

# Beryllium Surveillance Program Report



**2002**

## **Beryllium Surveillance Program Report**

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Additional information about the Department of Energy's Office of Health Programs, the Beryllium Surveillance Program, and annual reports for Department of Energy sites participating in this program can be found at:

**<http://tis.eh.doe.gov/health/beryllium/index.html>**

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## **Introduction**

### **History of the Program**

Beryllium (Be) is a hard, lightweight metal that is very strong and easy to shape. Beryllium and beryllium compounds have many industrial uses. Beryllium copper alloys and beryllium oxide ceramics are used in the electronic, nuclear, and aerospace industries. Beryllium parts for nuclear weapons have been manufactured and used at a number of U.S. Department of Energy (DOE) facilities since the 1950s.

Before the late 1940s, little was known about the delayed health effects that could be caused by exposure to beryllium. The first occupational exposure limits were put in place in 1949 to prevent acute and chronic beryllium disease (CBD). These limits were 2 micrograms per cubic meter as a quarterly average and 25 micrograms per cubic meter as a 30-minute average. The adoption of exposure limits led to reduced exposure levels, prevention of acute beryllium disease, and the perception that CBD was also being controlled. Many former workers report that they did not know they were working with beryllium or they were told working conditions were safe. As more cases of CBD began to be reported, DOE officials became concerned and began looking for a way to see how many people had health problems due to beryllium exposure.

The DOE Beryllium Medical Surveillance Program (BMSP) is a medical surveillance program that was developed to find out how widespread beryllium sensitization (BeS) and CBD were among former employees (those who had retired or gone to other jobs) from DOE sites throughout the country. The Oak Ridge Institute for Science and Education (ORISE) manages the surveillance program for DOE.

### **Purpose of the Program**

The BMSP provides medical screening for CBD that is generally not available in the community. Individuals with abnormal findings are eligible for government-provided recommended medical evaluations and care. In some cases, the disability caused by CBD can be minimized through early detection and treatment. Results from the program provide information that may help DOE identify and offer screening to other workers who may be at risk of getting CBD. The knowledge that is obtained may also help DOE evaluate the effectiveness of its health protection programs by finding the number of former workers from each site who have been affected by exposure to beryllium.

### **Beryllium Exposure and CBD**

Workers may have come into contact with beryllium in a number of jobs over the years. Machinists, welders, and operators may have been exposed through direct handling of beryllium and beryllium compounds. Other workers may have been exposed by performing laboratory analyses on beryllium compounds, coming into contact with contaminated equipment, or working near a beryllium operation.

Exposure usually occurs when a person breathes in beryllium mists, dusts, and fumes. Beryllium can then travel to the lungs where it can cause damage. Exposure to very small amounts can cause some people to become sensitized to the metal. It usually develops over several years or even decades and can be mild or severe. Beryllium-related granulomas (non-cancerous tumors or growths) can cause inflammation and scarring of the lungs,

making it more difficult for the lungs to get oxygen to the bloodstream and body. These granulomas can also develop in other body tissues but do not usually result in a loss of function.

Symptoms of CBD include shortness of breath, cough, chest pain, fatigue, loss of appetite, and weight loss. Since these symptoms are also associated with other conditions, it is important to note that not all individuals who experience them have CBD. It is also possible to have CBD without having any of these symptoms. For workers to be diagnosed with CBD, they must have a clinical evaluation by a pulmonologist.

Usually, less than 3% of workers exposed to beryllium develop the disease. Today, CBD is not considered a fatal condition. For a few people, however, it can become serious enough to cause disability. Most people with the disease are able to control the symptoms with medication and regular medical evaluations.

Beryllium is identified by the International Agency for Research on Cancer as a cancer-causing substance. In humans, one study found beryllium caused a small but significant increase in the amount of lung cancers. However, other researchers have pointed out flaws in that study. The National Toxicology Program identified beryllium as a known human carcinogen based on sufficient evidence of carcinogenicity in humans, supported by data from animal studies.

### **The Beryllium Lymphocyte Proliferation Test**

The beryllium lymphocyte proliferation test (BeLPT) is a blood test that examines how lymphocytes, which are cells in the immune system that fight disease, react to beryllium. A BeLPT is considered abnormal if a person's lymphocytes react strongly to beryllium. This may also indicate that a person is

more likely than others with similar exposure to develop CBD in the future or may be an early sign of CBD. An individual must have 2 abnormal blood tests to be considered beryllium sensitized. If a worker has an abnormal BeLPT, it is suggested that he/she discuss it with their personal physician, especially if they are being treated for another health condition.

As of December 31, 2002, a total of 17,363 participants had been tested by the Oak Ridge Institute for Science and Education BMSP, and 15,598 had been tested by other programs providing comprehensive health evaluations for former DOE workers at selected sites. These other programs are collectively referred to as the Former Workers Program (FWP). Of the 17,363 participants in the BMSP, 495 were determined to have BeS, and 192 were diagnosed with CBD. Of the 15,598 FWP participants, 214 had been determined to be BeS, and 149 had received clinical evaluations of which 28 were diagnosed with CBD. The Energy Employees Occupational Illness Compensation Program Act (EEOICPA) of 2000 created a federal medical insurance program that covers medical care costs for individuals who have 1 or more abnormal BeLPT results. There are 1,446 participants who are eligible for EEOICPA benefits, which provide follow-on testing, initial or periodic clinical evaluations, and treatment for those who are diagnosed with CBD.

