

Health Consultation

Brush Ceramic Products

Evaluation of Beryllium Exposure

Tucson, Pima County, Arizona

EPA Facility ID: AZD037612702

August 8, 2005

Prepared by

**Arizona Department of Health Services
Office of Environmental Health
Environmental Health Consultation Services**

Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Purpose

The officials of Sunnyside High School District and a United States Representative have expressed great concerns regarding the potential adverse health effects due to beryllium exposure in the vicinity of Brush Ceramic Products. Thus, the Pima County Department of Environmental Quality (PDEQ) and the Arizona Department of Environmental Quality (ADEQ) requested the Arizona Department of Health Services to determine whether beryllium released from Brush Ceramic's plant poses a health threat to school children and employees, and residents in the vicinity of the facility.

Background and Statement of Issues

Brush Ceramic Products facility, located at 6100 South Tucson Boulevard, Tucson, Arizona, has produced beryllium oxide ceramic components since 1980. Beryllium is a hard, grayish metal naturally found in mineral rocks, coal, soil, and volcanic dust. Beryllium oxide is made from beryllium ores and is used to make specialty ceramics for electrical and high technology applications (ATSDR 2002; Kolanz 2001).

Some people exposed to beryllium may develop a sensitization to the metal, which may lead to an allergic response. Some sensitized individuals may develop an inflammatory reaction in the respiratory system. That is called chronic beryllium disease (CBD). Long-term inhalation of beryllium can increase the risk of developing lung cancer in people.

There are six schools (about 5,612 students) within a half-mile from the Brush Ceramic Products facility. As a result of development, the land directly north of the Brush Ceramic Products is now a residential area, which will have over 600 homes as shown in Figure 1.

Discussion

The Arizona Department of Health Services assessed the potential health effects due to beryllium exposure by comparing the average concentrations to various health-based reference values developed by the Agency for Toxic Substances and Disease Registry (ATSDR), the Arizona Department of Health Services, and the U.S. EPA (United States Environmental Protection Agency). These health-based reference values are conservatively developed based on the most sensitive receptors (e.g., children). They are screening values used in the public health assessment process to determine if the contaminants are present in the environment at levels that warrant future evaluation. The conclusion that a contaminant exceeds a health-based reference value does not mean that the contaminant will cause adverse health effects, but rather there is a need for a more thorough, contaminant-specific investigation. Environmental concentration below a health-based reference value is unlikely to cause adverse health effects regardless of exposure duration.

The Arizona Department of Health Services used average concentrations to evaluate the potential health effects because they are most representative of the concentration that would be contacted at a site, over time. For example, if we assume that an exposed individual moves randomly across an exposure area, the spatially averaged soil

concentration can be used to estimate the true average concentration contacted over time. In this example, the average concentration contacted over time would equal the spatially averaged concentration over the exposure area. While an individual may not actually exhibit a truly random pattern of movement across an exposure area, the assumption of equal time spent in different parts of the area is a reasonable approach.

