THE Ames Laboratory
Creating Materials & Energy Solutions

Alexander H. King, Director

December, 2010

Characterization of Beryllium Contamination at the Ames Laboratory

Dear Ames Laboratory Stakeholders:

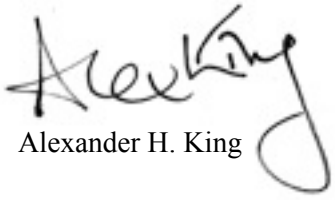
With this letter, we release the 2010 Ames Laboratory Beryllium Survey Report. The primary goal of the Laboratory's characterization effort is to assure the protection of our current workers, the public and the environment. A secondary goal is to better understand and document the extent and level of historical contamination due to research activities during the early years of the Ames Laboratory.

In 2009, we identified beryllium contamination in fume-hood ventilation stacks in Spedding Hall and we issued a news release announcing our discovery. We also undertook extensive sampling and analysis of the fume-hood stacks. Next, we collected samples from work surfaces and collected air samples in rooms where the highest levels of beryllium were found in the fume-hood stacks. We also began monitoring breathing-zone air during sampling, maintenance and remodeling activities. As a result, a research support shop on the 2nd floor of Spedding was closed and remediated after elevated levels of beryllium were identified on the shop's equipment. Potentially affected employees were offered medical testing. Other sampling results indicate that the beryllium contained in the fume-hood stacks does not pose a potential exposure hazard to current employees conducting research and support activities. Also, emission testing indicates the ventilation-stack exhausts do not release beryllium to the environment.

The 2010 survey efforts have yielded a wealth of new information regarding historical contamination. We have identified that recessed trough-like areas at the tops of interior doors in our research facilities are deposition sites that accumulated dust and building contaminants over 50+ years. Analysis of the door-top dust for beryllium content suggests that a fairly wide dispersion of beryllium occurred (most likely in the 1950's and 60's) in Wilhelm Hall and in certain areas of Spedding Hall and Metals Development. These door tops were not accessible to the general workforce or the public, and have now been cleaned. Area air-sampling results and work-area surface characterizations also indicate the exposure potential to current workers, building visitors and the public remains extremely low.

The information gained from the 2010 beryllium survey effort considerably expands our understanding of the level and extent of beryllium contamination in Wilhelm Hall, Spedding Hall and Metals Development. This information is being used to guide cleaning efforts and to provide worker protection during remodeling and maintenance activities in our facilities. The results are being shared with the DOE's Former Worker Program to support former worker medical testing and compensation programs.

Sincerely,



Alexander H. King

2010 Ames Laboratory Beryllium Survey Report

Executive Summary

Ames Laboratory continued characterization and decontamination efforts in its research facilities during 2009 and 2010, and this report details the results as of October 1, 2010. The primary goal of the Laboratory's efforts was the continued assurance of the protection of current workers and the public, with a secondary goal of further documentation of the extent and levels of historical contamination.

Initial characterization efforts focused on fume hood stack sampling in Spedding Hall. The results, based on surface wipe samples, indicated: 20% of stacks below 0.2 μg/100 cm^2 beryllium; 65% of stacks at 0.2 to 3.0 μg/100 cm^2 beryllium; and 15% with greater than 3.0 μg/100 cm^2 beryllium. Characterization of the exhausts from the fume hood stacks from research buildings indicated emissions significantly less than the standard.

All personal and area air sampling results were below detection limits and applicable exposure limits, indicating that no employee exposures occur as the results of current research and support activities, and that current dust control procedures are effective. Respiratory protection was utilized during sampling, remediation, and remodeling activities to provide supplementary protection from dust.

Remediation efforts were conducted in 24-28 Wilhelm Hall, the location of beryllium processing activities during the late 1940's and early 1950's. Remediation included replacement of suspended ceilings and lights, and vacuuming of fixtures. Also, a Spedding Hall research support shop in rooms 237-238 was identified as containing beryllium contamination on some equipment and some elevated room fixtures, such as fume hood ventilation ducts and electrical conduits. Remediation was in progress as of October 1, 2010, and alternative work facilities were established to continue research support.

Survey sampling was conducted in the Spedding Hall auditorium area in anticipation of planned remodeling activities. Beryllium concentrations in bulk samples were similar to beryllium concentrations of local soils.

Cabinet tops in Metals Development were sampled to identify areas where beryllium levels exceeded site soil levels. The areas identified were within known materials processing facilities, and these cabinets were cleaned.

An analysis of recessed areas at the tops of doors, scheduled for replacement as part of a 2010 access control upgrade project in Wilhelm Hall, revealed elevated levels of beryllium. These areas were cleaned and a DOE Occurrence Report was issued to alert other sites of the potential for such recessed areas in doors to accumulate building dust and contamination. Efforts were undertaken to sample door tops in all Ames Laboratory research buildings. Sampling results suggest a fairly wide dispersion of beryllium occurred (most likely in the 1950's and 1960's) in Wilhelm Hall as well as the west end of second floor Spedding Hall and select areas of Metals Development.

The exposure potential to current workers, building visitors, and the public remains extremely low as the contaminated areas are not accessible to the general workforce and the public. The contaminated areas are periodically accessed by crafts people, but appropriate precautions are applied to ensure their safety, and personnel monitoring has confirmed the efficacy of the procedural controls. The Laboratory continues to assess the need for periodic air sampling as sampling and remediation activities are performed and during the performance of remodeling and maintenance activities in areas of known or suspected beryllium contamination.

