THE DERIVATION AND IMPLEMENTATION OF A COST-EFFECTIVE METHOD TO CHARACTERIZE AN EXHAUST STACK CONTAMINATED WITH RADIOACTIVE CONSTITUENTS

T. H. Proffitt and J. P. Robertson
EcoTek, Inc.

ABSTRACT

Managerial decisions concerning demolition or decontamination of exhaust stacks must be based on the most current, economical and accurate information available. In many cases, however, the logs and reports regarding material exhausted through a stack are outdated, incomplete or non-existent. Therefore, a good characterization plan for sampling of a stack interior and recording of valid data must be employed to determine the degree of contamination present. This characterization data will inform management whether a stack is contaminated beyond feasible repair or if it can be decontaminated in a cost-effective manner. The degree of propagation of contaminants through the interior wall will be another important piece of information gained by characterization data. The amount of waste generated, in the form of removed mortar, can be determined by the distance contaminants have propagated into the stack interior wall. While the possibility of sampling the entire surface of a stack may exist, it is hardly economical or timely. Through several assumptions and mathematical derivations a good approximation of potentially contaminated areas can be shown. By sampling/coring these selected areas, the entire stack can be "characterized" in a cost-effective manner.

IMPLEMENTATION

To perform the actual characterization, several field operations are necessary. Affixed with silicone sealant, most stacks are designed with a clean out port which serves as a point of manned entry for all interior sampling operations. In order to minimize any potential release due to the opening of this manway, a containment area should be constructed. This containment area consists of a simple aluminum frame which supports a "tent" made of high strength reinforced plastic sheeting. The containment area has the ability to be butted against and "sealed" to the stack for the extent of the characterization effort. This area has two distinct compartments which serve as a "hot" zone and decon area while still being within the confines of a contained environment. These compartments are separated by a door made of the same plastic material and duct taped to the hole between the two areas. A good way to support this high strength plastic "tent" is to have the tent constructed with grommets on the outer edges and use bunji cords to attach the tent to the aluminum frame. An important item to remember is the negative effect of the stack draft on the structural integrity of the tent and aluminum frame. Although the exhaust fan should be shut down during all sampling operations, a substantial negative pressure will exist due to the inherent stack effect. The addition of simple check valves will minimize this effect. These valves are made by cutting a hole in the containment area and affixing a plastic piece larger than the hole to the inside of the containment thereby allowing flow in through the containment area and into the stack while resisting flow out to the environment.

One factor that holds considerable importance in the fate of a stack is the structural integrity. Small fissures and cracks within the inner layers of a stack may indicate insufficient structural integrity to withstand decontamination procedures. In order to minimize personnel exposure and time constraints, the best way to evaluate the interior structural integrity is through the use of a videography system. Several aspects about the interior of the stack should be known before designing a system. Some stacks are equipped with an isokinetic probe to measure exhausted particles. These probes usually span the entire diameter of a stack and, therefore, must be circumvented to allow the camera to pass. Sometimes this can be done by simply removing the probe to allow the camera to pass and later returning it to its original position. If the probe is permanently installed, modifications may need to be made to the camera housing to permit a bump and move type of passage. The condition of the stack floor plays an important part in the design of a videography system. If the stack floor allows the attachment of a guide wire for the camera to ride on, this is the best way to achieve good video performance. If the stack floor does not allow the attachment of a guide wire, a free-hanging, trolley-type arrangement can be designed. However, the concept of sufficient counter-inertial torque must be kept in mind to avoid a rocking sensation as the camera rotates to achieve a panoramic view. The camera system itself should be equipped with a light and separate instrumentation to allow for data acquisition other than video. For instance, a radiation detection probe with remote readout can be installed to measure activity at different stack elevations. The height of the corresponding video picture is obtained by simply dropping four measuring tapes down the inside wall of the stack at 90 degree angles of each other (east, west, etc...). This allows the camera operator to know his location at any time down the stack and to document any fissures/cracks with polar coordinates. The corresponding cords that operate the video/data acquisition equipment are given a great deal of consideration. Heavy line losses in the data acquisition equipment will eliminate sufficient readings. The mechanism to transport the cords into the stack should be smooth and provide a sufficient angle of deployment so as not to pinch the cords as they go into the stack.