### **Major Job Categories and Outcomes of Exposure**

The 5 sites covered in the text of this report are BMSP sites where at least 1,000 former workers were tested before the end of calendar year 2002: Y-12 National Security Complex (Y-12), Kansas City Plant (KCP), Lawrence Livermore National Laboratory (LLNL), Rocky Flats Environmental Technology Site (RFETS), and Pantex Plant. For the purpose of

better understanding the circumstances (working conditions) that lead to beryllium sensitivity and/or CBD, job titles from each of these sites were placed in 7 job categories, as well as 1 category for workers with unknown job titles. The job titles were categorized based on similar potentials for beryllium exposures. Among the sites, the Be Fabrication workers have the highest potential for exposure, while the Scientific group of workers has the lowest potential. However, there is considerable variation from site to site in the sensitization rates for each group. Since many workers may have worked in more than 1 job category during their career and may also have worked at multiple DOE sites, each worker was classified in the job category with the greatest chance for beryllium exposure. For example, an individual who worked as a general laborer for 13 months (Labor and Decontamination and Decommission [D&D] category) while waiting for their DOE clearance to be completed and then transferred to a beryllium machinist position (Be Fabrication) for 1 year prior to becoming a machining supervisor for 7 years (Stand-By) would be classified as a Be Fabrication worker. Figure 1 shows an example of the illustrative tasks for each major job category.

Throughout this report, a table will be presented for each of the facilities showing job categories, the number of workers tested, those eligible for the EEOICPA, workers with beryllium sensitization and CBD, sensitization and disease rates, and the total number of clinical evaluations by pulmonologists. The information presented summarizes the results of screening at each of the facilities through the end of 2002. Since the programs are ongoing and additional

data are being collected, this report should not be used to draw conclusions regarding beryllium sensitization and CBD.

**Figure 1. Illustrative Tasks for Major Job Categories**

Category	Tasks
Be Fabrication	Machining, welding, grinding, cutting, process operations, polishing
Be Handling	Assembling, sample analysis, parts handling
Maintenance	Electrical, pipefitting and plumbing, machine maintenance, insulating, inspecting, operating equipment, general machining
Stand-By	Security, beryllium area supervision, beryllium area clerk, shipping and receiving, fire hazard inspections, firefighting
Labor and D&D	Equipment cleaning, janitorial duties, unskilled labor tasks, grounds and roads maintenance
Administrative	Planning and estimating, administrative security inspections, production scheduling, clerical tasks, computer tasks
Scientific	Engineering, research and development, radiography, nuclear materials control, material/product inspection, non-destructive testing
Unknown	Unknown

## Y-12 National Security Complex

### Beryllium Operations

The primary Y-12 beryllium operation has been the production of beryllium oxide ceramic weapons components. Beryllium oxide powder is received, mixed with other materials, pressed into a shape, and fired in a kiln. The blank work piece is machined to final tolerances using diamond-grinding tools. The operations are supported by quality assurance testing of materials when received and at various fabrication steps and by dimensional inspection of finished products. Beryllium oxide ceramic components from retired weapons are returned to Y-12 for declassification of the shapes and recycling of the materials. Y-12 performs engineering research and development of new beryllium oxide ceramic manufacturing methods.

In the past, Y-12 also had operations that produced beryllium metal components for nuclear weapons. The unique fabrication capabilities at Y-12 are occasionally used to support energy and defense projects that include the use of beryllium metal, ceramics, and alloys. Remodeling, decontamination, and decommissioning projects on the site can require work on beryllium-contaminated facilities, utilities, and equipment.

### Beryllium Workers

In 1991, Y-12 Occupational Medicine Clinic records were used to identify over 3,500 employees known to have worked with beryllium. Plant rules required supervisors to inform the plant medical clinic of workers who were expected to spend at least half their time working with beryllium. Workers also were given the opportunity to self-identify as having worked with beryllium. At Y-12, most participants recall working with beryllium and are identified in records as having been assigned beryllium work. Table 1 shows the major job categories and the number of workers tested in each category. A total of 2,535 Y-12 former employees (209 women, 8%, and 2,326 men, 92%) have been tested for beryllium sensitization.



## **Beryllium Sensitization and CBD Rates**

The rates of beryllium sensitization and CBD among workers in each job category are shown in Table 1. The sensitization rate was highest for workers in the Labor and D&D category. Of the 105 Labor and D&D workers tested, 7 (6.67%) were sensitized to beryllium. The Unknown category appeared to have a high percentage of sensitized workers; however, there were only 18 people in the category, and 1 was sensitized (1 sensitized worker/18 workers = 5.56%). The workers tested who were in the Be Fabrication category had a sensitization rate of 5.21%. Of the 1,056 workers, 55 were sensitized. The category with the lowest rate was the Administrative category. Among this group of 136 workers, 4 (2.94%) were found to be sensitized to beryllium. The sensitization rate for all of the categories combined was 4.30%. Of the 2,535 workers tested, 109 showed beryllium sensitization. A total of 45 Y-12 workers (1.78%) who were tested have been diagnosed with CBD. The only person in the Unknown category who was sensitized to beryllium completed additional clinical testing and was diagnosed with CBD. The highest rate of CBD (2.86%) was observed among workers in the Labor and D&D group. Of the 7 sensitized workers, 3 were diagnosed with CBD. The rate of CBD for workers in the Be Fabrication category was 2.37%, slightly less than the rate for workers in

the Labor and D&D group. Of the 55 Be Fabrication workers who were sensitized, 25 were found to have CBD. Workers in the Stand-By and Administrative categories had CBD rates of 0.67% and 0.74%, respectively. In each of these groups, 1 worker was diagnosed with CBD.

## **Comments**

The prevalence of CBD and BeS varies among groups of Y-12 workers, which points to differences in exposure level as an important risk factor for CBD. This reflects both the amount of beryllium work at Y-12 and the fact that participants were predominantly workers with substantial opportunities for beryllium exposure. Y-12 work rules assigned craft and cleaning workers to specific operations, which helped reduce the number of workers exposed to beryllium. The prevalence of CBD was highest among those who cleaned beryllium areas (Labor and D&D); however, the majority of CBD cases occurred among workers who were exposed through working directly with beryllium in fabrication processes. Additional tables are included in Appendix 4 showing sensitization and CBD rates by length of employment and decade of hire. There is no apparent trend in BeS and CBD rates by length of employment. Rates of both BeS and CBD among those hired after 1980 seem to be lower. This could be due to lower exposure levels or a long latency period for some cases of BeS and CBD.