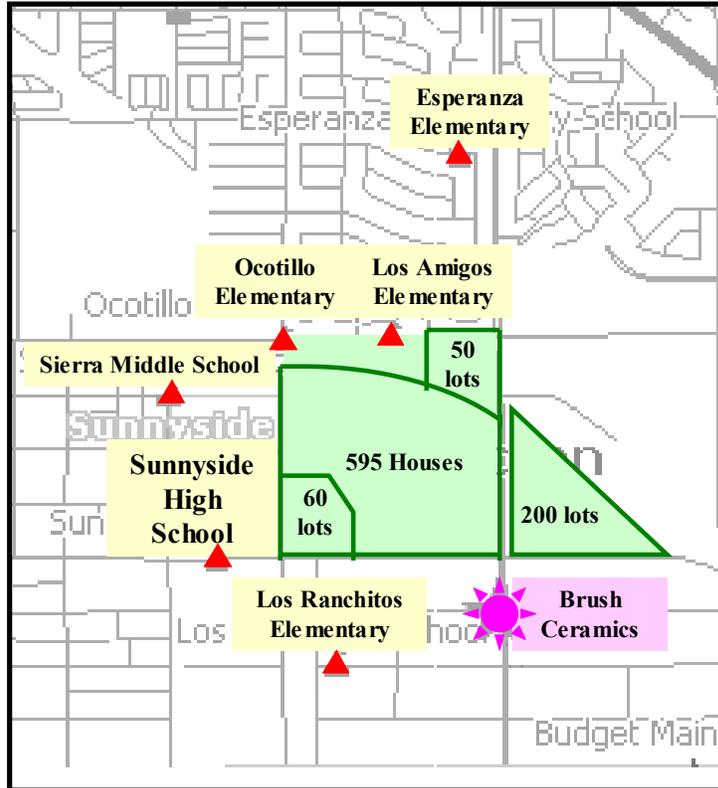


Figure 1. Brush Ceramic Products and surrounding area.

Brush Ceramic Products is located at 6100 S. Tucson Boulevard, Tucson, AZ. There are six schools within a half-mile from Brush Ceramic Products. Pink Sun indicates Brush Ceramic Products; Red triangles indicate schools; Green area is the location of future subdivisions.

Soil Data

In 1999, the Pima County Health Department (PCHD) investigated the beryllium concentrations in soil around Brush Ceramic Products facility. This sampling event was concentrated within a boundary (radius = 0.25 mile = 1320 feet, centered at Brush Ceramic Products) based on the air quality modeling results performed by the ADEQ. The air quality modeling results indicated that the largest amount of beryllium would fall within 450 – 510 feet of the emissions stack at the facility.

In 2000, the Sunnyside High School District conducted another investigation. The selected soil sampling locations could have increased beryllium concentrations based on the occurrence of a prevailing morning northwest wind pattern over the Brush Ceramic

Products. The sampling locations include children's playgrounds, busy sidewalks and soils adjacent to roof drains. Table 1 shows the average beryllium concentrations in soil samples collected in 1999 and 2000. The measured beryllium concentrations in soils ranged from 0.31 to 0.94 milligrams per kilogram (mg/kg) for 1999 samples and from 0.17 to 1.2 mg/kg for 2000 samples.

The average beryllium soil concentrations were compared to ATSDR's chronic (long-term) Comparison Values (CVs) for beryllium in soil, Arizona Soil Remediation Levels (SRLs) for beryllium in residential areas, and U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) for beryllium in residential areas. Arizona SRLs are developed by the Arizona Department of Health Services. These values are developed to provide health protection of human exposure, over a lifetime. Table 1 indicates that the average beryllium concentrations in soils sampled at various locations are lower than ATSDR's soil CV, Arizona's SRL and U.S. EPA Region 9's PRG for beryllium.

In 1999, two beryllium soil measurements exceeded the Arizona residential SRL for beryllium of 1.4 mg/kg. These samples were collected within a circle centered at Brush Ceramic Products (radius = 530 ft) and the measured concentrations were 1.9 and 3.0 mg/kg. Many years ago, the U.S. EPA listed beryllium as a carcinogen through the ingestion pathway. However, more studies showed that animals do not get cancer from ingestion of beryllium. Because of these findings, the U.S. EPA reevaluated its past classification and amended this classification in 1998. The Arizona SRLs were published in 1997 and have not been updated since then. The Arizona SRL for beryllium was developed based on the past classification of U.S. EPA (i.e., beryllium is a carcinogen through ingestion). As a result, the Arizona SRL overestimates the health risk posed by beryllium through ingestion. The Arizona Department of Health Services determined that these two soil measurements do not need further evaluation since they are far lower than the ATSDR's soil CV and the U.S. EPA Region 9 PRG for beryllium.