Additional sampling and decontamination efforts are planned for FY2011, with the goal of furthering the understanding of contamination at Ames Laboratory and ensuring the protection of workers.

Introduction

During 2010, the Ames Laboratory performed sampling and decontamination efforts in Spedding Hall, Wilhelm Hall, and Metals Development. The primary goal of the Laboratory's characterization efforts was the continued assurance of the protection of current workers and the public. An additional interest was further documentation of the extent and levels of historical contamination due to beryllium research activities in the early history of the Ames Laboratory.

The Laboratory's past understanding of the level and extent of beryllium contamination was based on the review of current and historical records, interviews with workers, and survey sampling of facilities. The sampling efforts reported within this report were designed to provide greater understanding of beryllium contamination. Characterization efforts include air, surface, and bulk materials, and reflect lessons learned and practices from other Department of Energy (DOE) sites.

Air sampling consisted of emission sampling from the ganged fume hood stacks exhausts on the Laboratory's research buildings and personal and area air sampling during standard laboratory activities and select dust-generating activities related to sampling, maintenance, and remodeling operations. Surface wipe sampling was performed according to standard practices employing GhostWipe™ and Berylliant™ techniques. A micro vacuum bulk sampling technique and multi-element analysis was employed to assist in the determination of the source of beryllium in building dust.

Statistical analysis was performed with assistance from Iowa State University's Department of Statistics. A release limit of 0.2 µg/100 cm^2 was applied to the results of wipe (surface loaded) samples. A derived site value has been established as 1.47 ppm (parts per million, mg/kg) based on site soils and this value was applied to bulk samples.

Background

In the early 1940's, Iowa State College, now Iowa State University (ISU), participated in a classified research and development effort, known as the Manhattan Project. These efforts produced over one thousand tons of uranium from 1942 to 1945 by a metallothermic reduction process. After the war, other metals were produced in limited quantities, thorium being the next most prevalent in the production process. Beryllium, as beryllia, was used in crucibles, and produced by the reduction of beryllium fluoride.

Early research and some production activities were conducted in the Chemistry Building (Gilman Hall), primarily on the east section of the first and ground floors. Eventually, the production activities were expanded and relocated to a building near the current site of the journalism building (Hamilton Hall), known subsequently as the Physical Chemistry Annex, Chemistry Annex 1, and "Little Ankeny." Little Ankeny was dismantled in 1953, and extensive remediation/renovation was also performed in the impacted areas of Gilman Hall.

In 1947, the Ames Laboratory was established at ISU under the newly formed U.S. Atomic Energy Commission. ISU has operated the Ames Laboratory throughout its existence, currently under a management and operations contract with the Department of Energy (DOE) Office of Science. In the late 1940's, the initial facilities of the Ames Laboratory (Office and Laboratory Building in 1947, Metallurgy in 1949 [Wilhelm Hall], and Research Building in 1953 [Spedding Hall]) were constructed and commissioned. The Metals Development building was added in 1961. The building names imply the general nature of the primary activities performed in these facilities. The Office and Laboratory Building was primarily administrative, Metallurgy included material preparation and foundry-like activities, and the Research Building was more directed to research and bench-scale process development. Discussions with employees from the 1950's confirm that the building names (Metallurgy, Research, and Metals Development) are a general indication of the type of work performed initially in these buildings.

History of Beryllium Contamination at the Ames Laboratory

In 1952, the AEC (Atomic Energy Commission, now DOE) Chicago Operations Office assessed occupational exposure to thorium at Ames Laboratory and conducted a brief study of several beryllium operations. The beryllium results indicated that several of the operations in Wilhelm Hall exposed technicians to concentrations exceeding the AEC maximum concentration for a single exposure by 6 to 8 times. No other surveys were made in other buildings.

Evidence of documented beryllium testing exists from episodic beryllium activities, including limited production of beryllium crucibles, in the 1960's indicate that safety practices, oversight, and monitoring were utilized, with the level of rigor and analytical accuracy available at that time. Discussions with researchers revealed that sporadic research activities with beryllium have taken place since the 1960's and such information was considered in the development of survey sampling plans.

An August 2001 Ames Laboratory Beryllium Survey report details sampling efforts focused on Gilman Hall, (Old) Physics Hall, and Wilhelm Hall. One hundred fifteen surface wipe samples were analyzed, indicating that beryllium concentrations were below the analytical method's detection limit in all accessible public areas. Nine samples collected from restricted access mechanical spaces had beryllium concentrations greater than detection limit, with results ranging from 0.5 µg/100 cm^2 to 9.0 µg/100 cm^2. Warning signs and administrative controls were utilized to provide awareness of the contaminated areas.

Sampling for beryllium was conducted by Ames Laboratory in select Spedding Hall ventilation system exhaust stacks in the fall of 2005. At that time, Ames Laboratory was working with an outside contractor to evaluate a process for lining the fume hood exhaust stacks (via spray application of epoxy) to seal leaks. Beryllium sampling was conducted as a best management practice and to confirm the historical understanding that no significant beryllium work had been done in Spedding Hall. The tops and bottoms of seven stacks (rooms B22, 15, 22, 115, 222, 315, 322) were sampled, and sampling results were reported as being below the analytical detection limit.

