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Lawrence Livermore National Laboratory Beryllium-Affected Cases, 1998–2009

An Epidemiologic Descriptive Analysis

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Table of Contents

1.0 Executive Summary

This report details an epidemiologic descriptive analysis of 46 beryllium-affected workers identified by the LLNL Health Services Department (HSD) between 1998 and 2009. The cases include 3 workers diagnosed with chronic beryllium disease (CBD), 30 sensitized workers (2 abnormal beryllium lymphocyte proliferation tests (BeLPT)) and 13 beryllium concern workers (1 abnormal and 1 or more borderline BeLPTs). In this report, these 46 cases will collectively be referred to as "beryllium-affected workers". The analysis was conducted to evaluate the factors that may have contributed to the identification of the beryllium-affected workers and to the apparent increase seen in 2007. As a part of this analysis, a focused review of the machinists and waste processing was conducted. In addition, the analysis included a comparative review of the beryllium-affected cases (n=61) identified in past workers through the DOE Beryllium Medical Surveillance Program (BMSP) and sensitized workers (n=16) identified through the DOE Former Worker Program (FWP).

1.1 LLNL HSD Identified Beryllium-Affected Cases

The analysis showed that beryllium-affected worker status not only occurred among workers who had direct contact with beryllium, such as machinists, but also among those individuals who had incidental exposure through an unknown pathway, and included occupational activities such as facility support, and managerial/administrative work. The following were identified as major factors that potentially contributed to the increase in beryllium-affected workers identified at LLNL beginning in 2007.

- In 2006, the Health Services Department (HSD) adopted the new medical diagnostic descriptive category "beryllium concern" in an attempt to increase the margin of safety for workers at LLNL. This new diagnostic category ensures that employees with one abnormal and at least one borderline BeLPT are properly protected from further exposure to beryllium while in the workplace. This change is consistent with the approach used by the DOE National Supplemental Screening Program and the recommendations of the National Academy of Science Committee on Beryllium Alloy Exposures. The order in which the abnormal and the borderline BeLPT results occurred is not an issue. This change did result in an increase in the total number of beryllium-affected cases. Although this change did not account for the total increase, those categorized as beryllium concern did account for 39% of the cases (7/18) identified in 2007 and for 3 of the 9 cases seen in 2008. It is important to recognize that the concern classification is an important diagnostic tool, and through March 2007 one of the three diagnosed CBD cases occurred in an individual identified as "beryllium concern".

- While the largest number of beryllium-affected employees came from previously identified direct exposure groups such as machinists, other indirect exposure groups, such as waste processing, technicians, crafts and trades, and those with incidental exposure to beryllium (managerial/administrative, laborers, security) were also identified as being beryllium-affected.
- Employees who worked in B321C NC Shop or who worked in the Waste Complex (n=34) accounted for 74% of the 46 beryllium-affected cases.
- Increased awareness by beryllium-affected individuals and discussions regarding beryllium with line management may have led workers who had not been previously involved in beryllium surveillance to seek testing.
- Repeat testing of individuals with first abnormal or borderline test results in prior years accounted for two-thirds of the new beryllium-affected cases in 2007.
- With a few exceptions the beryllium-affected cases had work histories that provided the potential for incidental, indirect, or direct exposure to beryllium at some point during employment at LLNL. Exposure in all but a few of the beryllium-affected cases reviewed can be linked to a facility with current beryllium operations, legacy facility contamination or tasked based activities involving beryllium. There were three cases (an administrative assistant, a chemist, and a security employee) in which the opportunity for exposure was not identifiable and there was no apparent spatial or temporal relationship with beryllium operations in the facility. The chemist from this group had reported a potential for exposure to beryllium while employed at the Pantex Plant (1991-1999). However, interview based information indicated the potential for legacy beryllium exposure for these three cases. All three cases reported having been in buildings where legacy beryllium might be present.
- LLNL HSD's beryllium surveillance program (1998-2009), the BMSP (1999-2003), and Boston University and the University of California at San Francisco (BU-UCSF) FWP (2007-2009) had distinct differences in job category distributions. Although partially the result of the selection process for participation in each surveillance program, the differences demonstrated the value of increasing participation by incidental and indirect job category employees in the LLNL beryllium surveillance program.
- Industrial hygiene beryllium personal air sampling data for the 46 individuals was limited; however, historical monitoring for identified beryllium activities and areas at LLNL indicated typical airborne exposure levels below the action level (0.2 $\mu g/m^3$).
- Given the occupational diversity of the beryllium-affected population from 2007 no common factor (job function, beryllium exposure incident(s), work location) was identified that would have resulted in the increase seen in beryllium sensitivity.
- Of the 46 beryllium-affected cases 18 employees were identified as having begun work at LLNL as subcontractors (17) or as a student (1), and 7 subcontractors and the only student reported the potential for beryllium exposure as non-LLNL employees.