The representatives of the Sunnyside School District would like to know (1) a method to differentiate industrial beryllium sources from the naturally occurring beryllium sources and (2) the background beryllium concentration in soil within this area. The Arizona Department Health Services spoke with Mr. Jason Mihalic (Public Health Scientist III, Office of Environmental and Analytical Chemistry, Arizona Department of Health Services, Phoenix, AZ). He indicated that sometimes one can identify and compare isotopic ratios of an element to differentiate source A (industrial) from source B (natural). Unfortunately, beryllium has only one naturally occurring isotope, Be9. This means that Beryllium emissions from Brush Ceramic will contain only Be9, just as the natural soil contains only Be9, thus making it impossible to distinguish between possible industrial sources and natural background sources by isotopic ratio analysis. Dr. Eric Betterton (Professor, Department of Atmospheric Sciences, University of Arizona, Tucson, AZ) agreed with above statement at the Brush Ceramics Meeting on May 16, 2005.

Isotopes are different forms of a single element, which cannot be broken down into simpler components by any non-nuclear chemical reaction. For example, carbon 12 and carbon 14 are both isotopes of carbon. The ratio of carbon 12 and carbon 14 (C12/C14) is called isotopic ratio.

The ADEQ and the United States Geological Survey (USGS) investigated the background concentrations of metals in Arizona soils. Their report indicated that the beryllium concentrations in Arizona soil ranged from 5 mg/kg to non-detected, and the average beryllium concentration in soil is 0.52 mg/kg (ADEQ 1991). Three soil samples were taken from Pima County. They were located at 1 mile east of Ajo (non-detected), 2 miles west of Quijotoa (non-detected), and Robles Junction (1.5 mg/kg). The average beryllium concentration of these three locations was 0.5 mg/kg. That is similar to the average background beryllium concentrations in soil around the Brush Ceramic Products. The average background beryllium concentration in soil was 0.69 mg/kg for 1999 soil samples and 0.61 mg/kg for 2000 soil samples.

Table 1. Measured beryllium concentrations in soils in milligrams per kilogram (mg/kg) compared to reference or screening values.

Sampling Location	Year	Average beryllium concentration in soil	Number of samples	Does it exceed ATSDR Comparison Values (CVs)?		Does it exceed Arizona Soil Remediation Levels (SRLs)?	Does it exceed USEPA Region 9 Preliminary Remediation Goals (PRGs)?
				Child	Adult	Residential	Residential
				100 (mg/kg)	1,000 (mg/kg)	1.4 (mg/kg)	150 (mg/kg)
Immediately adjacent to Brush Ceramics Products	1999	0.77	5	No	No	No	No
Within a circle centered at Brush Ceramics Products (radius = 530 ft)	1999	1.05	17	No	No	No	No
Within a circle centered at Brush Ceramics Products (radius = 0.25 mile)	1999	0.69	8	No	No	No	No
Sunnyside High School	2000	0.40	4	No	No	No	No
Los Amingo Elementray School	2000	0.44	4	No	No	No	No
Los Ranchitos Elementary School	2000	0.54	4	No	No	No	No
Fred Bull Asminstration Building	2000	0.72	4	No	No	No	No
Esperanza Elementary School	2000	0.83	4	No	No	No	No

Air Monitoring Data

To measure the levels of beryllium in outdoor air, or in the air that people breathe, the Sunnyside School District conducted an ambient air-monitoring program from November 19, 2002 to March 31, 2005. The Sunnyside School District personnel determined the sampling locations and schedule, and conducted the onsite monitoring. Chester LabNet performed the gravimetric and beryllium filter analyses.

The monitoring system consists of four Tisch Critical Flow High-Volume PM₁₀ samplers, which are U.S. EPA Reference Method samplers, installed at four locations surrounding the Brush Ceramic Products. Figure 2 shows the locations of the Sunnyside Air Monitoring Sites No.1, No.2, No.3 and No. 4. Two of the sampler inlets were located 2 meters above the ground and two sampler inlets were located approximately 10 meters above the ground. Monitoring was conducted on an every 6-day schedule for all four sites.

