CONTROL TECHNOLOGY AND EXPOSURE ASSESSMENT FOR OCCUPATIONAL EXPOSURE TO BERYLLIUM: ABRASIVE BLASTING WITH COAL-SLAG

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH), working under an interagency agreement with the Office of Regulatory Analysis of the Occupational Safety and Health Administration (OSHA), conducted a study to survey occupational exposures to beryllium and to document engineering controls and work practices affecting those exposures. The performance of a thorough industrial hygiene survey for a variety of individual employers provides valuable and useful information to the public and employers in the industries included in the work. The principal objectives of this study were:

1. To identify and describe the control technology and work practices in use in operations associated with occupational exposures to beryllium, as well to determine additional controls, work practices, substitute materials, or technology that can further reduce occupational beryllium exposures.

2. To measure full-shift, personal breathing zone, particulate exposures to beryllium. These samples provide examples of exposures to beryllium among workers across the many industries where beryllium is encountered. These exposure data, along with the control data described above, provide a picture of the conditions in the selected industries.

This site visit was conducted on June 21-23, 2004, by NIOSH researchers from the Engineering and Physical Hazards Branch, Division of Applied Research and Technology, in Cincinnati, Ohio.

Occupational exposure to beryllium occurs at places where the chemical is mined, processed, or converted into metal, alloys, and other chemicals. Workers engaged in machining metals containing beryllium, recycling beryllium from scrap alloys, or using beryllium products may also be exposed to higher levels of beryllium. The number of workers exposed to beryllium or beryllium compounds has been estimated to be 21,000 (ATSDR 2002). There is a need to understand the nature of these beryllium exposures, what is causing the exposures, and what steps are being taken or could be taken to reduce the exposures (e.g., engineering controls, work practices, and personal protective equipment).

Beryllium has been reported in mineral slag abrasives, including coal slag (Stettler et al. 1982, NIOSH 1998, Meeker et al. 2006). Stettler et al (1982) reported the results of the analysis of 12 coal slags; 9 contained beryllium, ranging from 7-48 micrograms per gram (μg/g). Meeker et al. (2006) found beryllium in clean coal slag samples, and found task-weighted personal exposures outside of the blasters' personal protective equipment that ranged from 2.5-9.5 micrograms of beryllium per cubic meter of air ($\mu g/m^3$). They reported a geometric mean beryllium exposure of 5 $\mu g/m^3$. NIOSH (1998) evaluated coal slags (including Black Beauty™) with and without the addition of a dust suppressant compound and reported a geometric mean airborne concentration of 2.040 milligrams $(mg)/m^3$ for the entire coal slag category tested.

The OSHA general industry standard sets a permissible exposure limit (PEL) at 2 μg/m^3 for an 8-hour time-weighted average (TWA), or 5 μg/m^3 of beryllium in air, not to exceed 30 minutes at a time (29 CFR 1910.1000). OSHA also requires that workers in general industry should never be exposed to more than 25 μg/m^3 of beryllium in air, regardless of how short the exposure. The OSHA PEL for the construction industry for beryllium and beryllium compounds (as Be) is 0.002 mg/m^3 (2 μg/m^3) as an 8-hour TWA (29 CFR 1926.55). The current NIOSH Recommended Exposure Limit (REL) for beryllium is 0.5 μg/m^3, while the current American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Value (TLV®) is an 8-hr TWA of 2 μg/m^3, and a Short Term Exposure Limit (STEL) of 10 μg/m^3 (NIOSH 1997, ACGIH 2001). The OSHA PEL for the construction industry for particulates not otherwise regulated, total dust organic and inorganic is 15 mg/m^3, 8-hour TWA (29 CFR 1926.55).

Surface sampling is not appropriate for estimating exposures but is useful for evaluating process control and cleanliness and for determining suitability for release of equipment. There are no surface contamination regulations applicable to the use of beryllium in general industry or construction. However, a useful guideline is provided by the U.S. Department of Energy (DOE), where DOE and its contractors are required to conduct routine surface sampling to determine housekeeping conditions wherever beryllium is present in operational areas of DOE/NNSA facilities (10 CFR 850). Those facilities must maintain removable surface contamination levels that do not exceed 3μg/100 cm^2 during non-operational periods (10 CFR 850). The DOE also has release criteria that must be met before beryllium-contaminated equipment or other items can be released to the general public or released for use in a non-beryllium area of a DOE facility. These criteria state that the removable contamination level of equipment or item surfaces does not exceed the higher of 0.2 μg/100 cm^2 or the level of beryllium in the soil in the area of release. Removable contamination is defined as "beryllium contamination that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing" (10 CFR 850).

