



## Analytical Performance Criteria

Standardized Surface Dust Sampling Methods for Metals, with Emphasis on Beryllium

Kevin Ashley , Geoffrey Braybrooke , Steven D. Jahn , Michael J. Brisson & Kenneth T. White

To cite this article: Kevin Ashley , Geoffrey Braybrooke , Steven D. Jahn , Michael J. Brisson & Kenneth T. White (2009) Analytical Performance Criteria, Journal of Occupational and Environmental Hygiene, 6:12, D97-D100, DOI: [10.1080/15459620903022597](https://doi.org/10.1080/15459620903022597)

To link to this article: <https://doi.org/10.1080/15459620903022597>



Published online: 05 Nov 2009.



Submit your article to this journal [↗](#)



Article views: 137



View related articles [↗](#)



Citing articles: 9 View citing articles [↗](#)

# Analytical Performance Criteria Standardized Surface Dust Sampling Methods for Metals, with Emphasis on Beryllium

---

## INTRODUCTION

Workers may become sensitized to beryllium via dermal contact with beryllium-containing dust.<sup>(1–3)</sup> This exposure route, when coupled with subsequent inhalation exposures to airborne beryllium, has been hypothesized to lead to chronic beryllium disease (CBD).<sup>(2)</sup> In efforts to monitor surface beryllium contamination and prevent dermal exposures due to contact with this highly toxic element, methods are needed for collection of surface dust for subsequent beryllium determination.

Surface contamination regulatory limits at U.S. Department of Energy (DOE) sites have been established by the *Chronic Beryllium Disease Prevention Program Rule*.<sup>(4)</sup> These limits are 0.2  $\mu\text{g}/100\text{ cm}^2$  for release of equipment from a beryllium area and 3  $\mu\text{g}/100\text{ cm}^2$  as a housekeeping limit inside a beryllium area. Surface contamination limits are also under consideration by the U.S. Occupational Safety and Health Administration (OSHA) as part of a proposed rulemaking that is currently in progress.<sup>(5)</sup>

Conformity in methods for sampling and analysis of beryllium from surfaces is desired, but inconsistencies in sampling and analytical practices often occur among industrial hygienists and laboratory personnel, respectively.<sup>(6)</sup> If sampling and analysis methods are not standardized, analytical results from different investigators, locations, or points in time may not be comparable. Variations in sampling practices are of special concern, since the greatest contribution to measurement uncertainty in the overall analysis is ordinarily associated with sampling. Efforts to minimize measurement uncertainty through method standardization have been realized for many workplace toxicants and, as a consequence, standard methods for surface sampling of hazardous substances in workplaces have been promulgated. Standardized protocols for surface and dermal sampling have been produced by governmental agencies, e.g., OSHA and the U.S. National Institute for Occupational Safety and Health (NIOSH), as well as voluntary consensus standards bodies such as ASTM International. An ultimate goal is to provide standard surface sampling methods that will ensure comparability of data obtained from different locations and times.

## SURFACE SAMPLING TECHNIQUES FOR METALS, INCLUDING BERYLLIUM

Some representative surfaces and substrates of interest that are applicable to beryllium sampling include the following:

- Hard/smooth /nonporous surfaces
- Soft/rough/porous substrates

### Column Editor

Kevin Ashley

### Reported by

Kevin Ashley,<sup>1</sup>  
Geoffrey Braybrooke,<sup>2</sup>  
Steven D. Jahn,<sup>3</sup>  
Michael J. Brisson,<sup>3</sup>  
and Kenneth T. White<sup>4</sup>

<sup>1</sup>U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, Ohio

<sup>2</sup>U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland

<sup>3</sup>Savannah River Nuclear Solutions, Aiken, South Carolina

<sup>4</sup>Consultive Services, Virginia Beach, Virginia

This article was prepared by U.S. government employees as part of their official duties and legally may not be copyrighted in the United States of America. Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention, the U.S. Departments of Defense and Energy, or their contractors. The contents and conclusions of this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

- Fragile substrates
- Oily/grossly contaminated surfaces
- Dermal surfaces
- Bulk materials, e.g., soils, accumulated dust

For maximum collection efficiency (and excluding collection of bulk samples), “wet” sampling techniques using wipes are generally preferred.<sup>(7,8)</sup> However, there are instances where wet sampling of certain components and equipment are not desirable and dry sampling techniques are required. As an example, for technical reasons, surfaces of certain materials and components must be protected against damage from the action of wetting agents and/or sample collection; hence, sampling methods that are less aggressive are sometimes required.