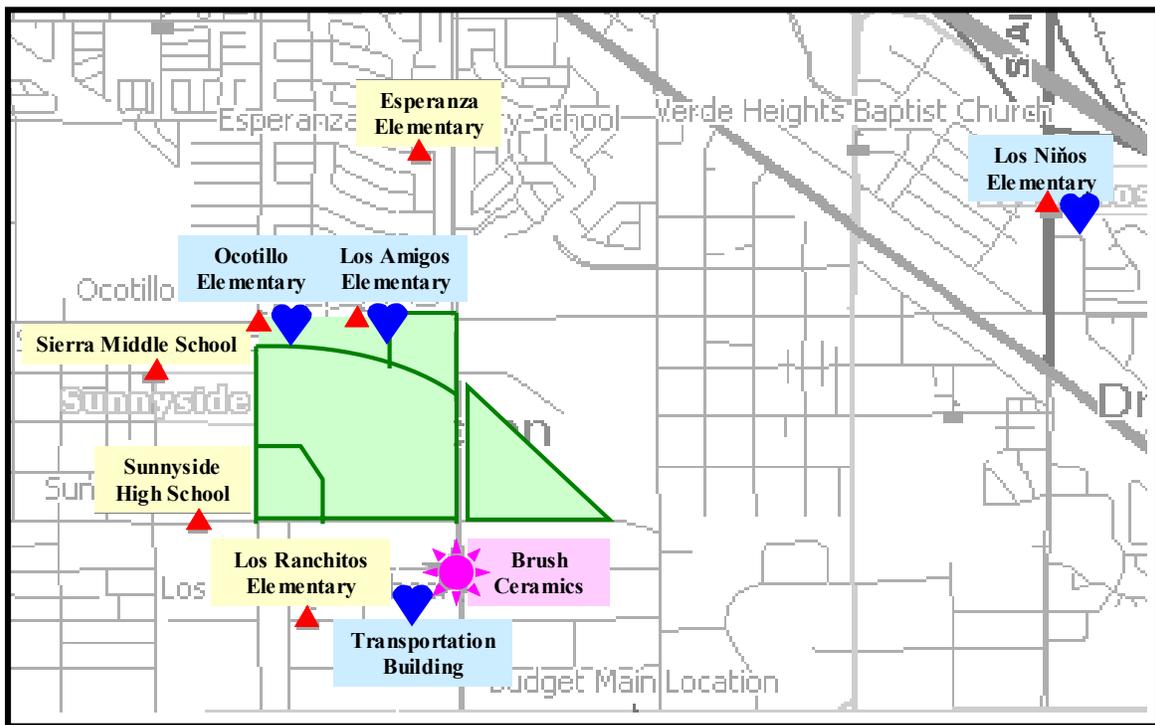


Figure 2. Air monitoring stations and the surrounding area.

The four air monitoring locations are Site No. 1: Transportation Building; Site No. 2: Los Niños Elementary School; Site No. 3: Los Amigo Elementary School; and Site No. 4: Ocotillo Elementary School. Blue hearts indicate the air monitoring stations; Red triangles indicate schools; Pink sun indicates Brush Ceramic Products.

Table 2 summarizes the average beryllium concentration in ambient air from November 19, 2002, to March 31, 2005. The measured beryllium concentrations in ambient air ranged from 0.0000038 to 0.0003087 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). The Arizona

Department of Health Services compared the average beryllium concentrations in ambient air to ATSDR’s Cancer Risk Evaluation Guides (CREGs), Arizona Ambient Air Quality Guidelines (AAAQGs) and National Emission Standard for beryllium. The ATSDR developed CREGs, which are used to identify concentrations of cancer-causing substances in specific media are unlikely to result in an increase of cancer rates in an exposed population. Arizona Ambient Air Quality Guidelines (AAAQGs) are developed by the Arizona Department of Health Services. AAAQGs are screening values that are protective of human health, including children, over a lifetime. The results in Table 2 indicate that the average beryllium concentrations in ambient air at various locations are far lower than the reference or screening values.

Table 2. Measured beryllium concentrations in ambient air in microgram per cubic meter ($\mu\text{g}/\text{m}^3$) compared to reference or screening values.