In 2008, questions were raised by former employees regarding potential historical beryllium exposure in Spedding Hall as part of the Former Worker Medical Screening Program. The Ames Laboratory corporate knowledge indicated that very little beryllium work was conducted in Spedding Hall and only incidental exposure pathways existed overall at Ames Laboratory. Irrespective of this understanding and in support of the concern for potential exposure of current employees, a beryllium survey was conducted of spaces, such as floor, wall, ceiling, and horizontal work surfaces in representative areas of hallways, shops, and offices in Metals Development, Spedding Hall, TASF, and Wilhelm Hall. The 2008 Beryllium Survey Report documents that the wipe samples had concentrations less than the analytical detection limit of 0.5 µg/100 cm^2.

In 2009, a survey of exhaust stacks in Spedding was performed in preparation for a stack-vent lining project designed to reduce energy loss due to leaking exhaust stacks in Spedding Hall. In April 2009, the bottoms of 29 inactive stacks were surveyed for radiological and beryllium contamination. Some radiological contamination was anticipated, due to historical activities related to uranium and thorium research activities, and in some of the stacks elevated levels of radiological contamination were recorded, mostly as fixed contamination. Results of beryllium wipe tests also indicated levels of beryllium above the analytical detection limits (0.5 µg/100 cm^2) in several of the inactive stacks. This contamination was unexpected due to the historical understanding that beryllium work had been very limited in Spedding Hall and not of the type that would result in residual contamination. Upon identification of the extent and level of beryllium contamination in Spedding Hall stacks, Ames Laboratory leadership initiated actions designed to ensure the protection of employees and the public, and to communicate the concern to its stakeholders. In June 2009, a news release was issued announcing the discovery of beryllium contamination in Spedding Hall fume-hood ventilation stacks, and an Ames Laboratory website was established to provide additional beryllium information.

Release Limits and Derived Background Limit

Title 10 of the U.S. Code of Federal Regulations (CFR), Part 850, Section 850.31(b) (1) sets the removable contamination level for equipment and other items to be released to the general public or for use in DOE non-beryllium work areas at 0.2 μg/100 cm^2 or the concentration level of beryllium in soil at the point of release, whichever is greater.

The DOE draft technical standard, *Management of Items and Areas Containing Low Levels of Beryllium*, established a method of calculating a derived background limit based on the beryllium concentration for soils near the point of release. Twenty-five bulk local soil type samples, obtained through the Iowa State University Agronomy Department, were analyzed for beryllium concentration. The data from these soil samples (shown in the table below) were used to establish a derived background limit for beryllium. For Ames Laboratory, a derived value (based on variation of beryllium concentration in soil) of 1.47 ppm (parts per million, mg/kg) has been established. The release limit of 0.2 μg/100 cm^2 beryllium was applied to the results of wipe (surface loaded) samples and a derived background level of 1.47 ppm beryllium was applied to the results of micro vacuum bulk samples.

A micro vacuum bulk sampling technique and multi-element analysis has been employed to assist in the determination of the source of beryllium in Ames Laboratory building dust. Micro vacuum bulk survey samples were obtained from 10 Iowa State University (ISU) buildings with no known potential for beryllium usage, and the results (shown in the table below) are similar to the Iowa soil results.

	sample size	LCL (95%)	UCL (95%)	Mean	Stdev.	Min	Median	Max
Iowa soils	25	0.47	0.59	0.52	0.154	0.25	0.55	0.94
ISU buildings	30	0.35	0.44	0.39	0.153	0.18	0.38	0.94

LCL = lower confidence limit, UCL = upper confidence limit

A test of significance of the mean of beryllium results from ISU buildings indicates the beryllium results for the ISU buildings are less than beryllium results for Iowa soils.

Spedding Hall Stack Sampling

During 2009 and 2010, additional sampling of Spedding Hall fume-hood ventilation stacks was undertaken. Active and inactive stack vents were characterized for beryllium and radiological contamination. Beryllium sampling was limited to surface wipe techniques. The results of the stack bottom sampling indicated 20% of stacks have beryllium levels below 0.2 μg/100 cm^2, 65% of stacks have beryllium levels at 0.2 to 3.0 μg/100 cm^2 beryllium, and 15% have levels of greater than 3.0 μg/100 cm^2 beryllium, with levels up to 460 μg/100 cm^2. The results of the stack-top sampling indicate 83% of stacks have beryllium levels below 0.2 μg/100 cm^2, 15% of stacks have beryllium levels at 0.2 to 3.0 μg/100 cm^2 beryllium, and 2% have levels greater than 3.0 μg/100 cm^2 beryllium.

Spedding Hall Stack Sampling	Bottom	Top
<0.2 mg/100 cm^2 Be	20%	83%
0.2-3.0 mg/100 cm^2 Be	65%	15%
>3mg/100 cm^2 Be	15%	2%

Surface wipe samples were taken in rooms where stacks had elevated levels of beryllium. Results indicate surface concentrations of beryllium were below detection limits or below the 0.2 µg/100 cm^2 DOE release criteria in the rooms where elevated levels of beryllium were identified in inactive stacks. Air samples were taken in rooms where stacks had elevated levels of beryllium. Results were below the analytical detection limits and OSHA permissible exposure limits.