1.2 LLNL Machinists and Waste Processing

Machinists and waste processing accounted for 15 of the 46 beryllium-affected individuals. These individuals represent direct and indirect exposures to beryllium and account for the majority of the individuals working in B321C NC Shop and Waste Complex buildings (B513, B514, B625, B695), respectively.

- Employees from all job categories who worked in B321C NC Shop accounted for a significant portion of the beryllium-affected population (29 of 46, 63%). Machinists (n=11), and waste processing (n=2) accounted for a significant portion (13 of 30, 43%) of the beryllium-affected cases who worked in B321C NC Shop.
- Employees who worked in the Waste Complex also accounted for a significant portion of the beryllium-affected population (14 of 46). Waste processing (n=4) personnel accounted for 29% of the beryllium-affected cases who worked in the Waste Complex.

1.3 The Beryllium Medical Surveillance Program (BMSP) and the DOE Former Worker Program (FWP)

The Department of Energy (DOE) in cooperation with Oak Ridge Institute for Science and Education (ORISE) conducted a voluntary Beryllium Medical Surveillance Program (BMSP) for former employees of several DOE Sites between 1998 and 2003. The BMSP was initiated to detect possible long-term health effects of exposure to beryllium and beryllium alloys. The DOE Former Worker Program (FWP) offers free medical screening to former DOE workers who may have been exposed to hazardous substances while employed at DOE sites/facilites. The legislative mandate for this program is the 1993 Defense Authorization Act (Public Law 102-484, Section 3162). Boston University and the University of California at San Francisco (BU-UCSF), manage the FWP for former employees of LLNL, which began in April 2007.

- A comparison of the beryllium-affected former workers from the BMSP (n=61), the BU-UCSF FWP (n=16, does not include beryllium concern category), and the HSD identified beryllium-affected cases (n=46) showed some distinct differences. The difference in job category distributions for each of the respective surveillance programs was at least partially based on the voluntary participation of former workers for the BMSP and FWP, and the more managed selection process used by the LLNL beryllium medical surveillance program. However, the job category differences between the two former worker beryllium surveillance beryllium-affected populations and the HSD identified cases, suggested that additional beryllium medical surveillance participation by indirect or incidentally beryllium exposed LLNL employees might identify additional beryllium-affected cases.

- Beryllium sensitization, beryllium concern, and CBD rates for LLNL HSD identified cases (n=46), BMSP cases (n=61), and BU-UCSF FWP cases (n=16, sensitization only reported) as of March 31, 2009 were as follows. Please note that some beryllium-affected cases may be counted twice due to the de-identified nature of the BU-UCSF population.

Group Tested	Number Tested	Beryllium Sensitization Rate	Beryllium Concern Rate	CBD Rate	Beryllium-Affected Rate
HSD Identified	1,007	2.98%	1.29%	0.30%	4.57%
BMSP	1,804	2.61%	0.33%	0.44%	3.38%
BU-UCSF	525	3.05%	n/a	n/a	3.05%

2.0 Methods

An epidemiologic descriptive analysis was conducted concerning 46 LLNL beryllium-affected employees who had worked at LLNL between January 1, 1998 and March 31, 2009. The individuals were identified through the LLNL HSD beryllium surveillance program. Some of these individuals (n=12, 9 participating in interviews) were no longer employed by LLNL. Interviews either in person or via the telephone were offered to each of the 46 cases regardless of present LLNL employment status. Interviews were conducted by Bill Stange, Ph.D., ORAU, in association with Kathleen Noonan, LLNL Health Services, and Steve Lee, LLNL Hazards Control using a questionnaire (**Attachment 1**), which was based on questionnaires used as part of the BMSP and the LLNL beryllium surveillance program. Self-reported work history questionnaires, medical records, and industrial hygiene personal beryllium air sampling reports provided additional information for beryllium-affected cases. Categorization of cases based upon a common occupational characteristic (job type, work location, shift, etc.) is often used in occupational epidemiology investigations. Several categorization schemes were reviewed (e.g., official LLNL job title, LLNL directorate, buildings worked in). These schemes were determined to be non-specific in nature, and would not have been as beneficial for characterizing LLNL beryllium-affected cases. Categorization of functional job-specific duties was selected as it more appropriately approximated the potential for beryllium exposure. This categorization scheme resulted in the following groups: engineer/scientist, machinist (beryllium and general), technician, demolition, laborer, crafts and trades, facility support, administrative, security, and waste processing. In addition beryllium-affected cases were also categorized based on the most probable type of beryllium exposure that occurred while at LLNL: direct (hands-on work with beryllium), indirect work (work in an area where beryllium work was performed), and incidental (inadvertent exposure). Functional job-specific duties and beryllium exposure categorizations were based on the information provided through beryllium-affected case interviews and information provided through LLNL Health Services and Hazards Control. De-identified timelines for each of the 46 beryllium-affected cases (cases were listed by the LLNL Health Services assigned case numbers) were developed that covered major LLNL events including date of hire as a LLNL employee and/or as a subcontractor, date of first BeLPT, date of first abnormal BeLPT, date of repeat abnormal BeLPT (sensitization/concern date), the date(s) of personal air sampling for beryllium, and job titles held (**Appendix 1**). A timeline for LLNL was also produced that provided important beryllium related events including dates of beryllium-affected case identification, and dates of major beryllium exposure incidents at LLNL since beryllium was introduced at LLNL in 1952, at its inception (**Appendix 2**). For the LLNL timeline, cases were listed in chronological order based on the date of beryllium-affected identification and were referenced by the LLNL Health Services assigned case numbers.

