Key Findings of CDC's LAHDRA Project: Early Airborne Beryllium Releases

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CDC's LAHDRA — Los Alamos Historical Document Retrieval & Assessment

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Uses of Beryllium at Los Alamos

Los Alamos scientists used significant quantities of beryllium before the health hazards of the material were fully appreciated (Hempelmann and Henrickson, 1986; Shipman, 1951). Two main types of operations at LANL– machining and firing tests– have resulted in releases of beryllium to the environment. The machining, grinding, sanding, and general handling of beryllium components typically occurred in machine shops or experimental laboratory settings. Figure 1 shows the "Old Beryllium Shop" in V Building at the Original Technical Area. A new beryllium shop at Technical Area 3 (TA-3) Building SM-39 became operational in 1953. Dynamic testing has involved use of beryllium and other materials in explosive tests in the open air or with various forms of containment or confinement at facilities such as the Pulsed High Energy Radiographic Machine Emitting X-rays (PHERMEX) facility at TA-15 (see Figure 2). Industrial Hygiene records indicate that activities involving beryllium were performed at 20 different Technical Areas between 1943 and 1980.

Fig.1. A lathe used in the "Old Beryllium Shop" in V Building at the Original Technical Area

Fig. 2. An explosive testing "shot" at the PHERMEX facility, TA-15

The main facilities that housed beryllium operations within the Original Technical Area are shown in Figure 3. Beryllium metal was processed in the shops and metallurgical labs, and soluble beryllium salts were handled in the chemical labs (JHSPH, 1999). Early in the 1940s, beryllium oxide powder was hot pressed to make moderator bricks for the "Water Boiler" reactor (Figure 4) that was built late in 1943 (Bunker, 1983; Smith, 1945). A 1945 memorandum discusses placement of an order for 6,000 lb of beryllium for use in machining of initiators, production of tamper rods, and metallurgy experiments (Bradbury, 1945). LANL personnel have estimated that 1,224 kg of beryllium was used in dynamic testing at Los Alamos through 1997 (see Figure 5), with a peak of over 100 kg in 1964 (Becker and Vigil, 1999).

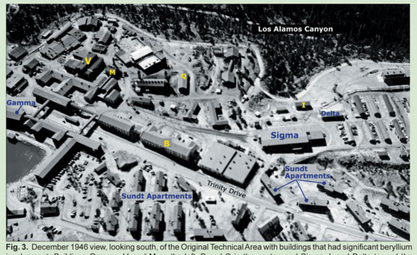

Fig. 3. December 1946 view, looking south, of the Original Technical Area with buildings that had significant beryllium involvement; Buildings Gamma, V, and M on the left, B and Q in the center, and Sigma, I, and Delta toward the right.

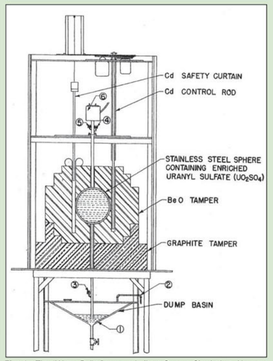

Fig. 4. The "Water Boiler" reactor built at Omega Site in Los Alamos Canyon used beryllium oxide bricks to moderate neutrons given off in the fissioning of uranium

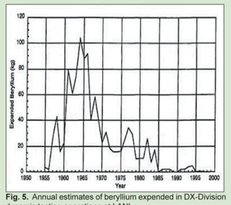

Fig. 5. Annual estimates of beryllium expended in DX-Division dynamic testing operations at LANL.

In an annex to B Building in the original Technical Area, which was located just across the street from residential apartments, a 20-mm Hispano-Suiza anti-aircraft autocannon (Figure 6) was used for testing scaled-down versions of gun-type weapon components and initiators. By the end of September 1944, the cannon had been used in nearly 180 experiments at a frequency of approximately one per day in the annex that was an unmonitored release point for beryllium and polonium (LASL, 1944-1945).

In a memorandum issued in late 1947, Health Division leader Louis H. Hempelmann, M.D. referred to accumulating evidence of health hazards to workers that handled beryllium (Hempelmann, November 13, 1947) and suggested that work with beryllium be discouraged until more knowledge was gained concerning the hazards involved. In a 1962 memorandum (Shipman, 1962), Health Division leader Dr. Thomas Shipman refers to "two and possibly a third fatal case from beryllium" exposure to LANL workers.

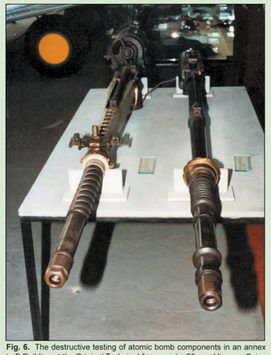

Fig. 6. The destructive testing of atomic bomb components in an annex to B Building at the Original Technical Area used a 20-mm Hispano-Suiza anti-aircraft autocannon that was likely similar to the ones pictured here

Release Estimates to Support Screening-Level Assessment of Beryllium Exposures

A screening assessment of beryllium concentrations in public areas was performed based on information from historical documents and the atmospheric dispersion screening methods of National Council on Radiation Protection and Measurements (NCRP) Report No. 123 (NCRP, 1996).