For beryllium surface dust sampling, a hierarchy of sample collection methods is recommended. At the outset, when it is determined that surface samples must be obtained, wet wipe sample collection methods should be considered as primary. Such techniques are routinely applicable to smooth, hard, nonporous surfaces and also to dermal sampling. OSHA<sup>(9)</sup> and NIOSH<sup>(10)</sup> methods and ASTM International voluntary consensus standards<sup>(11)</sup> have been published describing wet wipe sample collection (Table I). The use of collection wipes meeting the specifications of ASTM E1792,<sup>(11)</sup> while written to sampling for lead, may be appropriate for beryllium sampling. However, if the surface to be sampled is rough or

porous, and wet wipe sampling is deemed to be impractical, the use of vacuum collection methods should be considered next.<sup>(12)</sup> Only in special cases where the surface to be sampled is energized, fragile, or reactive, and beryllium is the only analyte of interest, is dry wipe sampling an option.

Dermal sampling by use of patch samples or rinsates has been described briefly in OSHA and NIOSH methods; such techniques are presently under further development as voluntary consensus standards within the ASTM International subcommittee on workplace exposure monitoring.<sup>(13)</sup> A tape stripping method (Table I) has also been promulgated by ASTM International, and this technique may be applicable in certain cases. Table I summarizes standardized procedures for wet and dry sampling of metals that have been produced by OSHA, NIOSH, and ASTM International.

### PERFORMANCE DATA FROM COLLECTION OF SURFACE SAMPLES

Some performance data have been published regarding collection efficiencies of the various sample collection methods mentioned above. Wet wipe sampling has been evaluated for the collection of lead oxide dust from smooth, hard surfaces where sample collection efficiencies exceeding 75% were routinely attained.<sup>(14,15)</sup> A comparison of wet vs. dry sampling was carried out on hard, smooth surfaces spiked with beryllium.<sup>(16)</sup> It was found that wet wipe sampling ordinarily

**TABLE I. Standardized Sampling Procedures for Collection of Dust Samples from Surfaces**

Method(s)	Sampling Media/Device	Substrate(s) Sampled	Comments
OSHA ID-125G and ID-206	“Wet” or “dry” filter or wipe	Smooth surfaces, dermal samples	Alcohol wipes widely used
NIOSH 9100 and 9102	“Wet” wipe	Smooth surfaces, dermal samples	Individually packaged wipes preferred
ASTM D6966	“Wet” wipe	Smooth surfaces	Preferred method in most cases; various wetting agents can be used
ASTM E1216	Adhesive tape	Smooth surfaces	Does not collect ultrafines; may damage fragile substrates
OSHA Technical Manual (various)	Patch samples, hand rinsates	Dermal samples	Various protocols; may sample clothing, gloves, etc.
NIOSH 2600, 3601, 9202, and 9205	Patch samples, hand rinsates	Dermal samples	Developed for application to pesticides, metalworking fluids, etc., can extend to metals sampling
ASTM D5438	Modified upright vacuum cleaner	Floors	Sampling from carpets
ASTM D7144	Sampling cassette with collection nozzle	Rough, porous, uneven surfaces; fragile surfaces	“Microvacuum” dust sampling for metals
ASTM D7296	“Dry” wipe	Fragile surfaces	Applicable to beryllium only; special cases

results in a much higher collection efficiency than does sample collection using dry wipes.

In earlier work, a comparison of wipe sampling methods for beryllium was carried out where dry, wet, and alcohol wipe methods were evaluated for their application in removing beryllium-containing dust from painted surfaces.<sup>(17)</sup> This study found alcohol to be most effective for removing beryllium dust from oily surfaces, while dry wipes were least effective for this purpose. These investigations have served to provide necessary backup data in support of the standardized wipe sampling methods for metals, including beryllium, e.g., ASTM D6966 and ASTM D7296.