Sampling Location	Site ID	Year	Number of samples	Average beryllium concentration in ambient air	Does it exceed ATSDR cancer risk evaluation guide (CREG)?	Does it exceed Arizona Ambient Air Quality Guidelines (AAAQG)?			Does it exceed National Emission Standards?
						1-hour	24-hour	Annual	30-day
Standards				$\mu\text{g}/\text{m}^3$	0.0004 $(\mu\text{g}/\text{m}^3)$	0.06 $(\mu\text{g}/\text{m}^3)$	0.16 $(\mu\text{g}/\text{m}^3)$	0.00042 $(\mu\text{g}/\text{m}^3)$	0.01 $(\mu\text{g}/\text{m}^3)$
Transporation Building	1	2002	7	0.000013	No	No	No	No	No
		2003	54	0.000028	No	No	No	No	No
		2004	49	0.000020	No	No	No	No	No
		2005	13	0.000008	No	No	No	No	No
Los Niños Elementary School	2	2002	7	0.000013	No	No	No	No	No
		2003	51	0.000028	No	No	No	No	No
		2004	45	0.000018	No	No	No	No	No
		2005	11	0.000008	No	No	No	No	No
Los Amingo Elementray School	3	2002	7	0.000014	No	No	No	No	No
		2003	53	0.000027	No	No	No	No	No
		2004	42	0.000024	No	No	No	No	No
		2005	11	0.000008	No	No	No	No	No
Ocotillo Elementary School	4	2002	7	0.000015	No	No	No	No	No
		2003	55	0.000031	No	No	No	No	No
		2004	48	0.000026	No	No	No	No	No
		2005	11	0.000009	No	No	No	No	No
Sample Blanks		2002	NA	NA					
		2003	14	0.000005					
		2004	9	0.000008					
		2005	1	0.000008					

NA: Not Available

Stack Emission Data

Brush Ceramic Products performed stack emission tests quarterly. The stack tests were conducted by an independent company with a protocol developed by Brush Ceramic Products and approved by the PDEQ. Table 3 summarizes the stack emissions test results from May 23, 2001 to December 16, 2004.

To protect the community from chronic beryllium disease, the U.S. EPA National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulation limits the amount of beryllium that plants can emit into the environment to either less than 10 grams in a 24-hour period, or to an amount that would give air levels of 0.01 micrograms beryllium per cubic meter of air ($\mu\text{g Be}/\text{m}^3$ air) near the source, averaged over a 30-day period (40 CFR 61.32). Brush Ceramic Products is regulated under this limit. Results in Table 3 indicate that the amount of beryllium released from stacks from 2001 to 2004 did not exceed the regulatory permit. That is, the stack emissions were an order of magnitude lower than the NESHAP standard.

Table 3. The amount of beryllium released from emission stacks to the ambient air per day compared to the National Emission Standard for Hazardous Air Pollutants (NESHAP).

Date	Location	Number of samples	g Be/day ^a	Does it exceed NESHAP ^b ?
05/23/01	Vent # 1	3	< 0.037	No
05/23/01	Vent # 3	3	< 0.038	No
05/23/01	Vent # 7	3	< 0.023	No
05/23/01	Exhaust Duct # 8	3	< 0.040	No
05/23/01	Vent # 12	3	< 0.005	No
05/29/01	Baghouse Stack	3	< 0.240	No
01/14/02	Baghouse Stack	3	< 0.251	No
04/18/02	Baghouse Stack	3	< 0.253	No
08/12/02	Baghouse Stack	3	< 0.245	No
11/18/02	Baghouse Stack	3	< 0.012	No
03/20/03	Baghouse Stack	3	< 1.588	No
06/30/03	Baghouse Stack	3	< 0.099	No
09/29/03	Baghouse Stack	3	< 0.094	No
12/18/03	Baghouse Stack	3	< 0.100	No
03/16/04	Baghouse Stack	3	< 0.100	No
06/10/04	Baghouse Stack	3	< 0.100	No
09/09/04	Baghouse Stack	3	< 0.100	No
12/16/04	Baghouse Stack	3	< 0.100	No

a. Be: Beryllium

b. NESHAP = National Emission Standard for Hazardous Air Pollutants

The current NESHAP for beryllium is 10 gram per day (g/day).