Multiple surface wipe samples were taken at the top and bottom of inactive stacks with high beryllium concentrations in order to characterize how the contamination may be distributed in the stack. Results indicate beryllium in the lower portion of the stack generally results in beryllium at the top of the stack, but at less surface concentrations. Also at low to moderate levels of beryllium, there is evidence that the contamination is uniformly distributed, but at high levels of contamination at the bottom of the stacks there can be significant variation between sampling locations, especially when an accumulation of dust exists.

Inactive stacks in room 253 and 317 were used to test simple remediation techniques. Both stacks had been surveyed in April 2009. These stacks were reopened, vacuumed and wipe sampled, then wiped with an all-purpose cleaner (*Fantastik*®) and again wipe sampled. The technique showed significant contamination reduction.

Air Sampling

Beryllium sampling and characterization efforts included emission air sampling from the ganged fume-hood stacks exhausts on the Laboratory's research buildings and personal and area sampling within buildings in the vicinity of dust generating activities. Sampling was conducted by an independent contractor to assess beryllium concentrations in emissions from ventilation stacks. Sampling results were compared to an Environmental Protection Agency (EPA) published ambient emission standard for beryllium of 10 grams per 24 hour period. Stack sampling results were well below ambient emission standards (below detection limits) and confirm that no significant concentrations of beryllium are actively being emitted from Ames Laboratory buildings.

Representative air sampling was conducted during select dust-generating activities associated with the beryllium characterization and remediation project, and during remodeling activities, such as a renovation of the heating, ventilation, and air conditioning system on the east end of second floor Spedding Hall. Personal and area sampling was performed to provide assurance of compliance with the permissible exposure limits (PELs) for beryllium (defined in 10 CFR 850 as 2.0 micrograms of beryllium per cubic meter of air) and to confirm that dust control methods were effective.

Beryllium samples were collected using personal sampling pumps connected to 5.0 micron polyvinyl chloride (PVC) filters. Pump flow rates were approximately 2.0 liters per minute and in accordance with the National Institute of Occupational Safety and Health (NIOSH) method 0500. All pumps were pre- and post-calibrated to ensure accurate air flow rates. For personal samples, the filtering media was placed in the breathing zone of the employee by attaching it to the lapel of the shirt. For the area sample, the sampling cassette was generally placed within 10 feet of where work was being conducted. Pumps were worn for the entire duration of the work activity. Sampling media was sent for analysis to ALS Laboratory in Salt Lake City, Utah, a laboratory accredited by the American Industrial Hygiene Association (AIHA).

All personal and area sampling results recorded to date have been below detection limits and applicable exposure limits. Sampling results indicate that no employee exposures have occurred and that dust control procedures have been effective. In addition, respiratory protection has been utilized during sampling, remediation, and remodeling activities to provide supplementary protection from dust. The Laboratory continues to assess the need for periodic air sampling as beryllium characterization and remediation activities are performed and during the performance of remodeling and maintenance activities in areas of known or suspected beryllium contamination.

Remediation of Identified Select Facilities

Several areas were identified as having potential or known beryllium activities. Two such areas include the Wilhelm Hall rooms where beryllium processing took place and a machine shop in 237-238 Spedding Hall.

Wilhelm Hall Beryllium Processing Facility

Survey sampling for beryllium contamination was performed in Wilhelm Hall (WH) in August and early September 2009. GhostWipe™ samples were collected primarily from the tops of hallway walls (above suspended ceilings) and from light fixtures and other deposition sites in areas suspected to have been used for beryllium research and beryllium oxide crucible production during the early years of WH occupancy. The results indicated fixtures in rooms 24, 26, 28, and 30 WH had surface levels with greater than 0.20 μg/100 cm^2 beryllium. The fixtures were not accessible to current research workers.

In October 2009, remediation efforts were undertaken in rooms 24, 26, 28, and 30 WH. Items previously identified with beryllium levels above 0.20 μg/100 cm^2 were cleaned or removed and replaced. Removed items, including the suspended ceiling and light fixtures, were sealed in plastic and transported to the Laboratory's waste facility for further characterization and appropriate disposal. Also, deposition areas in the rooms were vacuumed. Samples were obtained from the interiors of cabinets and work surface, and results were below 0.20 μg/100 cm^2 beryllium. Small black rails were revealed above the suspended ceilings in the combined 24, 26, and 28 rooms. These rails were part of a previous suspended ceiling system. A Berylliant™ surface wipe indicated a beryllium level of 1.00 μg/100 cm^2, and the rails were removed, sealed in plastic and transported to the Laboratory's waste facility.

Bulk samples were taken, according to a micro vacuum bulk procedure, from selected deposition sites in WH rooms 22, 24, 26, and 28, and from drill tailings in a concrete beam in room 30 WH. The results indicated beryllium concentrations greater than the site's derived background level on the tops of cabinets, a rail, and the electrical chase on the south side of the rooms.

Samples were obtained from plastic sheeting used to cover equipment in the rooms during vacuuming and removal of lights and suspended ceilings. Samples were also obtained from the floor during and after remediation activities. Sampling results indicated the plastic sheeting and floors contained less than 0.20 μg/100 cm^2 beryllium, indicating good contamination control during vacuuming and removal of items. Two samples from the top of an electrical chase in room 32 were determined to contain 0.08 and 0.36 μg/100 cm^2 beryllium. The chase was vacuumed and re-sampled with results showing 0.103 and 0.28 μg/100 cm^2 beryllium. The chase was then wet-wiped and re-sampled with results showing 0.04 and 0.07 μg/100 cm^2 beryllium.