**Table 1. Detailed Numbers for Each Job Category for Y-12 National Security Complex**

Job Category	Number of Workers Tested	Number Eligible for EEOICPA <sup>a</sup>	Number BeS <sup>b</sup>	Number Completed Clinical Evaluations	Number Diagnosed CBD	Number BeS + CBD	BeS Rate	CBD Rate	BeS + CBD Rate <sup>c</sup>
Be Fabrication	1,056	76	30	38	25	55	2.84%	2.37%	5.21%
Be Handling	366	17	4	9	7	11	1.09%	1.91%	3.01%
Maintenance	525	30	12	9	5	17	2.29%	0.95%	3.24%
Stand-By	150	9	5	4	1	6	3.33%	0.67%	4.00%
Labor and D&D	105	10	4	4	3	7	3.81%	2.86%	6.67%
Administrative	136	5	3	3	1	4	2.21%	0.74%	2.94%
Scientific	179	12	6	3	2	8	3.35%	1.12%	4.47%
Unknown	18	1	0	1	1	1	0.00%	5.56%	5.56%
All subjects	2,535	160	64	71	45	109	2.52%	1.78%	4.30%

<sup>a</sup> Eligible for EEOICPA defined as 1 abnormal BeLPT.

<sup>b</sup> BeS defined as 2 abnormal BeLPTs. Applies to workers who have not been diagnosed with CBD but are sensitized only.

<sup>c</sup> BeS + CBD rate includes both workers who are sensitized to beryllium and those who have been diagnosed with CBD.

## Kansas City Plant

### Beryllium Operations

At the Kansas City Plant (KCP), small quantities of copper beryllium alloys have been used for fabrication of electronic components. Exposure monitoring of these operations indicated very low potential for exposure compared with exposure limits, and no routine exposure monitoring programs were implemented. Subsequent to the finding of beryllium sensitization among KCP workers, the pattern of contamination detected by surface sampling indicated that beryllium oxide ceramic process equipment used in the production of engineered materials may have been a source of beryllium exposure at KCP. The space where this equipment was used to produce materials and the space where the material was used for subsequent parts fabrication operations were found to be contaminated with beryllium. Ongoing decontamination work creates the continuing potential for beryllium exposure.

### Beryllium Workers

The potential for significant beryllium exposure was not recognized at KCP, and no records have been found that might be useful in identifying who was exposed. The voluntary participants in the beryllium worker medical surveillance have self-identified as having worked with beryllium or believe their work may have exposed them. The manufacturing operations at KCP are highly flexible to produce small numbers of a wide variety of components and materials. Historically, a significant proportion of KCP workers performed the facility and equipment remodeling (retooling) needed to achieve manufacturing flexibility.



## **Beryllium Sensitization and CBD Rates**

A total of 2,963 KCP employees have been tested for beryllium exposure. The rate of beryllium sensitization and CBD among workers in each job category is shown in Table 2. It would appear that a high percentage of the workers in the Stand-By category were sensitized to beryllium; however, there were 31 people in this category, and 2 were sensitized. Rates for workers in the Be Fabrication, Be Handling, Labor and D&D, and Administrative categories were similar, ranging from 2.18% to 2.61%. The Scientific category had the lowest rate (1.28%). Of the 312 workers in this category, 4 were sensitized to beryllium. Of the 34 sensitized workers who underwent clinical evaluations, the Be Handling, Maintenance, and Labor and D&D categories each had 1 worker diagnosed with CBD.

## **Comments**

The prevalence of CBD and BeS at KCP is lower than at other DOE production sites. This is consistent with the limited use of beryllium at this site and exposure monitoring data indicating that exposures are currently low. There were limited beryllium fabrication activities at the Kansas City Plant, which is reflected by the low number of workers in the Be Fabrication category. The low predictive value of sensitization for CBD points to the need to focus future surveillance efforts on the highest risk groups (3 cases diagnosed out of 34 sensitized people undergoing diagnostic procedures). Neither the length of employment nor date of hire appear to correlate with BeS or CBD rates at KCP (see Appendix 4).

**Table 2. Detailed Numbers for Each Job Category for Kansas City Plant**

Job Category	Number of Workers Tested	Number Eligible for EEOICPA <sup>a</sup>	Number BeS <sup>b</sup>	Number Completed Clinical Evaluations	Number Diagnosed CBD	Number BeS + CBD	BeS Rate	CBD Rate	BeS + CBD Rate <sup>c</sup>
Be Fabrication	115	5	3	2	0	3	2.61%	0.00%	2.61%
Be Handling	687	26	15	8	1	16	2.18%	0.15%	2.33%
Maintenance	839	22	13	5	1	14	1.55%	0.12%	1.67%
Stand-By	31	3	2	1	0	2	6.45%	0.00%	6.45%
Labor and D&D	386	19	9	7	1	10	2.33%	0.26%	2.59%
Administrative	491	17	11	5	0	11	2.24%	0.00%	2.24%
Scientific	312	8	4	3	0	4	1.28%	0.00%	1.28%
Unknown	102	6	4	3	0	4	3.92%	0.00%	3.92%
All subjects	2,963	106	61	34	3	64	2.06%	0.10%	2.16%

<sup>a</sup> Eligible for EEOICPA defined as 1 abnormal BeLPT.

<sup>b</sup> BeS defined as 2 abnormal BeLPTs. Applies to workers who have not been diagnosed with CBD but are sensitized only.

<sup>c</sup> BeS + CBD rate includes both workers who are sensitized to beryllium and those who have been diagnosed with CBD.