"New" Beryllium Shops: Peak releases of airborne beryllium from the SM-39 Shops at TA-3 for years after 1963 were estimated based on documented annual releases for 1964-1966 and 1968-1970, within which the highest value was for 1970. Peak SM-39 Shop releases representative of 1953-1963, before high efficiency particulate air (HEPA) filters of nominal 99.97% efficiency were added, were estimated based on 1970 releases multiplied times a factor of 167. That value is the ratio of the effluent reduction factor for HEPA filters to the reduction factor for the filters (of assumed 95% efficiency) that were in place before HEPA filters were installed.

V-Building Shop: Because of similarity of operations, peak release rates of airborne beryllium from V Shop at TA-1 for 1949-53 were assumed to be equal to those from the SM-39 shop 1953-63, when only 95% efficient filters were used. For 1943-48, when not even crude filters were in place, release rates were assumed to be 20-times higher [1/(1-0.95)].

Beryllium Oxide Pressing: Releases from the hot pressing of beryllium oxide (BeO) powder in Q Building at TA-1 were estimated based on a document that indicates that 6,100 lbs of BeO was obtained during 1944 for production of reactor components. Based on an assumed release fraction of 0.25%, it was estimated that 6,900 g of BeO (containing 2,500 g of beryllium) was released over 1,600 working hours in 1944.

B-Building Gun Testing: Releases from the testing of beryllium-containing atomic weapon components fired from a cannon in an annex to B Building at TA-1 were estimated based on a frequency of 1 shot per day, 7 d per week. LAHDRA team members estimated that each 20-mm diameter projectile contained 120 g of beryllium, of which 10% was aerosolized, yielding a release of 12 g per test over a 6-minute period.

Dynamic Testing at PHERMEX: Peak beryllium releases from explosive testing at the PHERMEX facility at TA-15 were estimated based on a report that beryllium use in explosive tests peaked at 106 kg in 1964. The calculation assumed that 100 shots occurred in 1964, of which 80% did not involve beryllium and 20% did. Of the 20 shots that used beryllium, it was assumed that 16 used 3.31 kg beryllium and four used 13.25 kg. If 10% of the beryllium in one of the larger shots was aerosolized, 1.325 kg would have been released over 15 min.

Correction for Duration of Exposures

For the beryllium shops and oxide pressing operations, release or usage estimates were found only in the form of annual totals. In order to estimate how high release rates could have been over shorter periods, detailed monitoring data that are available for airborne plutonium releases from DP West site stacks for 1956 and 1957 were analyzed. The relationships between daily concentrations and weekly, monthly, and annual average concentrations were characterized (see Figure 7), and a table of multipliers was generated that can be applied to annual data to estimate peak releases over a series of shorter durations. To support preliminary screening, airborne beryllium releases were assumed to vary over time like the measured airborne plutonium releases, and annual beryllium releases were converted to release rates over shorter durations so that airborne concentrations could be compared to occupational and ambient exposure limits.

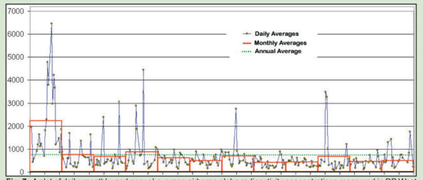

Fig. 7. A plot of daily, monthly, and annual-average airborne alpha radioactivity concentrations measured in DP West Building 12 stacks during 1956 (dpm/m³).

Screening Assessment of Concentrations in Residential Areas

For each beryllium emission source, the distance to the nearest residential area was estimated. Nearest residential areas for releases from the Original Technical Area, Building SM-39 at TA-3, and PHERMEX at TA-15 are shown in Figures, 8, 9, and 10, respectively. Dilution factors were estimated using the method of NCRP Report No. 123's Gaussian plume modeling of releases to the atmosphere.

The importance of the early beryllium releases is heightened by the fact that residential areas were unusually close to the Original Technical Area, with the nearest residences roughly 50 m from B Building, which was literally across Trinity Drive from numerous Sundt apartments. Sigma, Q, and V Buildings– which all housed beryllium operations– were all within 170 m or less of the nearest residences.

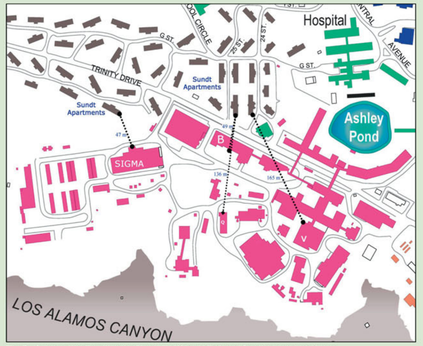

Fig. 8. Distances from beryllium facilities in the Original Technical Area to nearest residences

Fig. 9. The Western Area Housing in Los Alamos is approximately 960 meters north of Building SM-39, in which a beryllium shop became operational in 1953

Fig.10. Royal Crest Trailer Park lies about 4.5 km NNW of PHERMEX.