Interior sampling is best accomplished by manned entry. Once again, prior knowledge of stack interior should be obtained to ascertain personnel protective equipment requirements and tools needed to obtain samples. Mathematical techniques can be used here to determine an area, directly across the exhaust inlet, with a high probability of contamination. This technique is described in Appendix 1. Other areas of possible high contamination include the floor where heavy debris/particles fall, and a few feet from the top of the stack where the washing effect of rain has caused the contamination to collect. This washing along with the swirling effect inherent to stacks could cause a buildup of contamination. After these areas have been located, the personnel entering the stack via the clean out port can sample the interior in a timely and cost effective manner using wipe samples and chipping tools. The sampling personnel can also perform coring operations on the stack floor to determine a degree of contaminant penetration into the mortar. If time permits, while some personnel are sampling for activity levels, the testing of several decontamination agents/techniques may be done to gain understanding toward an optimal cleaning method to be used in the future. The coring operations will also take place at several of the mathematically derived locations as well as the higher elevations on the exterior of the stack. The coring operations determine the propagation of contaminants through the mortar and, therefore, yield important data concerning waste generated and resultant structural integrity following decontamination efforts. These cores are bagged out from the coring bit and different bits are used if cross contamination is a concern.

The cored samples must be divided into suitable layers to determine the propagation of contamination through the material. This can be done by using a jewelers table saw. Due to the potential for generating loose contamination, all operations are usually done in a glovebox. In order to minimize the potential of cross contamination from one layer to the other, it is a good practice to change blades between core cuts. To further guarantee the return of good lab results,each layer should be bagged and pulverized before being placed in separate containers en route to the laboratory for analysis.

DEMOBILIZATION OPERATIONS

After the acquisition of cores and samples, the glove box can be decontaminated or discarded depending on the level of contamination. The videography system should be removed from the stack top and lowered via a crane to the ground for disassembly. After the clean out port to the bottom of the stack has been resealed, checks should be made for the presence of contamination around the door. If no contamination exists, the secondary containment can be disassembled taking care to fold the tent in itself and not to generate airborne contamination as the sides are collapsed on each other.

Following this characterization effort, only the lab results remain to consider the job complete. Once these results are obtained, the decision to decontaminate or demolish a stack can be made with current and accurate data obtained in a cost-effective manner.

APPENDIX 1

Mathematical calculations to predict a likely impingement point of particles exhausted into a stack.

Assumptions:

- Exhaust Fan delivers particles at 20 m/s.
- Stack Diameter is 15 m at the inlet and 20 m at the floor.
- The exhaust inlet is located 20 m above the stack floor.
- No stack updraft effect is considered.

Using the Physical relations of a free-falling projectile where,

= x = horizontal distance across the stack diameter (meters)

= y = vertical distance down from the exhaust inlet (meters)

= V_x = Velocity in the x direction (m/s)

= a = gravitational acceleration = 9.81 (m/s^2)

$$x = V_x \times t \qquad \text{(Eq. 1)}$$

$$y = \frac{1}{2} \times a \times t^2 \qquad \text{(Eq. 2)}$$

From Equations (1) and (2) and the assumed values for stack parameters, a horizontal distance can be calculated for the falling particle.

$(Eq.2), y = 20\,m \therefore\ t = 2.0\,s$

$(Eq.1), x = 20 \times 2.0 = 40\,m$

Since the x distance is greater than the largest diameter, the particle must hit the wall at some x and y location. Assuming values for x, several y coordinates can be calculated.

$If\ x = 15\,m, Using\ (Eq.1), t = 0.75\,s \therefore\ Using\ (Eq.2)\ y = 2.75\,m$

$If\ x = 16\,m, Using\ (Eq.1), t = 0.80\,s \therefore\ Using\ (Eq.2) y = 3.13\,m$

$If\ x = 17\,m, Using\ (Eq.1), t = 0.85D\,s \therefore\ Using\ (Eq.2)\ y = 3.50\,m$

$If\ x = 18\,m, Using\ (Eq.1), t = 0.90\,s \therefore\ Using\ (Eq.2)\ y = 4.00\,m$

Graphing these x and y coordinates over the profile of a stack will give the location of impingement. The impingement of the material in the stack walls opposite the duct outlet is a result of material hardness and the relative hardness of the stack inner coating. The particle has a velocity (V_x) and a mass and impinges itself to the stack wall on the microscopic level. An elastic collision between the wall and the particles causes the particles to remain entrained in the wall. An inelastic collision would cause the particles to rebound from the wall where stack effect or gravity would dictate the particle's location.