## Lawrence Livermore National Laboratory

### Beryllium Operations

The primary beryllium operations at Lawrence Livermore National Laboratory (LLNL) relate to research and development and experimental activities. This process includes machining, welding, polishing, assembling, and testing of solid beryllium components. Experiments with beryllium oxide did occur in chemistry laboratories, and it is one of the metals studied in Site 300 non-nuclear experiments. LLNL has about 500 kg to 600 kg (1100 lb to 1320 lb) of beryllium onsite, mostly in solid form, such as blocks, sheets, wires, foils, and



about 20 kg (44 lb) of beryllium in powder form. It is unknown how many people worked with beryllium over the 50 years that LLNL has been in operation. Only about 100 employees actually handle beryllium today; however, work with beryllium is on a part-time basis. Beryllium work is performed at many areas of the Laboratory, including buildings 121, 131, 151, 212, 222, 231, 235, 241, 298, the 321 complex, 327, 329, the Superblock, and Site 300.

### Beryllium Workers

In 2000, LLNL identified over 20,000 former employees known to have worked at Lawrence Livermore National Laboratory. It is unknown how many former employees worked directly with beryllium. Former workers were given the opportunity to self-identify as having been exposed to beryllium and have been given the opportunity to participate in beryllium sensitization testing.

### Beryllium Sensitization and CBD Rates

A total of 1,560 LLNL former employees have been tested for beryllium exposure. The rate of sensitization and CBD among workers in each job category is shown in Table 3. It would appear that a high percentage of the workers in the Unknown category were sensitized to beryllium; however, there were 40 people in the job category, and 2 were sensitized. Approximately 3% of the workers in the Administrative (18 workers) and Scientific (15 workers) categories were sensitized. There was only 1 worker tested who was in the Be Fabrication job category. None of the Stand-By workers had test results indicating beryllium sensitization. Of the 36 sensitized workers who underwent clinical evaluations, 3 (<1%) Administrative workers and 4 (<1%) workers in the Scientific category were diagnosed with CBD.

## Comments

The prevalence of CBD and BeS varies among groups of Lawrence Livermore workers. This points to differences in exposure level as an important risk factor for CBD. The prevalence of CBD was highest among the Scientific and Administrative job categories, which have been low-risk groups at other sites. These categories account for 65% of those who have received testing. This reflects the fact that beryllium operations at

LLNL were largely in research and development and not manufacturing. The fact that the groups with the highest numbers of participants have the highest CBD rates indicates that on the whole, individuals who choose to participate are making sound decisions. Communicating information about higher than expected rates in Scientific and Administrative job categories may increase participation rates among those who worked with beryllium but have discounted their risk for CBD.

**Table 3. Detailed Numbers for Each Job Category for Lawrence Livermore National Laboratory**

Job Category	Number of Workers Tested	Number Eligible for EEOICPA <sup>a</sup>	Number BeS <sup>b</sup>	Number Completed Clinical Evaluations	Number Diagnosed CBD	Number BeS + CBD	BeS Rate	CBD Rate	BeS + CBD Rate <sup>c</sup>
Be Fabrication	1	0	0	0	0	0	0.00%	0.00%	0.00%
Be Handling	68	3	2	2	0	2	2.94%	0.00%	2.94%
Maintenance	327	14	8	5	0	8	2.45%	0.00%	2.45%
Stand-By	60	1	0	0	0	0	0.00%	0.00%	0.00%
Labor and D&D	50	1	1	1	0	1	2.00%	0.00%	2.00%
Administrative	528	27	18	16	3	21	3.41%	0.57%	3.98%
Scientific	486	22	15	10	4	19	3.09%	0.82%	3.91%
Unknown	40	3	2	2	0	2	5.00%	0.00%	5.00%
All subjects	1,560	71	46	36	7	53	2.95%	0.45%	3.40%

<sup>a</sup> Eligible for EEOICPA defined as 1 abnormal BeLPT.

<sup>b</sup> BeS defined as 2 abnormal BeLPTs. Applies to workers who have not been diagnosed with CBD but are sensitized only.

<sup>c</sup> BeS + CBD rate includes both workers who are sensitized to beryllium and those who have been diagnosed with CBD.

## Rocky Flats Environmental Technology Site (RFETS)

### Beryllium Operations

The primary Rocky Flats beryllium operation was the production of beryllium metal nuclear weapons components. Beryllium research and development activities began at Rocky Flats in 1953 and continued until full-scale beryllium production work began in 1958. Beryllium metal was received from a commercial supplier, analyzed for purity, and machined to final tolerances using precision metal working tools. Beryllium production operations included machining (milling, drilling, turning, and polishing); rolling and forming operations; component assembly (cleaning, machine welding and brazing, and hand welding); disassembly of returned components for decommissioning; beryllium electro-refining; casting of beryllium ingots; pressed powder beryllium heat-treated and machined to required specifications; analytical analysis; research and development; and quality control assurance testing (polishing and non-destructive testing including x-ray diffraction analysis).



Weapons production ended at Rocky Flats in 1989, and all beryllium production operations at Rocky Flats were eliminated in 1992.

### Beryllium Workers

In 1984, the first case of CBD at Rocky Flats was diagnosed in a beryllium machinist. In 1986, National Jewish Medical and Research Center conducted a pilot program to determine the prevalence of beryllium sensitization and CBD in a group (n = 55) of beryllium machinists. Based on the results of this program and with funding from the National Institutes of Health, National Jewish expanded testing to include approximately 900 additional Rocky Flats workers who had a known opportunity for exposure to beryllium. In 1992, testing was offered to Rocky Flats former workers. It is unknown how many former employees worked directly with beryllium. Former workers have been given the opportunity to self-identify as having been exposed to beryllium and are given the opportunity to participate in beryllium sensitization testing. Beryllium sensitization testing began at Rocky Flats earlier than at any other facility, so the results shown in this report reflect a mature screening program where most of the participants have been tested more than 1 time.

### Beryllium Sensitization and CBD Rates

The rate of beryllium sensitization and CBD among workers in each job category is shown in Table 4. The sensitization rate appears to be highest for workers in the Unknown category; however, there were 26 workers in this category tested, and 3 were sensitized (11.54%). Of the 380 Be Fabrication workers, 19 were sensitized, resulting in a rate of 5.00%. The lowest rate (1.51%) was found among workers in the Stand-By category. Of 265 workers, 4 were sensitized. Of the 308 sensitized

workers who underwent clinical evaluations, the rate of CBD appears to be highest for the workers in the Unknown category; however, there were 26 people in the category, and 2 (7.69%) were diagnosed with CBD. The rate of CBD for the Be Fabrication workers (6.58%) was the second highest. There were 380 people in this category, and 25 were diagnosed with CBD. The Stand-By group had a CBD rate of 0.75%, which was the lowest of all the categories.

