EM-5.22 Lessons Learned Bulletin

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Lessons Learned on Demolition of a Mercury Contaminated Facility

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Decontamination and demolition (D&D) of the West Column Exchange (COLEX) Equipment at Y-12 has proven to be extremely difficult resulting in cost and schedule issues. The COLEX equipment, installed in the mid-1950s, was used in a lithium separation process. The process required significant usage of mercury in performing the chemical separation process. This process was used until 1963 when operations were terminated due to environmental concerns.

In preparing the strategy for performing D&D of the system and facilities, the contractor, URS/CH2M Oak Ridge LLC (UCOR) attempted to gain as much process knowledge of the system as possible. Due to the age of the system, limited amounts of data, documentation and procedures were available. As the D&D was initiated, significant levels of mercury, well above what was anticipated, were discovered not only in process piping, but in secondary and support piping as well. In addition, performing the D&D operations generated high levels of mercury vapor that limited personnel productivity. This higher level of mercury contamination caused significant cost and schedule issues. This bulletin provides some lessons learned on dealing with legacy facilities that were contaminated with mercury.

Discussion:

Background

UCOR was awarded a contract in July 2016 to (1) demolish the West COLEX equipment, (2) isolate the system to make East, South and West COLEX cold and dark, and (3) characterize East and South COLEX for future demolition at the Y-12 National Security Complex in Oak Ridge, Tennessee. The COLEX equipment was installed in 1955 and was used for lithium separation, a process that required the use of large amounts of mercury. The process was used in the US between 1955 and 1963 in the Y12 Plant. Due to environmental concerns, the US stopped lithium enrichments operations in 1963.

Limited knowledge of the system was available for the contractor to adequately plan the demolition. Documentation such as drawings, piping and instrumentation diagrams, operating procedures, etc. was not available. In addition, process knowledge regarding the original draining and shutdown performed in the 1960's was not available. An assumption was made that during shutdown, most of the mercury in the process was removed, and therefore, only a residual amount was remaining in the mercury system's piping and process equipment. UCOR believed that experience gained from the D&D of the K25/27 gaseous diffusion systems would be transferable to this scope of work and, therefore, based their D&D approach, assumptions, and throughputs on this knowledge.

Discussion

In order to develop an effective project strategy for D&D of the equipment, the UCOR team began by researching available process knowledge on the West COLEX equipment. Numerous data sources were investigated including details provided by the DOE within the contract scope of work, COLEX operational records, OPEXSHARE information on mercury related D&D projects, and interviews with remaining personnel who had worked with the COLEX facility when it was still running and were considered Subject Matter Experts (SME).

During initial tap and drain operations on process piping, it became apparent that there was significantly more residual mercury still in the system than anticipated. Mercury was also found in large quantities in secondary and support piping, and was found to have bridged and crusted creating areas that were inaccessible. Removal of mercury required cutting open piping and hand scraping. The baseline schedule assumed there was approximately 5,000 linear feet of piping to be deactivated at a rate of 300 lf/day, meaning it would take 17 working days to complete. Due to the

significant amount and physical form of additional mercury found, the tap and drain operations ended up taking more than 300 days. Additionally, higher levels of mercury vapor than anticipated were encountered, which complicated demolition activities even more. There was no initial assumption of the need for respiratory equipment for project personnel. Therefore, a significant productivity hit of 30-50% was experienced due to the need for these additional personnel protective equipment. As UCOR progressed with the work, the mercury related issues impacted cost and schedule.

These issues are categorized in two general categories: Volume and physical form of mercury and mercury vapor concentration impacts:

Volume and physical form of mercury - UCOR initially based the project cost and schedule on the assumption that only residual volumes of mercury remained in the system, based on information in the Scope of Work and in available process knowledge. It was also assumed the mercury would freely flow during tap and drain operations. Several factors contributed to the underestimation of mercury still present in the system and the difficulty of removing it:

- Although it was noted in process knowledge documentation that the system had been purged of mercury prior to shut down, mercury was discovered in almost every system (even those that were not supposed to contain mercury) of the West side of COLEX.
- Documents containing process knowledge related to COLEX were difficult to acquire or unattainable due to security criteria.
- Traditional characterization methods of coupon sampling proved ineffective in the identification of mercury within systems.
- Boroscope evaluations of process lines were ineffective at identifying mercury due to debris and oxidation layers that would camouflage the presence of mercury. This camouflage was the result of the age of the systems and existing breaches that allowed water and debris to enter over many years.
- Boroscope investigations were not performed on systems that were designed to be operationally free from mercury, thus, cross contamination of mercury was unknown until revealed during D&D activities.
- There was limited availability to SMEs who could share details related to operational conditions prior to the facility being placed in a Surveillance & Maintenance mode. Access to SMEs could have identified system issues and vulnerabilities that could have provided advanced insight into problem areas during the D&D process.
- Drawings and records of historical events for COLEX were incomplete, maintaining a gap between the as-anticipated and as-found conditions.[1]