In 1999, the DOE published airborne beryllium and surface contamination limits in 10 CFR 850, the "Chronic Beryllium Disease Prevention Plan" (CBDPP). The DOE regulation focused on efforts to reduce exposure through controls associated with airborne beryllium and, as such, established a beryllium action level of 0.2 $\mu g/m^3$ for airborne beryllium, and a permissible exposure limit of 2.0 $\mu g/m^3$. To reduce potential exposure due to surface contamination, DOE instituted a release level of 0.2 $\mu g/100cm^2$ for the release of contaminated equipment and established a housekeeping level of 3.0 $\mu g/100cm^2$ for cleaning practices followed during non-operational periods. Since surface contamination in operational areas may pose a potential employee exposure to airborne beryllium either through the resuspension of settled dust or transfer from contaminated surfaces via a worker's hand or clothing, LLNL has expanded its definition of exposure to include surface contamination levels greater than the release level.

2.1 Categorizations

The categorization of LLNL beryllium-affected cases based upon specific occupational characteristics was used for this review.

2.1.1 Beryllium Exposure

- **Direct** - Included employees who had hands-on work with beryllium or beryllium components. Beryllium may be in the form of metal, ceramic, or an alloy. Some representative types of work include: machining, milling, boring, drilling, grinding, polishing, brazing, sputtering, welding, inspecting beryllium components, and handling beryllium contaminated materials in waste streams.

- **Indirect** - Included individuals working in an area where any type of beryllium work is presently occurring or has occurred, but had no direct contact with beryllium.

- **Incidental** - Included employees responsible for repairing and/or calibrating machines associated with beryllium. Also included employees who walk through or visit areas where beryllium work was being conducted or had previously been conducted, with no direct beryllium contact.

2.1.2 Functional Job-Specific Duties

- **Engineer/Scientist** - Employees who indicated that their work was in areas primarily associated with research involving biology, chemistry, physics, engineering, or mathematics.

- **Machinist (general or beryllium) -** Employees who indicated that they conducted any of the following operations on non-beryllium metal components (included special nuclear material) and beryllium components: machining, milling, grinding, drilling, boring, polishing, or sputtering.

- **Technician** - This category involved positions that were technical in nature, may or may have not involved the potential for direct exposure, and crossed several different areas of site and facility support.

- **Demolition** - Decontamination and decommissioning activities for buildings and facilities at the site. Decontamination and decommissioning is one component of the job activities assigned to Space Action Team (SAT) personnel.

- **Laborer** - General maintenance activities for the grounds and buildings of the site.

- **Crafts and Trades** - Employees from building trades including electricians, carpenters, plumbers, pipefitters, and heating/ventilation/air-conditioning workers.

- **Facility Support** - Employees from this group provided general services to LLNL such as custodial, general repairs and maintenance.

- **Managerial/Administrative** - Employees who were in managerial or administrative support positions.

- **Security** - Employees whose specific duties were associated with the administration of security procedures, the inspection of buildings and facilities for security compliance assurance, and the guard force.

- **Waste Processing** - Employees whose primary activity was waste handling, processing, or characterization of waste. This category specifically included those who worked in the Radioactive Hazardous Waste Management (RHWM) group. Waste Processing personnel are made up of specially assigned Decontamination/Crafts & Trades/Laborers that process waste resulting from building decontamination and decommissioning.