### **Comments**

The prevalence of CBD and BeS varies among groups of Rocky Flats workers. This points to differences in exposure levels as an important risk factor for CBD. The Rocky Flats work force has received considerable

information/education concerning the possible health effects associated with exposure to airborne beryllium. As at other locations, while the prevalence of CBD was highest among those who directly fabricated beryllium components, 49 (38%) of the 129 CBD cases occurred among Maintenance workers, who were probably exposed through work in beryllium-contaminated facilities. Appendix 4 shows the prevalence of BeS and CBD by length of employment and decade of first hire. There appears to be a trend of increasing rates for BeS and CBD due to length of employment. Rates of both BeS and CBD among those hired after 1980 seem to be lower. This could be due to lower exposure levels or a long latency period for some cases of BeS and CBD.

**Table 4. Detailed Numbers for Each Job Category for Rocky Flats Environmental Technology Site**

Job Category	Number of Workers Tested	Number Eligible for EEOICPA <sup>a</sup>	Number BeS <sup>b</sup>	Number Completed Clinical Evaluations	Number Diagnosed CBD	Number BeS + CBD	BeS Rate	CBD Rate	BeS + CBD Rate <sup>c</sup>
Be Fabrication	380	57	19	40	25	44	5.00%	6.58%	11.58%
Be Handling	1,066	103	40	55	23	63	3.75%	2.16%	5.91%
Maintenance	3,023	242	93	121	49	142	3.08%	1.62%	4.70%
Stand-By	265	10	4	5	2	6	1.51%	0.75%	2.26%
Labor and D&D	451	26	11	15	5	16	2.44%	1.11%	3.55%
Administrative	1,406	86	34	47	15	49	2.42%	1.07%	3.49%
Scientific	781	43	15	21	8	23	1.92%	1.02%	2.94%
Unknown	26	7	3	4	2	56	11.54%	7.69%	19.23%
All subjects	7,398	574	219	308	129	348	2.96%	1.74%	4.70%

<sup>a</sup> Eligible for EEOICPA defined as 1 abnormal BeLPT.

<sup>b</sup> BeS defined as 2 abnormal BeLPTs. Applies to workers who have not been diagnosed with CBD but are sensitized only.

<sup>c</sup> BeS + CBD rate includes both workers who are sensitized to beryllium and those who have been diagnosed with CBD.

## Pantex Plant

### Beryllium Operations

At the Pantex Plant, beryllium and beryllium-containing alloys were used in the fabrication of weapons components. For demilitarization/sanitization of weapon components, beryllium is crushed, shredded, or otherwise deformed in disfigurement operations to make it unusable for military purposes and to ensure declassification. Firing Site operations require energetic demilitarization (firing to disable) of components that contain small amounts of beryllium. Pit characterization, which was categorized as a special operation and is now inactive, sometimes involved minimal abrasion of the pit exterior with Scotchbrite or Brillo Pads. Pantex performed destructive testing involving explosives and beryllium weapons components. Conducting the tests and recovering data from the tests were considered highly hazardous activities, and workers were required to wear protective ensembles.



### Beryllium Workers

Over time, there have been approximately 6,600 Pantex workers who have potentially been exposed to beryllium. This number includes beryllium workers, beryllium-associated workers, and self-identified individuals.

### Beryllium Sensitization and CBD Rates

The rate of beryllium sensitization and CBD among workers in each job category is shown in Table 5. It would appear that the rate of sensitization to beryllium was highest for workers in the Unknown category: however, there were 42 workers tested in this group, and 2 were sensitized. The second highest rates were seen in the Labor and D&D (3.70%) and Stand-By (3.37%) categories. The lowest sensitization rates were found among workers in the Be Handling (1.53%) and Administrative (1.60%) categories. Of the 21 sensitized workers who underwent clinical evaluations, 4 were diagnosed with CBD. The Be Handling job category had 2 workers diagnosed with CBD, and the Maintenance and Administrative job categories each had 1 worker diagnosed with CBD.

## Comments

The prevalence of CBD and BeS varies among groups at Pantex. The prevalence is similar to other facilities where beryllium fabrication is not a major activity (KCP and LLNL). The exposure levels at Pantex were probably relatively low for those workers who

worked directly with beryllium. The largest number of sensitized workers (8) came from the group performing maintenance activities. The former worker surveillance program at Pantex began in 2000, and the majority of participants from this facility have been tested only 1 time.

**Table 5. Detailed Numbers for Each Job Category for Pantex Plant**

Job Category	Number of Workers Tested	Number Eligible for EEOICPA <sup>a</sup>	Number BeS <sup>b</sup>	Number Completed Clinical Evaluations	Number Diagnosed CBD	Number BeS + CBD	BeS Rate	CBD Rate	BeS + CBD Rate <sup>c</sup>
Be Fabrication	0	0	0	0	0	0	0.00%	0.00%	0.00%
Be Handling	196	7	3	4	2	5	1.53%	1.02%	2.55%
Maintenance	316	17	8	8	1	9	2.53%	0.32%	2.85%
Stand-By	89	4	3	1	0	3	3.37%	0.00%	3.37%
Labor and D&D	54	2	2	1	0	2	3.70%	0.00%	3.70%
Administrative	188	6	3	4	1	4	1.60%	0.53%	2.13%
Scientific	76	2	2	1	0	2	2.63%	0.00%	2.63%
Unknown	42	3	2	2	0	2	4.76%	0.00%	4.76%
All subjects	961	41	23	21	4	27	2.39%	0.42%	2.81%

<sup>a</sup> Eligible for EEOICPA defined as 1 abnormal BeLPT.