Spedding Hall 237-238 Shop Facility

A research support shop facility in 237-238 Spedding Hall (SH) was selected for remediation due to elevated radiological and beryllium contamination levels identified in fume hood ducts during sampling performed in June and September 2009. The stack in 237 was sampled in September 2009 with four GhostWipe™ samples from the bottom ranging between 760 and 5000 μg/100 cm^2 beryllium and two samples from the top indicating 2.1 and 5.7 μg/100 cm^2 beryllium. The debris in the bottom of the room 237 stack was vacuumed, and analysis indicated the debris contained 1300 ppm beryllium.

GhostWipe™ samples were collected in 237-238 SH from a band saw, the south wall, the top of the east cabinet, and the top of a wooden workbench, and the results were below 0.20 μg/100 cm^2 beryllium. Although below the release limit, an attempt was made to further reduce the beryllium level on the band saw by vacuuming and wiping, and a second sampling showed a significant reduction was achieved by the cleaning.

In April 2010, the 237-238 facility underwent several remediation steps, including replacement of overhead lighting fixtures and the fume ventilation duct connected to the stack in 237. Potential deposition surfaces above approximately six feet from the floor were vacuumed and representative bulk and surface wipe samples were taken before and after the vacuuming. Dust collected from the top of the canopy, a table top, the top of the spot welder, and the top of the east cabinet were determined to contain beryllium concentrations above the site limits. Results of dust samples collected from the top of an electrical chase near the ceiling of the room were highly elevated. Cleaning was performed and either reduced the beryllium levels below the release limit or the item was removed from service. The top of the electrical chase was subjected to multiple cleaning attempts without reduction below the release limit, and appropriate postings were established. Additional sampling, cleaning and removal of items was performed. Cleaned items are being utilized in another location, as the 237-238 SH shop remains closed as of October 2010.

Renovation Projects

Several renovation and facility upgrade projects were performed during 2010. A heating, ventilation and air conditioning (HVAC) upgrade project was conducted on the second floor, east end of Spedding Hall, and an access control project was conducted on building exterior and interior doors in the Wilhelm Hall and TASF buildings.

Spedding Hall HVAC Upgrade Project (Second Floor East)

In November 2009, the Ames Laboratory conducted a comprehensive upgrade of the heating, ventilating, and air conditioning (HVAC) system in Spedding Hall. In this upgrade, the zoned reheat distribution system was removed and replaced with a variable air volume distribution system. All work was conducted with concern for control of radiological and beryllium contamination. Beryllium wipe samples from above the suspended ceilings and on ductwork were analyzed and a small portion of the sample results were above the 0.20 μg/100 cm^2 beryllium release limit. Although all micro vacuum bulk sample results were below the site limit, due to the proximity of the work to an area identified as having high beryllium levels (rooms 237-238), extensive personal protection and contamination control practices were employed. Results from a sampling on door tops performed several months later on the east end of second floor confirmed concentrations of beryllium above the site limit in some parts of the work area. The application of safe work protocols included vacuuming and personal protective equipment for craftspeople and air and surface wipe sampling. These practices combined with good project management and communication ensured the protection of workers and control of potential contamination.

Spedding Hall Auditorium Renovation

In May 2010, a sampling effort was undertaken above the ceilings in the areas near and including the Spedding Hall auditorium (rooms 301-305) in preparation for a potential renovation of the Laboratory's conference facilities. Samples were taken from items located above the ceilings. Berylliant™ wipe samples and GhostWipe™ samples were compared to the 0.20 μg/100 cm^2 beryllium limit for surface contamination. Micro

vacuum bulk samples were assessed according to the site limit. A t-test of two means was performed to compare the sampling results from the auditorium area and the Iowa soils. Results suggest that the auditorium beryllium levels are similar to soil beryllium levels.

Access Control Project

During 2010, Ames Laboratory completed a major access control project involving replacement of a significant number of internal and external doors as well as replacement of an existing Marlok system with a programmable card reader system. The project involved preparatory actions (primarily electrical) completed by Ames Laboratory Facilities Services personnel followed by door replacement and card swipe system installation activities performed by contractor personnel. The project entailed significant safety oversight and monitoring efforts to ensure that both Laboratory and contractor personnel were able to complete the project in a safe and healthy manner and to control potential exposures to beryllium contamination.

A thorough review of the project scope and associated work activities was conducted to determine exposure potential to Laboratory or contractor personnel via dust-generating activities (e.g. drilling) in areas with higher than background beryllium contamination. Some of the preparatory actions performed by Laboratory personnel were conducted in contaminated areas and, accordingly, previously-established dust control procedures were followed that included use of personal protective equipment, including respiratory protection (prior air and surface sampling during similar work activities had shown below-detection and below-exposure limit levels of beryllium that confirmed the adequacy of dust control measures). A review of door replacement and card system installation activities planned by contractor personnel concluded that no work activities would be conducted in areas with higher than background beryllium levels. Regardless, hazard communication training was provided to all contractor personnel, which included information on beryllium as well as other potential workplace hazards. In addition to pre-project scrutiny and training, Ames Laboratory personnel provided significant safety oversight during the entire project. Contractor personnel utilized appropriate personal protective devices and engineering controls, including ventilated containments for contaminant control throughout the project.