Mercury Vapor Concentrations - It has long been recognized that the vapor pressure of a material (mercury in this case) increases as the temperature increases thus a general correlation of airborne mercury vapor to ambient temperature is a consequence of mercury vapor pressure as derived from physical laws. However, UCOR was unable to establish a correlation between saturation vapor pressure derived from daily high temperature and measured mercury vapor concentrations in the work zone. Multiple other workplace variables appear to have a significant enough contributing factor to the overall mercury vapor concentrations that each variable must be recognized and controls established. Additional variables believed to contribute to overall mercury vapor concentrations are:

- Emanation rate variations from contaminated building and equipment surfaces
- Confounding mixtures of mercury with water and other system liquids
- Extent of direct sunlight (UV radiation) on process systems and spill areas impacted by natural cloud cover, shading due to existing structures, and shading due to installed covers
- Other ambient environmental factors including wind speed, wind direction, and relative humidity
- Mechanical disturbance of process system and spoil piles with tools and equipment. [1]
- Initial mercury vapor concentrations in the work area were misleading. Any system or surface disturbance (in or out of scope) increased concentrations in the work zone.

Conclusion

DOE's Oak Ridge Office of Environmental Management (OREM) declared demolition completion on the West COLEX equipment at Y-12 National Security Complex in November 2018. The UCOR D&D plans were based on Process Knowledge that could be obtained from documentation and operator knowledge from the design and operation of the

West COLEX system. However, key information was either unavailable, limited or incomplete. Based on initial assumptions, the UCOR team was planning to deactivate 5,000 linear feet or piping, however, at completion, operations crews had drained and removed nearly 10,000 linear feet of piping and had recovered 6,500 pounds of mercury. The larger quantity of piping and higher volume of mercury required more effort and introduced different worker hazards than previously encountered during other D&D projects at Oak Ridge. In addition, the project experienced further complications with the high level of mercury vapor generated during demolition activities that impacted cost and schedule.

Recommended Actions:

Lessons Learned:

The following lessons learned actions were identified as a result of performing D&D of the West COLEX system at the Y-12 National Security Complex:

1. Legacy Facilities are unique and it is risky to infer that experience gained on one process will be transferable to what appear to be similar systems when preparing to perform D&D.
2. In older facilities, the lack of procedures, plans or drawings of systems and components make planning for their deactivation and demolition extremely difficult. Actions should be taken if adequate documentation of systems is not available, such as:
    a. Perform detailed walk downs of systems and perform literature searches on components as needed by DOE and site contractors.
    b. Review other D&D activities at the site or review similar equipment at other sites to gain knowledge of systems operations.
    c. Review pilot studies and case studies to gain more knowledge of unknown equipment.
    d. Interview personnel, if available, that were present during the design or operations of the facility in order to close data gaps and better understand system processes.[3]

    For additional information, please see the EM-5.22 Lessons Learned Bulletin dated September 2015.
3. Mercury based processes and facilities need to be thoroughly researched prior to establishing technical approaches and project baselines to determine the amount of mercury present.
4. Robust engineering controls for control of mercury vapor need to be incorporated into project planning and execution.
5. Liberal use of mercury decontamination agents, such as HgX®, are necessary to control ambient mercury vapors.
6. Covering mercury contaminated areas with UV resistant plastic during periods of bright sunlight was proven to reduce mercury vapor generation.
7. Daily housekeeping of mercury process areas to remove all accessible elemental mercury and reduce source term was beneficial in reducing ambient mercury vapors.

Critical Decision(s):	CD-1, CD-2, CD-3
Facility Type(s):	Decontamination and Decommissioning facilities
Work Function(s):	Project Management, Engineering, Operations
Technical Discipline(s):	All

References:

1. Bock, Thomas and McGinnis, Gregory, “Demolition of a Mercury Contaminated Facility”, B-2018-OR-UCORY12CE-0901, UCOR, September 20, 2018.
2. “Oak Ridge Crews Finish Removing Mercury-Contaminated Equipment”, US Department of Energy Office of Environmental Management, EM Update, Volume 10, Issue 46, November 20, 2018.
3. Lehman, Rodney, “Lessons Learned on Documentation for D&D Projects”, DOE Office of Project Management, EM-5.22, September 2015.