<sup>b</sup> BeS defined as 2 abnormal BeLPTs. Applies to workers who have not been diagnosed with CBD but are sensitized only.

<sup>c</sup> BeS + CBD rate includes both workers who are sensitized to beryllium and those who have been diagnosed with CBD.

## Facility Comparisons

To have meaningful facility comparisons, it is necessary to look at the combined prevalence of BeS and CBD. Most of the participants with 2 abnormal BeLPTs from facilities where surveillance was started in the late 1990s or early 2000 have not completed clinical evaluations.

Overall, the prevalence of BeS + CBD is highest at RFETS (4.70%) and Y-12 (4.30%), followed by LLNL (3.40%), Pantex (2.81%), and KCP (2.16%). The differences in the types of workers screened can be seen by examining the most prevalent jobs in each facility. At RFETS, 85% of the workers screened were involved in Be Handling, Maintenance, Administrative, or Scientific jobs (Table 4). For Y-12, 84% of the workers screened were involved in Be Fabrication, Be Handling,

Maintenance, or Scientific jobs (Table 1). At LLNL, 86% of the workers screened were involved in only 3 jobs: Maintenance, Administrative, and Scientific (Table 3). At Pantex, 82% of the workers screened were involved in Be Handling, Maintenance, Stand-By, or Administrative activities (Table 5). And finally, at KCP, 81% of the workers screened were involved in Be Handling, Maintenance, Labor and D&D, or Administrative activities (Table 2).

In each job category, the highest prevalence among the facilities is either at RFETS or Y-12, with the exception of the Administrative job category, which has the highest BeS + CBD prevalence at LLNL. KCP has the lowest prevalence of sensitization for all job categories except Administrative, which is the lowest at Pantex (2.13%).

**Table 6. BeS + CBD Rates for Major Testing Sites**

Job Category	Y-12	KCP	LLNL	RFETS	Pantex	Total
Be Fabrication	5.21%	2.61%	0 <sup>b</sup>	11.58%	0 <sup>b</sup>	6.57%
Be Handling	3.01%	2.33%	<100 <sup>a</sup>	5.91%	2.55%	4.07%
Maintenance	3.24%	1.67%	2.45%	4.70%	2.85%	3.78%
Stand-By	4.00%	<100 <sup>a</sup>	0 <sup>b</sup>	2.26%	<100 <sup>a</sup>	2.86%
Labor and D&D	6.67%	2.59%	<100 <sup>a</sup>	3.55%	<100 <sup>a</sup>	3.44%
Administrative	2.94%	2.24%	3.98%	3.49%	2.13%	3.24%
Scientific	4.47%	1.28%	3.91%	2.94%	<100 <sup>a</sup>	3.05%
Total	4.30%	2.16%	3.40%	4.70%	2.81%	3.90%

Sites where more than 1,000 workers were tested.

<sup>a</sup> <100 = less than 100 people tested in this job category.

<sup>b</sup> 0 = no people tested in this job category.

## Appendix 1

### Summary Data for Sites Where Less Than 1,000 Former Workers Have Been Tested By ORISE<sup>a</sup>

Location	Number of Workers Tested	Number Eligible to Apply for EEOICPA <sup>b</sup>	Number BeS	Rate BeS	Number Completed Clinical Evaluations	Number CBD	Rate CBD	BeS + CBD	BeS + CBD Rate
Ames Laboratory	73	7	2	2.74%	4	2	2.74%	4	5.48%
Argonne, East	142 <sup>c</sup>	6 <sup>c</sup>	5 <sup>c</sup>	3.52%	3 <sup>c</sup>	1 <sup>c</sup>	0.70%	6	4.22%
Argonne, West (current)	33	1	1	3.03%	0	0	0.00%	1	3.03%
Brookhaven	19	0	0	0.00%	0	0	0.00%	0	0.00%
Fermi	8	0	0	0.00%	0	0	0.00%	0	0.00%
Chicago Operations	17	1	1	5.88%	1	1	5.88%	2	11.76%
Iowa Army Ammunition Plant	336	12	9	2.68%	9	0	0.00%	9	2.68%
Knolls Atomic Power Plant	24	2	2	8.33%	1	1	4.17%	3	12.50%
Lawrence Berkeley National Laboratory	10	2	1	10.00%	0	0	0.00%	1	10.00%
Mound	681	1	1	0.15%	0	0	0.00%	1	0.15%
Oak Ridge National Laboratory (X-10)	407	10	8	1.97%	7	0	0.00%	8	1.97%
Sandia, Albuquerque	86	1	1	1.16%	0	0	0.00%	1	1.16%
Sandia, Livermore	68	4	2	2.94%	2	0	0.00%	2	2.94%
Argonne National Laboratory Site B	3 <sup>c</sup>	2 <sup>c</sup>	2 <sup>c</sup>	66.67%	2 <sup>c</sup>	0	0.00%	2	66.67%

<sup>a</sup> Includes Former Worker Program Participants transferring to the ORISE program for follow-up.

<sup>b</sup> One abnormal BeLPT or sensitized.

<sup>c</sup> Includes 1 former employee who had been diagnosed with CBD prior to the commencement of the beryllium sensitivity screening program but had never been screened for beryllium sensitivity.

## Appendix 2

### Summary Data for Sites Where Testing Was Provided By Former Worker Projects

Location	Number of Workers Tested	Number Eligible to apply for EEOICPA <sup>a</sup>	Number BeS	Rate BeS	Number Completed Clinical Evaluations	Number CBD	Rate CBD	BeS Only + CBD	BeS + CBD Rate
<b>Iowa Army Ammunition Plant</b>	707	13	7	0.99%	12	5	0.71%	12	1.70%
<b>Gaseous Diffusion Plants</b>	4,514	192	66	1.46%	42	9	0.20%	75	1.66%
<b>Hanford Construction</b>	1,522	45	21	1.38%	13	3	0.20%	24	1.58%
<b>Hanford Production</b>	1,111	48	26	2.34%	23	4	0.36%	30	2.70%
<b>Idaho National Engineering and Environmental Laboratory</b>	1,428	40	13	0.91%	6	2	0.14%	15	1.05%
<b>Los Alamos National Laboratory</b>	1,739	29	26	1.50%	23	2	0.11%	28	1.61%
<b>Nevada Test Site Tunnel Workers</b>	891	13	10	1.12%	5	1	0.11%	11	1.23%
<b>Oak Ridge Construction</b>	1,385	22	13	0.94%	5	1	0.07%	14	1.01%
<b>Savannah River Construction</b>	610	13	9	1.48%	5	0	0.00%	9	1.48%
<b>Savannah River Production</b>	1,691	30	23	1.36%	15	1	0.06%	24	1.42%

<sup>a</sup> One abnormal BeLPT or sensitized.