3.0 Findings

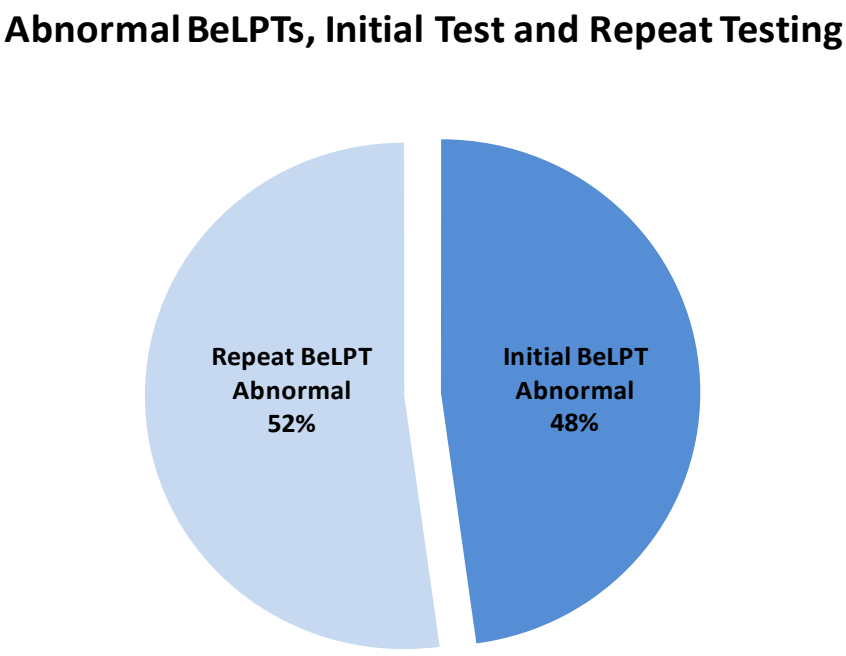
The findings of this review will be presented in a question and answer format. The questions are those that may potentially be asked as a consequence of the LLNL beryllium surveillance program and its outcomes.

3.1 LLNL Beryllium Surveillance Program

- Were the 46 LLNL beryllium-affected cases identified predominantly as the result of initial testing or during the course of on-going medical surveillance, i.e., repeated testing over the years?

  Since 1998, 22 individuals have been identified as being beryllium-affected as the result of an initial BeLPT (the first BeLPT test) being abnormal/borderline (and an immediate confirming BeLPT also being abnormal/borderline), and 24 individuals have been identified as being beryllium-affected (**Figure 1**) as the result of an initial BeLPT being normal and the repeat BeLPT in subsequent years being abnormal/borderline (and a confirming BeLPT also being abnormal/borderline) (**Attachment 2**)**.** Beryllium sensitivity, as defined by the DOE (10 CFR 850), requires two abnormal BeLPT results either in combination (two tests) or as the result of repeat testing. BeLPT results can be from the same laboratory or from different BeLPT laboratories. Abnormal BeLPT results do not have to be on consecutive tests. The medical diagnosis of sensitization is generally based on the date of the confirming abnormal BeLPT, rather than the date of the first abnormal result. However, from an epidemiologic perspective the date of the first abnormal BeLPT result is often used as the date of sensitivity. The term "first abnormal" refers to the first BeLPT result where an abnormal/borderline result is identified. The first abnormal/borderline can be the result from any of the BeLPTs performed during surveillance testing, i.e., the first BeLPT, the second, the third, etc. The “initial BeLPT” refers to the first BeLPT that an employee receives, without regard to the result outcome. The Department of Labor (DOL) under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) requires only one abnormal for a worker to be classified as beryllium sensitized and be eligible to file for DOL benefits. Borderline test results are not regarded as abnormal results by the DOL.

Figure 1



As previously mentioned, abnormal/borderline BeLPT results can occur the very first time individuals are tested or as the result of repeat testing. There are several factors that play a role in determining when an abnormal result is obtained. The first is the genetic make-up of the individual, as not all individuals have the genetic ability to develop sensitivity to beryllium. Additional factors include the time between an individual's first exposure to beryllium and the BeLPT (latency), the level and the frequency of beryllium exposure, and the health status of the individual being tested.

Since 1998, there have been increases in beryllium-affected rates for both those identified as the result of an initial abnormal BeLPT result and those identified as the result of regular retesting. These increases were based on factors already mentioned, and did not result from a particular exposure incident, working in a particular beryllium contaminated building, or being in a particular beryllium exposure group. Based on observations taken from beryllium surveillance in other DOE populations the distribution of individuals between the LLNL initial and retesting groups is not unusual.

