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Analytical Performance Criteria

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Sampling and Analysis Issues Relating to the ACGIH Notice of Intended Change for the Beryllium Threshold Limit Value

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INTRODUCTION

Beryllium in various forms is widely used throughout the world in ceramics, aerospace and military applications, electronics, and sports equipment. Workplace exposure to beryllium is a growing industrial hygiene concern due to the potential for development of chronic beryllium disease (CBD), a lung condition with no known cure, in a small percentage of those exposed.¹ There are workplace exposure limits for beryllium that have been in place for several decades.² However, recent studies suggest that the current American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) may not be sufficiently protective for workers who are potentially exposed to airborne beryllium.

Early in 2005, ACGIH issued a Notice of Intended Change (NIC) to the current TLV for beryllium which entails a 100-fold reduction (from 2 to 0.02 micrograms per cubic meter of sampled air).³ It is noted that ACGIH TLVs do not carry legal force in the manner that OSHA PELs or other federal regulations do. Nevertheless, OSHA plans a beryllium rulemaking in the near future, and a reduction in the PEL is anticipated.⁴ Also, if this change in the TLV for beryllium is adopted, it is reasonable to assume that at least some

sampling and analysis activities will need to be modified to address airborne beryllium at the lower levels. There are implications to both the industrial hygiene and the laboratory communities, which are discussed below.

BERYLLIUM LIMIT VALUES

Since 1997, ACGIH and OSHA have had a TLV and PEL, respectively, for beryllium of 2 micrograms per cubic meter of air. The National Institute for Occupational Safety and Health (NIOSH) has a Recommended Exposure Limit (REL) for beryllium of 0.5 $\mu\text{g}/\text{m}^3$. Subsequent studies have indicated that beryllium sensitization and/or CBD can occur at lower exposure levels. In 1999, ACGIH promulgated a NIC to reduce the TLV to 0.2 $\mu\text{g}/\text{m}^3$. Although the proposed change in the TLV was not enacted, the U. S. Department of Energy (DOE) adopted this value as an action level in its Beryllium Rule (10 CFR 850) in January 2000.

The NIC issued earlier this year by ACGIH was based on the results of three studies, most notably a 2001 study by Kelleher et. al.,⁵ which suggested instances of CBD from exposures as low as 0.024 $\mu\text{g}/\text{m}^3$. In addition, ACGIH in its NIC proposed that the TLV apply to the inhalable fraction, rather than to the respirable fraction as is currently the case. As of this writing, ACGIH intended to accept comments on the NIC through July 31, 2005, for consideration at the fall 2005 meeting of the TLV committee.

ACGIH, as a matter of policy, does not consider technical feasibility or economic impacts in determining TLVs. Also, to reiterate, ACGIH does not intend for its TLVs to have regulatory force. However, it should be noted that some federal contractors, particularly at Department of Energy (DOE) sites, are required by contract to comply with ACGIH TLVs. Additionally, OSHA is in the process of a beryllium rulemaking that could possibly be influenced by a change in the ACGIH TLV. Since OSHA has recently announced that some of its inspectors have become sensitized to beryllium, it is reasonable to expect that OSHA may also lower its PEL, which would have regulatory

force. Thus, ACGIH policy notwithstanding, its actions regarding the NIC are likely to have implications for the industrial hygiene and laboratory communities.

SAMPLING ISSUES

In the U.S., the current workplace air sampling convention for compliance measurements entails the use of close-faced sampling cassettes (e.g., through the use of applicable NIOSH and OSHA analytical methods). As larger particles (~50 - 100 microns aerodynamic diameter) are under-sampled by close-faced cassettes,⁶ the performance of these samplers more closely matches respirable fraction of sampled air. A change to inhalable sampling would require the use of different samplers that are designed to collect the inhalable fraction. Such samplers are commercially available and have been used in the U.K. and Germany for compliance monitoring purposes. The use of inhalable samplers is recommended in recently promulgated voluntary consensus standards pertaining to the determination of metals and metalloids in workplace air: ASTM D7035⁷ and ISO 15202-1.⁸

It is also noted that the lower analytical detection limits for beryllium that would be required as a result of a change in the limit value will necessitate longer sampling times for task-based monitoring.

ANALYTICAL TECHNOLOGIES AND OPTIONS

Beryllium samples collected on air filters and other media require a digestion or extraction step prior to analysis. The digestion technique has an impact on the detection limit. For instance, if only water-soluble forms of beryllium are involved, a relatively mild, low-volume digestion technique can be applied. However, for more refractory forms of beryllium such as beryllium oxide, a more robust digestion is required, and this

results in a higher detection limit. Laboratories concerned with such refractory forms of beryllium employ a wide variety of digestion protocols¹¹.

A variety of analytical methods are sufficient for conducting measurements around the current TLV of $2 \mu\text{g}/\text{m}^3$. In the U.S. and Canada, the primary analytical instrument used for these analyses is inductively coupled plasma atomic emission spectroscopy (ICP-AES). In the U.K., graphite furnace atomic absorption spectrometry (GFAAS) is more prevalent. Typically, a laboratory detection limit should be 10% (or below) of an established limit value or action level.⁹ Thus, for a proposed limit value of $0.02 \mu\text{g}/\text{m}^3$, a detection limit of $2 \text{ ng}/\text{m}^3$ would be desired. For water-soluble forms of beryllium, this can be achieved by ICP-AES or GFAAS. However, for beryllium oxide, the required digestion technique does not allow detection limits in the ng/m^3 range (owing to matrix effects). This limitation likely can be overcome by using inductively coupled plasma mass spectroscopy (ICP-MS), which typically has lower detection limits than ICP-AES; however, validation work would be needed to verify this. Most laboratories performing beryllium analyses do not use ICP-MS, which is relatively expensive. Also, while ICP-MS could be used for air filter samples, laboratories may need to retain ICP-AES for other sample matrices (e.g., wipe samples) due to matrix effects. Thus, the economic impact to support analyses with respect to a TLV of $0.02 \mu\text{g}/\text{m}^3$ could be considerable.

A new analytical technique based on fluorescence has recently been developed and shows potential for detection levels in the ng/m^3 range.¹⁰ The fluorescence method is field-portable and is also less expensive than ICP-MS. However, this technique is not yet able to process large numbers of samples quickly, and some additional evaluation of the extraction step is needed for beryllium oxide samples.

CONCLUSIONS

Implementation of a TLV of $0.02 \mu\text{g}/\text{m}^3$ could have considerable impacts in both sampling and laboratory analysis. For these reasons, it is important that any exposure

limit adopted by ACGIH, OSHA, or other agencies and organizations is health-based in consideration of worker protection. Both the industrial hygiene and the laboratory communities should stay informed on the progress of the ACGIH NIC and the OSHA rulemaking.

DISCLAIMER

This column represents the viewpoint of the authors and does not necessarily reflect the position of either DOE or NIOSH.

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