### Appendix 3

#### Summary of Earliest Available Personal Exposure Monitoring Data

##### Micrograms of Beryllium per Cubic Meter of Air

Site	Y-12	LLNL	RFETS	Pantex
Year	1990	1995 - 1997	1984 - 1985	1990 - 1999
Number of samples	319	89	99	297
Minimum	<LOQ	<LOQ	0.04	<LOQ
Maximum	5.44	0.688	11.5	8.4
Median	0.10	<LOQ	0.67	<LOQ
Limit of quantitation (LOQ)	0.10	0.013	0.01	0.1
Percent below LOQ	40%	92%	0%	91%
Estimated Mean <sup>a</sup>	0.28	0.029	1.18	0.057
Mean 90% confidence interval	0.24 - 0.34	0.0018 - 0.056	0.93 - 1.52	0.007 - 0.11
95/95 upper tolerance limit (UTL) <sup>b</sup>	1.70	0.688	5.24	0.28

LOQ, limit of quantitation; UTL, upper tolerance limit.

- <sup>a</sup> The mean and 90% confidence intervals are estimated by Kaplan-Meier analysis methods except Rocky Flats, which used the minimum variance unbiased estimate of the mean and Land's Exact method for the 90% confidence interval.
- <sup>b</sup> The 95/95 UTL is the distribution free 95% upper tolerance limit of the 95<sup>th</sup> percentile except Rocky Flats, which is the geometric upper tolerance limit. UTLs are a metric for judging compliance with occupational exposure limits.

## Appendix 4

### Detailed Data for Length of Employment and Year of First Hire

The duration of an individual's employment is sometimes used as a surrogate for exposure when no exposure monitoring data are available. CBD is a long-latency period lung disease, and in theory, the total amount of beryllium accumulated in the lungs should be a risk factor for the disease. One expects that individuals with a long length of employment in a beryllium facility would have greater total lifetime exposures. However, this is not necessarily true, since a shorter duration of employment in a job with high exposure levels could result in a greater accumulation of beryllium in the lung. Other CBD health studies have not found length of employment to be a significant risk factor. The data for Rocky Flats and Y-12 are somewhat suggestive of an increasing CBD rate with increasing length of employment. No trend is apparent at other DOE sites and there does not seem to be the same trend in the beryllium sensitization rate at Y-12 or Rocky Flats. When compared with other plants, Rocky Flats has a large

proportion of workers with long lengths of employment, which may account for why a rather weak association between duration of employment and prevalence of CBD is more strongly suggested at these plants than others.

Year of hire is used as a surrogate for latency period from the time of first exposure to sensitization and disease. The latency period for beryllium sensitization and CBD are highly variable and not understood. It is known that the onset of sensitization and disease can be delayed months, years, or decades after exposure has ceased. It is thought that some event triggers the immune system to begin responding to beryllium but the nature of the event is not known. One expects that the rate of sensitization and disease in an exposed population would increase with increasing latency. However, this might not be true if there were eras when beryllium exposure was higher and more widespread.

**Y-12****Detailed Numbers by Length of Employment**

Years Worked	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
Less than 5	152	3	4	7	1.97%	2.63%	4.61%
5 to <10	142	4	1	5	2.82%	0.70%	3.52%
10 to <15	134	5	2	7	3.73%	1.49%	5.22%
15 to <20	459	6	5	11	1.31%	1.09%	2.40%
20 to <25	509	11	5	16	2.16%	0.98%	3.14%
25 to <30	273	9	7	16	3.30%	2.56%	5.86%
30 or >	866	26	21	47	3.00%	2.42%	5.43%
Not Reported	0	0	0	0	0.00%	0.00%	0.00%
<b>Total</b>	<b>2,535</b>	<b>64</b>	<b>45</b>	<b>109</b>	<b>2.52%</b>	<b>1.78%</b>	<b>4.30%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

**Detailed Numbers by Year of Hire**

Year of First Hire	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
<=1959	581	23	10	33	3.96%	1.72%	5.68%
1960-1969	486	10	14	24	2.06%	2.88%	4.94%
1970-1979	586	16	10	26	2.73%	1.71%	4.44%
1980-1989	723	12	9	21	1.66%	1.24%	2.90%
1990-1999	159	3	2	5	1.89%	1.26%	3.14%
Not Reported	0	0	0	0	0.00%	0.00%	0.00%
<b>Total</b>	<b>2,535</b>	<b>64</b>	<b>45</b>	<b>109</b>	<b>2.52%</b>	<b>1.78%</b>	<b>4.30%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

## Kansas City Plant

### Detailed Numbers by Length of Employment

Years Worked	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
Less than 5	636	19	1	20	2.99%	0.16%	3.14%
5 to <10	493	12	0	12	2.43%	0.00%	2.43%
10 to <15	449	6	0	6	1.34%	0.00%	1.34%
15 to <20	260	3	0	3	1.15%	0.00%	1.15%
20 to <25	149	1	1	2	0.67%	0.67%	1.34%
25 to <30	228	8	0	8	3.51%	0.00%	3.51%
30 or >	691	12	1	13	1.74%	0.14%	1.88%
Not Reported	57	0	0	0	0.00%	0.00%	0.00%
<b>Total</b>	<b>2,963</b>	<b>61</b>	<b>3</b>	<b>64</b>	<b>2.06%</b>	<b>0.10%</b>	<b>2.16%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