The ASTM International high-volume vacuum collection method (ASTM D5438) for worn carpeted surfaces has been evaluated using reference material spikes, and good dust collection efficiencies (~80% and greater) have been reported for various types of carpets.<sup>(18)</sup> Previous investigations of this high-volume vacuum collection system on new carpets had also reported effective collection of leaded dust from such substrates.<sup>(19)</sup>

The newer ASTM International low-air volume "micro-vacuum" collection method (ASTM D7144) was recently evaluated,<sup>(20)</sup> and collection efficiencies from a variety of representative substrates were reported based on gravimetric analysis. Although recoveries were, overall, nonquantitative, it was emphasized that standardization of the microvacuum sampling technique should ensure data comparability through harmonization of the sampling device and collection procedure.

However, capture of significant amounts of material within the collection nozzles of the microvacuum samplers was reported.<sup>(20)</sup> This realization will hopefully result in the design and development of improved samplers, where the collection inlet is incorporated into the body of the sampler.<sup>(12)</sup> While removal of material from within the collection nozzles is a possibility, in practice this is difficult to achieve.

Assessment of dermal wipe sampling using different sampling media has been carried out using lead as an analyte.<sup>(21)</sup> Most leaded dust is recovered after sample collection with one wipe, and successive wiping increases overall dust removal from workers' hands. Unfortunately, to date, dermal sampling procedures have not been well standardized, and this has led to difficulties in evaluating and comparing data from a variety of different studies.<sup>(22)</sup> Dermal sampling methods for beryllium need to be harmonized, and this remains an important area for further research and development efforts.

## BULK SAMPLING

Methods for obtaining bulk samples are outside the scope of this article, but they are briefly mentioned here. An excellent source of information on bulk sampling of soils, solid waste, water, field equipment, etc., is the U.S. Environmental Protection Agency (EPA), which has published

an exhaustive tome<sup>(23)</sup> that covers issues such as: (a) sampling strategies and design; (b) sampling techniques, media, and equipment; (c) standardized sampling procedures developed through voluntary consensus (notably ASTM standards); (d) data quality considerations pertaining to sample collection, sample handling, and transport; and (e) numerous related subjects.

A great many relevant ASTM standards on collecting bulk samples have also appeared in ASTM publications on environmental sampling.<sup>(24,25)</sup> Further study is also needed regarding when it is more appropriate to use bulk sampling as opposed to surface sampling for beryllium. Guidelines and performance data are limited in this area.

## SUMMARY

This column highlights available standardized methods that are applicable to surface samples for subsequent metals measurement, notably beryllium. Within the arena of beryllium surface sampling, our goal is to encourage the development of voluntary consensus standards in areas of interest for which such standards are presently unavailable. Methods for beryllium sampling from smooth, hard surfaces are now reasonably well standardized, as evidenced by the availability of relevant ASTM International standards.

Additionally, vacuum sampling methods for collecting dust from rough, porous (and other) surfaces have also been standardized in the form of ASTM International procedures. Bulk sampling methods are also well standardized, and the use of voluntary consensus standards is encouraged. However, dermal sampling methods for metals such as beryllium require better harmonization and evaluation. Efforts are currently under way to fill these gaps.

## ACKNOWLEDGMENTS

We thank the members of ASTM International Committee D22 and the Beryllium Health and Safety Committee (<http://www.sandia.gov/BHSC>) for their continued involvement and support. Critical review by John Snawder and Rob McCleery is gratefully appreciated.

## REFERENCES

1. Berlin, J.M., J.S. Taylor, J.E. Sigel, W.F. Bergfeld, and R.A. Dweik: Beryllium dermatitis. *J. Am. Acad. Dermatol.* 49:939-941 (2003).
2. Tinkle, S.S., J.M. Antonini, B.A. Rich, et al.: Skin as a route of exposure and sensitization in chronic beryllium disease. *Environ. Health Perspect.* 111:1202-1208 (2003).
3. Day, G.A., A. Dufresne, A.B. Stefaniak, et al.: Exposure pathway assessment at a copper-beryllium alloy facility. *Ann. Occup. Hyg.* 51:67-80 (2007).
4. "Chronic Beryllium Disease Prevention Program," *Code of Federal Regulations Title 10*, Part 850. 1999.