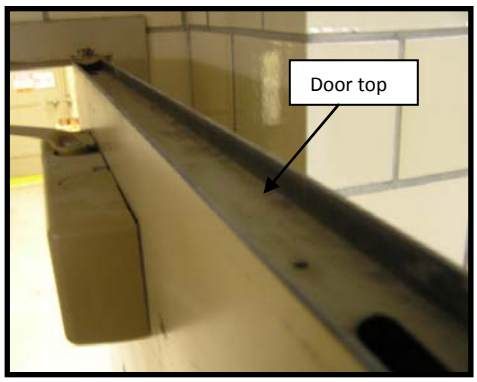
Metals Development Cabinet Tops

Survey sampling of potential deposition sites in Metals Development identified some cabinet tops in materials processing facilities with surface beryllium levels greater than 0.20 $\mu g/100\ cm^2$. All cabinet tops in Metals Development were inventoried and a stratified sampling protocol (judgment-based and random selection) was utilized to identify additional sampling sites. The judgment sites were based on historical knowledge of processing facilities. Wipe samples via Berylliant™ and GhostWipe™ techniques and micro-vacuum bulk samples were collected and analyzed. Results confirmed that the areas of interest were materials processing facilities. The cabinets in areas with elevated levels of beryllium were cleaned.

Door Tops

Ames Laboratory research facilities contain interior doors with trough-like sites on the door tops. These potential deposition sites could have accumulated dust and building contaminates over 50+ years as there is no recorded evidence to indicate these door tops were subject to periodic cleaning. The doors in Wilhelm Hall were surveyed for beryllium contamination, and these doors were removed as part of an access control upgrade of Ames Laboratory facilities. Sampling and cleaning protocol for doors included: a micro-vacuum sampling for determination of beryllium concentration, total vacuuming of the dust, wet wipe washing with all-purpose cleaner (*Fantastik*®), and Ghostwipe™ surface sample for clearance purposes. Additionally, doors in Spedding Hall, and Metals Development were also sampled in order to establish a record of contamination of facilities due

to historical research activities. At the time of preparation of this report, nearly all the interior doors in Wilhelm Hall and Spedding Hall have been sampled, whereas data was only available from doors in select areas of Metals Development.

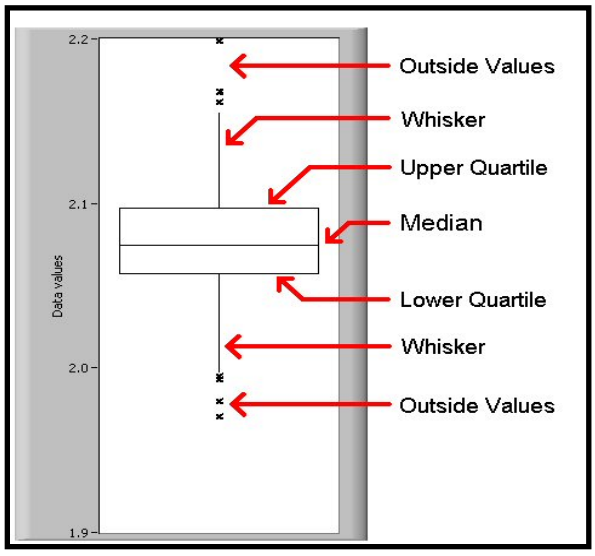


Results of door top samplings are reported as ppm beryllium. Some sample results were reported with limit of quantitation (LOQ) or limit of detection (LOD) notation. For the summary of data presented here, LOQ or LOD marked values are included. The table below lists summary results for Wilhelm Hall, Spedding Hall, and Metals Development. Examination of the median values indicates that in Wilhelm Hall (~3.3 ppm) over half of the values are above the site limit, whereas for Spedding Hall (~0.6 ppm) and Metals Development (1.2 ppm) over half of the values are below the site limit.

Ames Laboratory Research Facilities Door Tops	sample size	LCL 95%	UCL 95%	Mean	Stdev.	Min	Q1	Median	Q3	Max
Wilhelm Hall	137	6.97	12.40	9.08	18.37	0.11	1.35	3.30	7.20	130.00
Spedding Hall	265	1.43	2.15	3.09	14.14	0.01	0.27	0.57	1.40	170.00
Metals Development	53	1.38	2.17	1.71	1.79	0.18	0.78	1.20	1.80	10.00

LCL = lower confidence limit, UCL = upper confidence limit, Q1 = 1st quartile, Q3 = 3rd quartile

Another useful representation of the data is given by examining side-by-side boxplots. Boxplots are useful for determining how the majority of the data are distributed, as well as drawing attention to extreme data. Boxplots in this report are represented in logarithmic scales due to the log-normally distributed data.



The example boxplot shown at the left (figure is from http://zone.ni.com/devzone/cda/tut/p/id/3047) allows a quick review of the five-point summary—minimum, lower quartile (25%), median (50%), upper quartile (75%), and maximum values of data when ordered from the smallest to the largest quantity—and a check of the spread and the skewness of a single data set distribution. The divided rectangle shows the range of the middle 50% (upper quartile – lower quartile) of the data with the divided line representing median. Each whisker extends in both high and low direction as far as 1.5 times the inter-quartile range or to the minimum and maximum value if within 1.5 times the range. The remaining extreme values are marked with an asterisk or a circle.

