Lead & Arsenic Exposure Control for Waste to Energy Furnace Cleaning

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Abstract
In 1997, the Hampton/NASA Steam Plant implemented a successfully re-engineered wet cleaning process for controlling exposure to lead and cadmium during the cleaning and maintenance of electrostatic precipitators. The following year we were ready to apply the lessons learned to the initial furnace cleaning tasks.

As part of the initial process review, industrial hygiene (IH) tests were done during furnace cleaning using the in practice methods. Testing was done for respirable lead and cadmium. Lead exposure was found to be over the action level, but cadmium exposures were just around non-detect levels. May of 1999 the facility became aware, through an IWSA-MWMA-ASME Safety and Health Seminar, that other WTE facilities were testing for arsenic as well.

Another set of tests were performed that same month which included tests for respirable arsenic. The results showed that arsenic was present and found to be over the action level, and one test point was especially high during the sifting hopper cleaning part of the procedure. These results were surprising since IH testing for these tasks during 1987 indicated much lower exposures.

It was decided the procedures had to be changed. Two process improvement outcomes were targeted:
1) To prevent accidents, injuries and close calls during the furnace cleaning task, a safer procedure for the task of furnace cleaning would be developed.
2) The new procedure must control cadmium, lead and arsenic exposures during furnace and sifting hopper cleaning tasks, to below OSHA Action Levels.

The new procedure standardized cleaning methods and included use of water right from the initial entry into the furnace. Operators had respirators upgraded to Positive Pressure Air Purifying Respirators (PAPR) and wore special disposable coveralls. Subsequent Industrial Hygiene testing showed that exposure levels could be reduced to less than the OSHA Action Level and Permissible Exposure Limits for lead and arsenic.

The newly developed “wet cleaning” procedure provided a safer standardized procedure that the Operators helped to develop, and Operators feel safer doing the task. The new procedure has also reduced task worker exposures to Lead and Arsenic to below OSHA Action Levels.

Background Information
The Hampton/NASA Steam Plant is a Waste-to-Energy facility located on the NASA Langley Research Center in Hampton, Virginia. The facility provides the Center steam energy by burning municipal waste from the City of Hampton and neighboring communities. The Steam Plant operates 365 days a year 24 hours a day with a staff of 34 full time employees. The 240 ton per day plant has two units that produce a total of 66,000 pounds steam per hour.

Refuse is like other solid fuels, and its combustion produces a residue ash as a by-product. This ash contains trace amounts of lead, cadmium and arsenic from the trash that was burned. For maintenance activities, the furnace must be cleaned of all remaining ash, metal and slagging. Cleaning the furnace exposes the employees to these dust hazards.

Water applied by fire hose has always been used for cleaning furnaces, grate surfaces and sifting hoppers at the Hampton/NASA Steam Plant. However, initial cleaning of the grate surface and wall scaling was being done prior to introducing water into the furnace. This was the specific task targeted for process review and improvements.

Industrial hygiene testing for these tasks were done in 1987, and exposures were found to be below the Action Levels for lead and arsenic. At that time, the industrial hygiene review recommended the facility have employees wear full face respirators to increase the protection level. But initial testing for this review found exposures to be above OSHA Action Levels (AL).

What had changed since the earlier testing. The only new OSHA rule was for cadmium, but that was not a problem. Apparently, the nature of the trash and ash had changed with the recycling and composting programs of the 1990's. Before recycling and composting the facility combusted 80% household and institutional waste. That “wet trash” ratio dropped to 67%, and the balance was made up with drier commercial trash. Before recycling, melted aluminum and brown glass clinker captured much of the harmful dust. Less of these materials and finer dust from “post recycling” ash had increased occupational exposures dramatically. It was clear that the procedures needed to be standardized and improved with the use of water to minimize exposures.
Initial Process Review
The initial steps included review of past industrial hygiene reports, accident reports and close call incident reports. The current procedure was not very specific, so all of the operator’s methods were examined. The process improvement team included all operators who perform the tasks, the Safety Manager and two mechanics. Each operator performed the furnace cleaning tasks slightly different, to suit their personal safety confidence. The variations occurred mainly during the tasks required to remove sidewall slagging. Some operators would erect and secure a ladder for all wall cleaning. Other operators removed the slag from beneath most of the time.

Some minor injuries happened when operators knocked down furnace wall slagging while standing underneath the heavy slag. In this method, the entrant would have to dodge the falling slag. Injuries resulted from either being hit by the falling slag or falling while trying to flee. Over eighteen years of operations no serious injuries occurred during furnace cleaning. However, we could not determine whether that was due to the operator’s skill or luck.

A standard procedure would have to be adopted to provide repeatable industrial hygiene results for evaluation. A firm concurrence developed around a procedure that required erecting and securing a ladder for each wall scaling task. Using an extension ladder to get above the slag would get the operator clear of the falling slag clinker. The ladder would have to be staged in a secure way also away from the falling slag clinker. A consensus among operators was standardized as the specific method to foot and secure the ladder against the furnace wall opposite the slag.

Just prior to the initial procedure review, the operator’s respirators were upgraded to full face powered air purifying respirators with HEPA filters. This was a planned upgrade because of the overwhelming success we had with these respirators for the maintenance employees, who were upgraded in 1995. The Wilson full face PAPR respirators effectively control the fogging of lenses and eye glasses in warm and humid conditions such as when entering a furnace. Also, operators wore disposable coveralls to help control the containment of the hazardous contaminants. The same year, the facility converted to a “soiled coverall” program. This was also previously planned, and was not done specifically for improving the tasks being reviewed.