PROCESS DESCRIPTION AND CONTROL TECHNOLOGY

On June 21-23, 2004, research personnel from NIOSH conducted a site visit at the Annapolis Water Reclamation Facility in Annapolis, MD. The purpose of the study was to identify and describe the control technology and work practices in use during abrasive blasting operations in Secondary Clarifier No. 2, and measure beryllium exposures associated with the use of Black Beauty™ coal slag abrasive. Published reports indicate that coal slag abrasives, such as Black Beauty™, contain beryllium (Stettler et al. 1982, NIOSH 1998, Meeker et al. 2006).

Process Description and Work Practices

Abrasive blasting was conducted inside Secondary Clarifier no. 2, an empty open-top, in-ground circular vessel 110 feet in diameter and approximately 10 feet deep. The abrasive media, Black Beauty™ brand coal slag abrasive, was supplied in 100 pound bags. A helper loaded bags by hand into a blast pot with a capacity of 500 pounds. Compressed air was supplied by an Ingersoll Rand model P375 WJD compressor. The nozzle holder was a Clemco 0578 holder. The nozzle was a number 5 nozzle stamped 10TC5BP. The new steel on the side of the tank was being cleaned of mill scale down to white metal in preparation for painting, part of a tank renovation project.

Personal Protective Equipment

The blaster wore steel-toed shoes, cloth coveralls, leather blasting gloves and a Bullard type CE air-supplied respirator (88 series, Bullard, Cynthiana, Kentucky). See Figure 1. Air was supplied to the respirator from a compressor (Ingersoll Rand, Model P375WJD). The supply hose carrying air to the respirator from the compressor contained a CO alarm (Enmet Corp., Ann Arbor, MI, Model ISA 34 RAL). The blaster's helper wore steel-toed shoes, painter's pants, a T-shirt and a head cloth.

Control Technology

A temporary canvas enclosure had been erected surrounding areas of the tank being blasted, primarily to keep settled particles confined for easier cleanup. See Figure 2. An exhaust blower (Abatement Technologies, Model # H 2000 HP) was attached to the enclosure. The exhaust flow rate was nominally 2000 cfm. The exhaust was directed through a filter before release to the ambient environment. The main purpose of the blower was to clear the air of dust so the blaster could see well enough to perform his job. Although the air exiting the filter contained no visible dust, frequently large plumes of visible dust were released from gaps in the canvas enclosure during the blasting operations, at times, continuously.

CONCLUSIONS AND RECOMMENDATIONS

Although the percentage of beryllium in the fresh abrasive was relatively low, the blaster exceeded the NIOSH REL and OSHA PEL for beryllium in construction on the first day. He exceeded the OSHA PEL for total dust on both days. The respiratory protection worn by the blaster appeared to provide adequate protection from this potential exposure, based upon the assigned protection factor for that type of respirator. The settled dust near the blasting operation contained a lower surface concentration of beryllium than the maximum permitted by the DOE guidelines. Other guidelines for housekeeping in workplaces that use beryllium are available from several sources. In 1999, OSHA issued a Hazard Information Bulletin, Preventing Adverse Health Effects from Exposure to Beryllium on the Job (OSHA 1999). The following housekeeping steps were among the recommendations in that document.

Employers should ensure that employees use the following safe practices to reduce their exposure to beryllium:

- use high-efficiency particulate air (HEPA) vacuums to clean equipment and the floor around their work areas;
- do not leave a film of dust on the floor after the water dries if a wet mop is used to clean;
- do not use long vacuum hoses and do not loop the hoses that are used;
- never use compressed air to clean parts or working surfaces;
- avoid prolonged skin contact with beryllium particulate; and
- do not allow workers to eat, drink, smoke, or apply cosmetics at their work stations.

The above recommendations apply mostly to indoor abrasive blasting. A more thorough coverage of OSHA regulations covering abrasive blasting in construction is available (29 CFR 1926.57)

Also, when abrasive blasting is performed outdoors, in addition to worker protection considerations, U.S. Environmental Administration (EPA) regulations must be observed. Some guidance for EPA compliance can be found in the documents AP 42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.2.6 Abrasive Blasting (EPA 2007) and Emission Factor Documentation for AP-42 Section 13.2.6 (EPA 1997).