Surface Wipe Data

The Sunnyside High School District personnel took numerous surface wipe samples from various locations from December 2004 to April 2005. The results show that the amount of beryllium at different surfaces ranged from 0.00002 to 0.01052 micrograms beryllium per square centimeter (μg beryllium/ cm^2). Three surface wipe measurements exceeded the house keeping contamination limits established by the United States Department of Energy (DOE) (10 CFR 850.31). The Sunnyside High School District representatives have expressed their concern about the surface wipe results, and the probability for school students and employees to breathe in the beryllium particles that may be re-suspended from the surfaces.

In response to cases of chronic beryllium disease occurring at DOE facilities, DOE promulgated a Chronic Beryllium Disease Prevention regulation (10 CFR Part 850). As part of this program, DOE established surface contamination limits. Removable, i.e. loose, beryllium contamination must not exceed 3 micrograms beryllium per hundred-square centimeter (μg beryllium/ 100 cm^2) during non-operation periods. The requirement is intended to limit the spread of beryllium contamination and to assess the adequacy of housekeeping measures. Prior to releasing any equipment from designated beryllium work areas, the levels of removable beryllium must be below 0.1 μg beryllium/ 100 cm^2 .

To obtain specific background information of these three wipe samples, the Arizona Department of Health Services contacted the Sunnyside High School District representative, Mr. Gene Repola. The information listed below indicates that the dusts are accumulations over 15 years, and the students and employees only have limited access to these locations.

“The SSHS/ADM sample was taken in the attic space above the hallway, no student access only employees if they need to work on air handlers.

Warehouse ductwork sample was taken form the dirt and grime that was vacuumed from with in the ductwork that has built up in the ductwork for about 17 years, no access by employees.

Custodial supply closet sample was taken form above a lighting fixture that does not receive cleaning in a room that is 19 years old. Only employees have access to area maybe a child once in a while if they walked thru with an employee.” (Mr. Gene Repola, personal communication via e-mail, May 26, 2005)

In addition to stack emissions, background level of beryllium in soil could account for some of the beryllium detected in wipe samples. The average background beryllium concentration in soil was 0.69 milligrams per kilogram (mg/kg) for 1999 soil samples and 0.61 milligrams per kilogram (mg/kg) for 2000 soil samples.

A number of authors (McArthur 1992, Klingner 1994, Lichtenwalner 1992) have found that surface wipe sampling lacks the precision required for regulatory purposes. It is not highly reproducible, not completely efficient in removing material, and shows variable

recovery from different surfaces. After an extensive review of the literature and survey of industrial hygienists, Caplan (1993) made the assertion that “the wipe sample procedure seems to be increasingly misused as an indicator of health hazard from particulate aerosols.” He concluded “there is no general quantitative relationship between surface contamination and air concentration that is adequate for estimating inhalation dose with sufficient accuracy for use in Industrial Hygiene.”

Since the surface wipe data alone cannot be used to measure exposure or demonstrate regulatory compliance (Herr 1997), the Arizona Department of Health Services combined the soil, ambient air and stack emission results to evaluate the potential health risk posed by the surface wipe samples. Based on the beryllium concentrations in soil, ambient air, stack emission and wipe samples; the Arizona Department of Health Services determined that the school students and employees are unlikely to inhale beryllium particles that may be re-suspended from surfaces because their access to these locations are limited.

Limitations

There are many sources of uncertainty of risk analysis. The objective of this health consultation is to determine whether beryllium released from Brush Ceramic Products are present at levels that may cause adverse health effects. This health consultation is a screening level analysis of health risks, meaning that the report uses a conservative (or upper-bound) analysis.

The average air concentrations used in this health consultation are from the air monitoring stations located at Transportation Building, Los Niño’s Elementary School, Los Amigo Elementary School, and Ocotillo Elementary School. Thus, the average air concentrations used in this health consultation may not fully represent the environmental conditions directly north of the Brush Ceramic Products facility, which will be a subdivision with more than 600 houses. In addition, it cannot be used to predict potential health risk due to emergency situations, such as accidental release of beryllium from the facility.