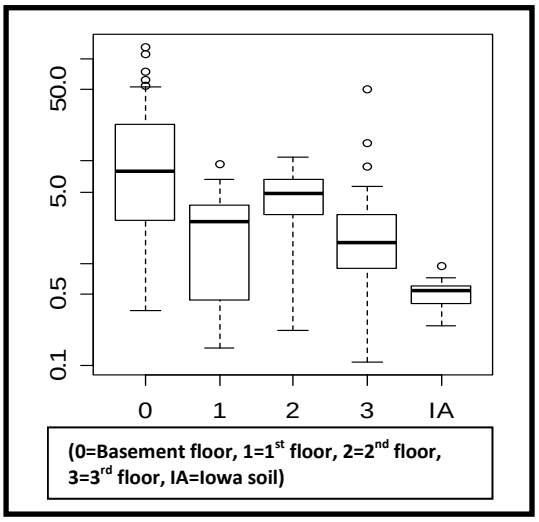
Wilhelm Hall

The following table lists the door top summary statistics for individual floors of Wilhelm Hall. The mean and median values for each floor are above the site limit and the mean value for the basement floor is ~20 ppm.

Wilhelm Hall	sample size	LCL 95%	UCL 95%	Mean	Stdev.	Min	Q1	Median	Q3	Max
All Wilhelm	137	6.97	12.40	9.08	18.37	0.11	1.35	3.30	7.20	130.00
Basement	44	14.58	42.41	20.09	28.59	0.39	3.08	7.90	22.00	130.00
First Floor	28	1.69	5.18	2.33	2.35	0.15	0.41	2.15	3.00	9.30
Second Floor	33	4.24	6.45	4.93	2.51	0.57	3.00	4.90	6.70	11.00
Third Floor	32	2.49	7.14	4.13	8.88	0.11	1.10	1.60	3.50	50.00

LCL = lower confidence limit, UCL = upper confidence limit, Q1 = 1st quartile, Q3 = 3rd quartile

First and third floors of Wilhelm Hall are different from rest of the building in that about half of the data are below 2.15 ppm and three quarters of the data from these two floors are below 3.5 ppm, while the basement and third floors have only one quarter of the data below ~3 ppm. The comparisons of individual floors in Wilhelm Hall versus the Iowa soil samples indicate levels of beryllium above what could be attributed to local soils. This is especially evident for the basement, second, and third floors. First floor Wilhelm Hall historically included a significant number of administrative offices and the data indicates more low values than the other floors. The data from second floor indicates higher levels than the first floor. Results from the basement show the greatest variation in beryllium levels and the highest overall values.



Spedding Hall

Spedding Hall data, as shown in the table below, indicates that mean values for the basement (~1 ppm), ground (~1.1 ppm), first (~0.8 ppm), and third (~0.9 ppm) floors are below the site limit. Also, more than three fourths of the values from these floors are below the site limit. These floors have maximum values ranging from ~4 to ~7 ppm.

Spedding Hall	sample size	LCL 95%	UCL 95%	Mean	Stdev.	Min	Q1	Median	Q3	Max
All Spedding	265	1.43	2.15	3.09	14.14	0.01	0.27	0.57	1.40	170.00
All Spedding, w/o two unusually high values (> 100)	263	1.26	1.83	2.05	7.09	0.01	0.27	0.57	1.40	75.00
Basement	54	0.83	1.58	0.96	0.89	0.06	0.30	0.74	1.28	4.40
Ground floor	42	0.92	2.85	1.07	1.22	0.01	0.17	0.75	1.40	6.30
First floor	54	0.50	0.81	0.66	0.86	0.06	0.26	0.38	0.62	5.10
Second floor	43	7.21	34.96	14.49	33.03	0.06	0.97	1.60	6.60	170.00
Third floor	72	0.66	1.61	0.88	1.27	0.06	0.25	0.42	0.74	6.20

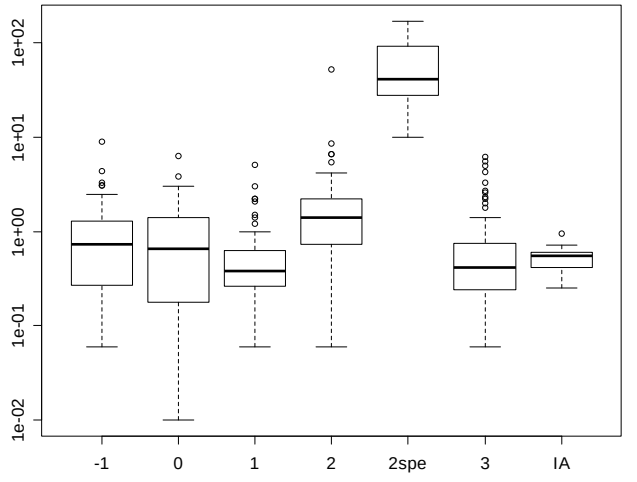
LCL = lower confidence limit, UCL = upper confidence limit, Q1 = 1st quartile, Q3 = 3rd quartile

Further results from second floor Spedding Hall are represented in the table below. The east side of second floor is similar to basement, ground, first, and third floors, but the west side of second floor has an elevated mean (~22 ppm) and a low median (2.7 ppm), indicating a significant influence of high values. Further examination of the data identifies the location of rooms as a special group exhibiting extremely elevated levels of beryllium, including the 237-238 research machine shop facility, adjacent rooms, and rooms across the hallway.