During early testing in the process review, the tasks of furnace cleaning and descaling were split from the sifting hopper cleaning. The sifting hopper cleaning sometimes occurs separately. These results did show that the sifting hopper cleaning in itself could not be eliminated from the specific dust hazard analysis. The final procedure has all tasks being done by one person, and total exposures are low.

Intention from the beginning were to include water as an important part of the new improved procedure, but the initial testing was done “dry” to get an understanding of the exposures to date. The last IH testing of these procedures was in 1987, and it found levels of lead, cadmium and arsenic much lower than the PEL’s. We did not expect to see exposures much higher than those levels.

Not only where the initial review exposures higher, but they varied amongst the operators due to slight variations in methods. Seasoned operators seemed to have developed a sense about staying down wind of the ash cloud.

The dry cleaning was tested a second time to include arsenic testing. Based on results gathered to that point, no cadmium testing was done during wet cleaning trials. During the testing, background IH data was gathered for the confined space attendants and the operators working in the plant.

Worker exposures went up significantly during the second dry testing. As the procedure became more specific, the time of the tasks and exposure increased. The average dry cleaning exposure to lead was 21.6 µg/m³. The highest exposure was 62 µg/m³, which exceeded the PEL. The average exposure to arsenic was 8 µg/m³, and that exceeded the OSHA Action Level. All background exposures for lead, cadmium and arsenic remained near non-detect levels during the days these tasks were done.

For regulatory purposes the OSHA Permissible Exposure Limit is evaluated against a time weighted average. Operators were soon going to a twelve hour shift rotation, and that would effectively reduce the PEL by one third. The OSHA Action Levels are evaluated against total exposures.

Implementing the “Wet Cleaning” Procedures
The results of the initial review and testing confirmed that we needed to incorporate water at initial furnace cleaning to reduce the exposure to below the applicable Action Levels.

The initial wet cleaning task testing showed that exposures were reduced, however not to the desired levels. Also the sifting hopper task exposure remained too high. After review with the operators it was decided more water was needed. The procedure was rewritten to include more points of wetting down the grate surface and walls. Generally applying water was more emphasized in the procedure.

The final wet cleaning procedure had these basic elements:

1) All LockOut/TagOut and confined space entry procedures are completed, then an entry permit is issued.

2) Operators spray down the ash on the grate surface to reduce ambient dust. This is done often during the grate surface cleaning.

3) Once the grate surface has been cleaned and washed, the operator sprays the wall slag with the garden hose.
4) An extension ladder is erected against one side of the furnace, shimmed for level footing, and jammed between the two furnace walls.

5) From above the slag, the operator uses a pinch bar to scale the slag from the furnace walls. As the slag falls to the grate surface, the outside attendant sprays it with water.

6) The process is repeated for the opposite wall.

7) The ladder is removed and the grate surface is cleared while generously applying water to control dust.

8) The operator then uses water as needed while cleaning the sifting hoppers. Special attention must be taken to control dust with water spray while shoveling and removing the sifting hoppers ash from the floor below.

9) The process is completed by maintenance personnel washing furnace and hoppers completely with a fire hose.

Results and Analysis

In reviews of these evolutions, background testing of confined space attendants and other roving operators showed non-detectable exposures. So we were confident that the hazard was being contained.

The operators felt much safer using the new procedure for removing scale from the furnace walls, and they were very enthusiastic about the new powered air purifying respirators. The success of the procedure could be seen with how clean the operator’s coveralls were after cleaning the furnace.

The three procedure verification trials were continuously observed and reviewed by a third party industrial hygienist for adherence to procedures and analysis of our results. Testing results showed that lead and arsenic levels were below the OSHA Action Levels and PEL’s.

IH testing results for each process iteration, background exposures and procedure verification were evaluated statistically by applying a Student’s T one-tail distribution at a 95% confidence to the Time Weighted Average (TWA). Because the degree of freedom (n-1) was only two, the T factor significantly raised the UCL from the average. Even so, the exposures for lead and arsenic were found to have Upper Control Limits (UCL) of much less than the PEL’s.

Lead has an OSHA Action Level of 30 micrograms per cubic meter, was applied against the maximum exposure. These exposures was reduced from a maximum of 234 micrograms per cubic meter to barely detectable levels for the wet cleaning procedure. Arsenic has an action level of 5 micrograms per cubic meter and was reduced from a maximum exposure of 37 micrograms per cubic meter to a consistent low of non-detect. Results are summarized in Figures 1 and 2. Data is presented at the end of the paper.

Summary

Procedure improvement and engineering controls were successful in reducing exposures and containing the Lead and Arsenic hazards. Employees felt much safer with the new procedure for removing wall slagging, and they were especially delighted with the new respirators.

This new procedure did cause a slight increase in hours, but that may decrease during times when the task is done without IH testing. The costs for the new “soiled coverall” and respirator upgrades to PAPR were planned expenses that would have occurred regardless of this process review.

The full task is performed eight to twelve times a year, so no employee is exposed to the full extent more than thirty days in a calendaryear. The partial task of cleaning sifting hoppers occurs weekly or more, so there is the possibility of a single employee having more than thirty days of exposure.

Periodic industrial hygiene re-testing of this procedure will be scheduled to ensure that procedures continue to be followed and exposures remain low.
References


Appendix: Industrial Hygiene Data from the Process Review

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<th>Time Weighted Exposures - micrograms per cubic meter</th>
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