of historical exposures to asbestos among skilled craftsmen (1940-2006). *Journal of Toxicology and Environmental Health, Part B Critical Reviews, 10*, 319-377.