ATSDR Child Health Initiative

ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contaminants in environmental media. Children’s developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Children breathe a greater volume of air and ingest a larger amount of soil relative to body weight, resulting in higher burden of pollutants. Furthermore, children, even those without pre-existing illness or chronic conditions, are susceptible to air pollution because their lungs are still developing, and they often engage in vigorous outdoor activities, making them more sensitive to pollution than healthy adults. All health analyses in this report take into consideration the unique vulnerability of children. Children will not be adversely affected by the levels of beryllium found at the Brush Ceramic Products site or adjacent area.

Conclusions

The Arizona Department of Health Services has classified the Brush Ceramic Products site as “No Apparent Public Health Hazard.” This classification is based upon the following conclusions:

- Some beryllium present in the environment, including soil and ambient air.
- Exposures to both site related and naturally occurring beryllium are not at levels likely to cause adverse health effects, even to children and sensitive populations.
- Because exposures are very low, the site does not pose a public health hazard.

If further information becomes available, the Arizona Department of Health Services will evaluate it and update conclusions as necessary.

Recommendations

- If additional wipe samples are taken, they should be taken at locations where people frequent on a regular basis, such as classrooms and the lunchrooms.
- All duct works should be professionally cleaned regularly.
- Inform school students and employees, and residents, including the new housing subdivision, what is known about the relationship between exposure and chronic beryllium disease.
- Educate school students and employees, and residents, including the new housing subdivision, how to respond during emergency situations.

Public Health Action Plan

The Arizona Department of Health Services staff will attend community meetings to communicate the results of this consultation. The Arizona Department of Health Services will gather community concerns and answer any additional questions that community members have.

The Arizona Department of Health Services staff will help the PDEQ and the PCHD to develop health education materials for school student, employees and residents.

References

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for beryllium. Atlanta: US Department of Health and Human Services: 2002 Sep. Report No: TP-02-09

Kolanz, M. Introduction to beryllium: uses, regulatory history, and disease. Applied Occupational and Environmental Hygiene. 2001 Vol. 16: 559-67.

Arizona Department of Environmental Quality (ADEQ). Evaluation of background metals concentrations in Arizona Soils. Phoenix, Arizona, 1991 June.

McArthur, B. Dermal measurement and wipe sampling methods: a review. *Applied Occupational and Environmental Hygiene*. 1992 Vol. 7: 599-606

Klingner, T.D., McCorkle, T. The application and significance of Wipe Samples. *American Industrial Hygiene Association Journal*. 1994 Vol. 55: 251-254

Lichtenwalner, C.P. Evaluation of wipe sampling procedures and elemental surface contamination. *American Industrial Hygiene Association Journal*. 1992 Vol. 53: 657-659

Caplan, K.J. The significance of Wipe Samples. *American Industrial Hygiene Association Journal*. 1993 Vol. 54: 70-75

Herr, M. Defense Programs: Beryllium Good Practice Guide. United States Department of Energy and Lawrence Livermore National Laboratory. 1997 July.

Prepared by

Hsin-I Lin, ScD
Program Manager, Office of Environmental Health
Bureau of Epidemiology and Disease Control
Arizona Department of Health Services

Don Herrington, Principle Investigator
Chief, Office of Environmental Health
Bureau of Epidemiology and Disease Control
Arizona Department of Health Services

ATSDR Regional Representative

Gwen Eng
Office of Regional Operations, Region IX
Office of the Assistant Administrator

ATSDR Technical Project Officer

Charisse J. Walcott
Division of Health Assessment and Consultation
Superfund Site Assessment Branch
State Programs Section

Certification

The Brush Ceramics Facility Health Consultation was prepared by the Arizona Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Charisse J. Walcott
Technical Project Officer
Superfund and Program Assessment Branch
Division of Health Assessment and Consultation

The Division of Health Assessment and Consultation, Agency for Toxic Substance and Disease Registry, has reviewed this health consultation and concurs with its findings.

Alan Yarbrough
Team Leader, Cooperative Agreement Team
Superfund and Program Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substance and Disease Registry