### Detailed Numbers by Year of Hire

Year of First Hire	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
< 1960	991	20	2	22	2.02%	0.20%	2.22%
1960-1969	735	15	1	16	2.04%	0.14%	2.18%
1970-1979	487	7	0	7	1.44%	0.00%	1.44%
1980-1989	585	17	0	17	2.91%	0.00%	2.91%
1990-1999	104	1	0	1	0.96%	0.00%	0.96%
2000 or >	14	1	0	1	7.14%	0.00%	7.14%
Not Reported	47	0	0	0	0.00%	0.00%	0.00%
<b>Total</b>	<b>2,963</b>	<b>61</b>	<b>3</b>	<b>64</b>	<b>2.06%</b>	<b>0.10%</b>	<b>2.16%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

## Lawrence Livermore National Laboratory

### Detailed Numbers by Length of Employment

Years Worked	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
Less than 5	531	10	2	12	1.88%	0.38%	2.26%
5 to <10	210	6	1	7	2.86%	0.48%	3.33%
10 to <15	168	6	1	7	3.57%	0.60%	4.17%
15 to <20	109	4	0	4	3.67%	0.00%	3.67%
20 to <25	92	5	0	5	5.43%	0.00%	5.43%
25 to <30	139	6	1	7	4.32%	0.72%	5.04%
30 or >	272	8	2	10	2.94%	0.74%	3.68%
Not Reported	39	1	0	1	2.56%	0.00%	2.56%
<b>Total</b>	<b>1,560</b>	<b>46</b>	<b>7</b>	<b>53</b>	<b>2.95%</b>	<b>0.45%</b>	<b>3.40%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

### Detailed Numbers by Year of Hire

Year of First Hire	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
< 1960	295	9	2	11	3.05%	0.68%	3.73%
1960-1969	491	17	1	18	3.46%	0.20%	3.67%
1970-1979	387	10	3	13	2.58%	0.78%	3.36%
1980-1989	268	9	1	10	3.36%	0.37%	3.73%
1990-1999	79	0	0	0	0.00%	0.00%	0.00%
2000 or >	0	0	0	0	0.00%	0.00%	0.00%
Not Reported	40	1	0	1	2.50%	0.00%	2.50%
<b>Total</b>	<b>1,560</b>	<b>46</b>	<b>7</b>	<b>53</b>	<b>2.95%</b>	<b>0.45%</b>	<b>3.40%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

## Rocky Flats Environmental Technology Site

### Detailed Numbers by Length of Employment

Years Worked	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
Less than 5	2,467	69	31	100	2.80%	1.26%	4.05%
5 to <10	1,150	24	16	40	2.09%	1.39%	3.48%
10 to <15	1,221	26	22	48	2.13%	1.80%	3.93%
15 to <20	707	27	15	42	3.82%	2.12%	5.94%
20 to <25	692	21	14	35	3.03%	2.02%	5.06%
25 to <30	524	20	14	34	3.82%	2.67%	6.49%
30 or >	518	12	16	28	2.32%	3.09%	5.41%
Not Reported	119	20	1	21	16.81%	0.84%	17.65%
<b>Total</b>	<b>7,398</b>	<b>219</b>	<b>129</b>	<b>348</b>	<b>2.96%</b>	<b>1.74%</b>	<b>4.70%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

### Detailed Numbers by Year of Hire

Year of First Hire	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
< 1960	980	32	30	62	3.27%	3.06%	6.33%
1960-1969	2,013	69	40	109	3.43%	1.99%	5.41%
1970-1979	1,289	46	30	76	3.57%	2.33%	5.90%
1980-1989	2,211	55	22	77	2.49%	1.00%	3.48%
1990-1999	883	15	7	22	1.70%	0.79%	2.49%
2000 or >	4	0	0	0	0.00%	0.00%	0.00%
Not Reported	18	2	0	2	11.11%	0.00%	11.11%
<b>Total</b>	<b>7,398</b>	<b>219</b>	<b>129</b>	<b>348</b>	<b>2.96%</b>	<b>1.74%</b>	<b>4.70%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

## Pantex Plant

### Detailed Numbers by Length of Employment

Years Worked	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
Less than 5	237	7	1	8	2.95%	0.42%	3.38%
5 to <10	123	1	1	2	0.81%	0.81%	1.63%
10 to <15	112	0	1	1	0.00%	0.89%	0.89%
15 to <20	110	3	0	3	2.73%	0.00%	2.73%
20 to <25	83	1	0	1	1.20%	0.00%	1.20%
25 to <30	82	2	0	2	2.44%	0.00%	2.44%
30 or >	184	8	1	9	4.35%	0.54%	4.89%
Not Reported	30	1	0	1	3.33%	0.00%	3.33%
<b>Total</b>	<b>961</b>	<b>23</b>	<b>4</b>	<b>27</b>	<b>2.39%</b>	<b>0.42%</b>	<b>2.81%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.

### Detailed Numbers by Year of Hire

Years Worked	Number of Workers Tested	Number BeS <sup>a</sup>	Number Diagnosed CBD	Total	BeS Rate	CBD Rate	BeS + CBD Rate
< 1960	156	6	1	7	3.85%	0.64%	4.49%
1960-1969	165	5	0	5	3.03%	0.00%	3.03%
1970-1979	236	4	2	6	1.69%	0.85%	2.54%
1980-1989	221	5	0	5	2.26%	0.00%	2.26%
1990-1999	153	3	1	4	1.96%	0.65%	2.61%
2000 or >	2	0	0	0	0.00%	0.00%	0.00%
Not Reported	28	0	0	0	0.00%	0.00%	0.00%
<b>Total</b>	<b>961</b>	<b>23</b>	<b>4</b>	<b>27</b>	<b>2.39%</b>	<b>0.42%</b>	<b>2.81%</b>

<sup>a</sup> BeS defined as 2 abnormal BeLPTs.