Spedding Hall second floor	sample size	LCL 95%	UCL 95%	Mean	Stdev.	Min	Q1	Median	Q3	Max
Second Floor, East	16	1.18	2.37	1.58	1.25	0.41	0.79	1.35	1.78	5.40
Second Floor, West	27	14.48	217.34	22.15	39.97	0.06	1.25	2.70	28.00	170.00
Second Floor, Special	9	40.61	156.48	61.78	50.30	10.00	30.00	41.50	83.75	170.00
Second Floor, Non-special	34	1.56	3.56	1.98	2.03	0.06	0.67	1.40	2.10	8.60

LCL = lower confidence limit, UCL = upper confidence limit, Q1 = 1st quartile, Q3 = 3rd quartile

The data in the table above and the boxplots at the right show the level of impact from beryllium research activities can be refined beyond the east versus west designation. The second floor special grouping exhibits a minimum level of 10 ppm, a mean of ~62 ppm, a median of ~42 ppm, and a maximum of 170 ppm, indicating an area with high levels of beryllium contamination.



The boxplots for the Spedding Hall basement and ground floor have similar distributions. First and third floor also display similar distributions whose median values are below that of the Iowa soils dataset. The data distribution from the second floor non-special locations is easily separable from the data from the second floor special location. These special locations include rooms 236-239 and 246-249. Surface sampling in and near these rooms identified spots with beryllium levels above 0.20 μg/100 cm^2, mostly on elevated surfaces such as hood and cabinet tops. These locations have been cleaned.

Metals Development

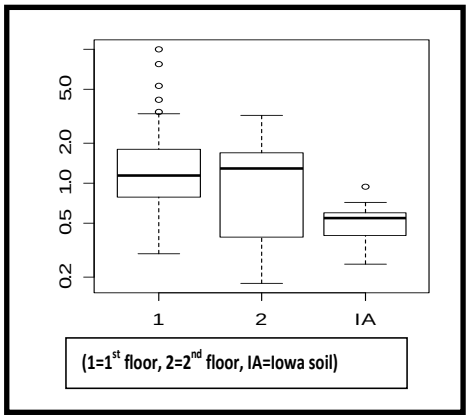
The door-top sampling in Metals Development was on-going at the time this report was prepared. The data consists of 53 samples, 42 from the first floor near or within known material processing laboratories in rooms 131, 135, 150, 187, 190 and 199, and 11 samples from the second floor near processing areas in rooms 290-297.

Metals Development	sample size	LCL 95%	UCL 95%	Mean	Stdev.	Min	Q1	Median	Q3	Max
Metals	53	1.38	2.17	1.71	1.79	0.18	0.78	1.20	1.80	10.00
First floor	42	1.41	2.25	1.81	1.93	0.30	0.80	1.15	1.80	10.00
Second floor	11	0.87	4.06	1.32	1.09	0.18	0.40	1.33	1.70	3.20

CL = lower confidence limit, UCL = upper confidence limit, Q1 = 1st quartile, Q3 = 3rd quartile

Both first and second floors show similar characterization of beryllium distributions. Over half of the values for each floor are below the site limit as indicated by the median values for first floor (1.15 ppm) and second floor (1.33 ppm). The primary difference is in the high values on the first floor. However, there are so few results from the second floor that additional comparisons are not currently useful.

Additional door top sampling has been undertaken in Metals Development and the results should provide additional delineation of the extent of beryllium contamination from materials processing activities.



Conclusions

All personal and area air sampling results indicate that current dust control procedures are effective and that current employees are not subjected to airborne beryllium. The exposure potential to current workers, building visitors, and the public remains extremely low as the contaminated areas are not accessible to the general workforce and the public. The contaminated areas are periodically accessed by crafts people, but appropriate precautions are applied to ensure their safety, and personnel monitoring has confirmed the efficacy of the procedural controls. The Laboratory continues to assess the need for periodic air sampling as beryllium characterization and remediation activities are performed and during the performance of remodeling and maintenance activities in areas of known or suspected beryllium contamination.

Sampling results, primarily from the tops of doors in research buildings, suggest a fairly wide dispersion of airborne beryllium occurred in Wilhelm Hall as well as the west end of second floor Spedding Hall and select areas of Metals Development. Testing also indicates historical airborne dispersion resulted in surface concentrations marginally above background levels in additional areas of Spedding Hall and Metals Development.

Although fume-hood stack sampling results from Spedding Hall indicate levels above the 0.2 $\mu g/100\ cm^2$ beryllium limit for items being released to the public, these stacks are designed to remove contaminants from the workplace, and are not accessible to workers. Results of stack exhaust air sampling from the Laboratory's research buildings indicate that the tested sources emit significantly less than the emission standard.

Remediation efforts were conducted in 24-28 Wilhelm Hall, the location of beryllium processing activities during the late 1940's and early 1950's. Remediation included replacement of suspended ceilings and lights, and vacuuming of fixtures. Also, a Spedding Hall research support shop in rooms 237-238 was identified as containing beryllium contamination on some equipment and some elevated room fixtures, such as fume hood ventilation ducts and electrical conduits.

Survey sampling was conducted in the Spedding Hall auditorium area in anticipation of remodeling activities, and concentrations in bulk samples were similar to beryllium concentrations of local soils. Also, cabinet tops in Metals Development were cleaned where sampling results revealed beryllium levels above site soil levels.