Results of Preliminary Screening

The results of screening of airborne releases from the beryllium operations are presented in Table 1. The release rate and concentration values for BeO powder pressing, V Shop, and SM-39 Shop releases are presented as 6-min, 30-min, and 8-h average values that would be expected to be reached or exceeded once per year and monthly average concentrations that would be expected to be reached or exceeded 5% of the time. For the explosive tests at TA-15, the results in Table 1 for periods longer than a week are average values over the periods shown based on 100 shots per year, each with 0.25-h duration, that together released 10% of the total beryllium reported expended in 1964. For periods shorter than a month, the results are average values over the periods shown based on one shot, with 0.25-h duration of exposure, occurring during the period and releasing 1.25% of the total beryllium reported expended in 1964.

Table 1. Results of Preliminary Screening of Airborne Beryllium Concentrations In Residential Areas From Identified Emissions Sources at LANL

	B-Building Gun Tests[a]	BeO Powder Pressing	V Shop 1943-48	V Shop 1949-53	SM-39 Shop 1953 to 1963	SM-39 Shop after 1963	PHERMEX Tests[a]
Distance to exposure point (m)	49	140	170	170	960	960	4500
Relative concentration (s m⁻³)	1.1×10^{-2}	2.5×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	6.9×10^{-5}	6.9×10^{-5}	2.5×10^{-6}
Release rates (μg s⁻¹) for relevant averaging periods;							
0.1 h:	33,000	64,000	12,000	610	610	3.7	1,500,000
0.5 h:	6,700	20,000	3,900	190	190	1.2	740,000
8 h:	420	3,600	680	34	34	0.20	46,000
730 h (1 month):	140	150	29	1.4	1.4	0.0086	670
Exposure point concentrations (μg m⁻³) for relevant averaging periods;							
0.1 h:	**350**[c,d]	**16**[d]	**1.4**[d]	**0.069**[d]	0.0042	0.000025	**3.7**[d]
0.5 h:	**71**[c,d]	**5.1**[d]	**0.44**[d]	**0.022**[d]	0.0013	0.0000080	**1.8**[d]
8 h:	**4.4**[b,c,d]	**0.90**[d]	**0.077**[d]	0.0038	0.00023	0.0000014	**0.12**[d]
730 h (1 month):	**1.5**[c,e]	**0.038**[d,e]	0.0033	0.00016	0.000010	0.000000059	0.0017

[a] Episodic releases
[b] Possible exceedance of OSHA/AEC 8-h time weighted average limit = 2 μg m⁻³
[c] Possible exceedance of OSHA/AEC ceiling limit = 25 μg m⁻³
[d] Possible exceedance of USEPA Reference Concentration = 0.02 μg m⁻³
[e] Possible exceedance of National Emission Standard for ambient air averaged over a 30-d period = 0.01 μg m⁻³

Comparison of Concentrations to Exposure Limits and Guidelines

The screening results summarized in Figure 11 indicate that the 8-h time weighted average permissible exposure limit of 2 μg m⁻³ for beryllium adopted for workers by the Occupational Health and Safety Administration (OSHA) and the AEC could have been exceeded in residential areas by releases from the B-Building gun tests. The OSHA/AEC ceiling limit of 25 μg m⁻³ for workers could also have been exceeded for releases from those tests based on concentrations estimated for 0.5-h and 0.1-h averaging periods. The USEPA reference concentration of 0.02 μg m⁻³ could have been exceeded in residential areas by releases from B-Building gun testing, BeO powder pressing, V-Shop machining, and tests at PHERMEX. The National Emission Standard of 0.01 μg m⁻³ for beryllium in ambient air averaged over a 30-d period could have been exceeded in residential areas from the B-Building gun tests and BeO powder pressing.

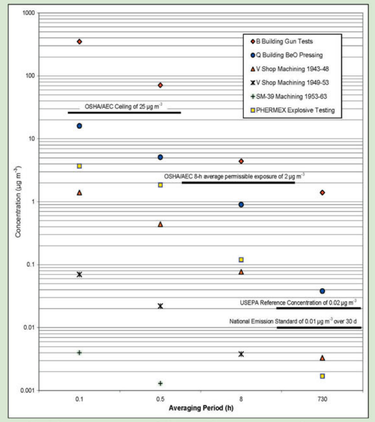

Fig. 11. Screening-level estimates of airborne beryllium concentrations in public areas near LANL for six historical operations, with levels corresponding to four beryllium concentration limits or guidelines

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