5. **U.S. Occupational Safety and Health Administration (OSHA):** *Preliminary Initial Regulatory Flexibility Analysis of the Preliminary Draft Standard for Occupational Exposure to Beryllium*. Washington, D.C.: OSHA, 2007.
6. **Ashley, K., M.J. Brisson, and S.D. Jahn:** Standard methods for beryllium sampling and analysis—Availabilities and needs. *J. ASTM Int.* Vol. 2, Issue 9, 2005.
7. **Lichtenwalner, C.P.:** Evaluation of wipe sampling procedures and elemental surface contamination. *Am. Ind. Hyg. Assoc. J.* 53:657–659 (1992).
8. **McArthur, B.:** Dermal measurement and wipe sampling methods — A review. *Appl. Occup. Environ. Hyg.* 7:599–606 (1992).
9. “OSHA Sampling and Analytical Methods.” [Online] Available at [www.osha.gov/dts/sltc/methods](http://www.osha.gov/dts/sltc/methods) (Accessed March 24, 2009).
10. “NIOSH Manual of Analytical Methods.” [Online] Available at [www.cdc.gov/niosh/nmam](http://www.cdc.gov/niosh/nmam) (Accessed March 23, 2009).
11. **ASTM International:** Website: [www.astm.org](http://www.astm.org) (accessed April 13, 2009).
12. **Creek, K.L., G. Whitney, and K. Ashley:** Vacuum sampling techniques for industrial hygienists, with emphasis on beryllium dust sampling. *J. Environ. Monit.* 8:612–618 (2006).
13. **Ashley, K.:** Analytical performance criteria—Standards activities of the ASTM International committee on atmospheric sampling and analysis. *J. Occup. Environ. Hyg.* 1:D7–D9 (2004).
14. **Chavalitnikul, C., and L. Levin:** A laboratory evaluation of wipe testing based on lead oxide surface contamination. *Am. Ind. Hyg. Assoc. J.* 45:311–317 (1984).
15. **U.S. Environmental Protection Agency (EPA):** *Residential Sampling for Lead: Protocols for Dust and Soil Sampling—Final Report* (EPA 747-R-95-001). Washington, DC: EPA, 1995.
16. **Dufay, S.K., and M. Archuleta:** Comparison of collection efficiencies of sampling methods for removable beryllium surface contamination. *J. Environ. Monit.* 8:630–633 (2006).
17. **Kerr, K.:** “Sampling Beryllium Surface Contamination Using Wet, Dry and Alcohol Wipe Methods.” M.S. thesis, Central Missouri State University, 2004.
18. **Svensden, E., P. Thorne, P. O’Shaughnessy, D. Zimmerman, and S. Reynolds:** House dust collection efficiency of the high volume small surface sampler on worn carpets. *J. Occup. Environ. Hyg.* 3:333–341 (2006).
19. **Environmental Protection Agency (EPA):** *Laboratory Evaluation of Dust and Dust Lead Recoveries for Samplers and Vacuum Cleaners—Vol. 1: Objectives, Methods, and Results* (EPA 747-R-94-004A). Research Triangle Park, N.C.: EPA, 1995.
20. **Ashley, K., G.T. Applegate, T.J. Wise, J.E. Fernback, and M.J. Goldcamp:** Evaluation of a standardized micro-vacuum sampling method for collection of surface dust. *J. Occup. Environ. Hyg.* 4:215–223 (2007).
21. **Boeniger, M.:** A comparison of surface-wipe media for sampling lead on hands. *J. Occup. Environ. Hyg.* 3:428–434 (2006).
22. **Brouwer, D.H., M.F. Boeniger, and J. Van Hemmen:** Hand wash and manual skin wipes. *Ann. Occup. Hyg.* 44:501–510 (2000).
23. **Environmental Protection Agency (EPA):** *RCRA Waste Sampling Draft Technical Guidance—Planning, Implementation and Assessment* (EPA 530-D-02-002). Washington, DC: EPA, 2002.
24. **ASTM International:** *ASTM Standards on Environmental Sampling*, 3<sup>rd</sup> ed. West Conshohocken, Pa.: ASTM International, 2006.
25. **ASTM International:** *ASTM Standards on Environmental Site Characterization*, 3<sup>rd</sup> ed. West Conshohocken, PA: ASTM International, 2006.