For the initial BeLPT abnormal/borderline group there is presently no recognized means that can be used to determine exactly when these individuals developed beryllium

sensitivity. Identification of the first opportunity for exposure to beryllium can provide the minimum date for the development of sensitivity. Because there is a delay that may be years in length between the first exposure and the first abnormal BeLPT, the exact date for the development of sensitivity usually cannot be determined. This is one of the reasons for routine periodic retesting in a surveillance program.

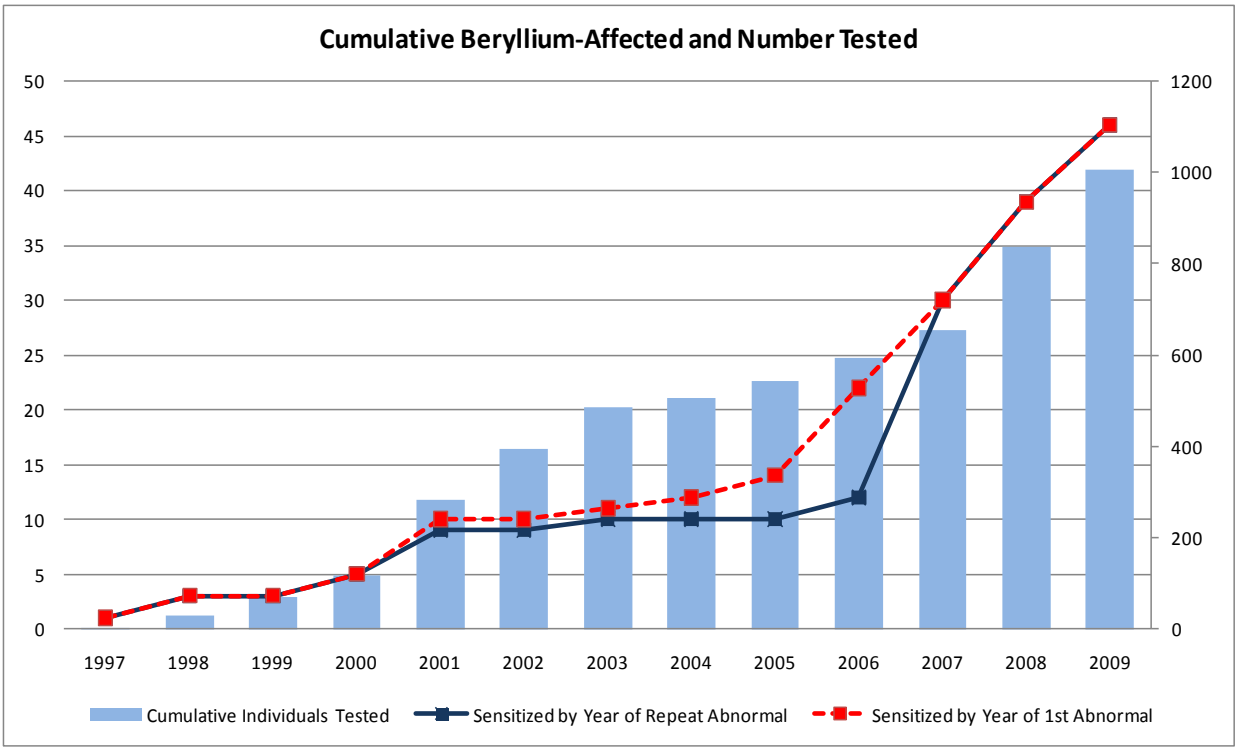
- Was there an increase in the beryllium-affected case incidence rate in 2007, and if so, what caused this increase in the incidence rate?

  Yes, there was an increase in beryllium-affected case identification in 2007. Prior to 2007 the beryllium sensitization rate was 1.36% with a CBD rate of 0.17% (one case). At the close of 2007 the corresponding rates were 4.48 % for sensitization (plus concern) and 0.31 % for CBD. The reasons for the increase in beryllium-affected incidence rate are multifaceted. The increase in cases was partially based on the increases in the first time beryllium surveillance program participation rate and partly on the number of rescreening BeLPTs performed on individuals with abnormal tests in prior years (**Attachment 2**). As the number of individuals participating in the LLNL beryllium surveillance program increased, the opportunity for the identification of new beryllium-affected cases also increased. First time surveillance participants provide an opportunity for new case identification. The identification of beryllium sensitization in individuals who had abnormal tests in prior years, many of whom tested normal in intervening years, demonstrates the importance of ongoing surveillance in this population.

  In 2007, retesting of first abnormals or borderlines accounted for two-thirds (12/18) of the newly identified beryllium-affected cases. Ten of the 12 identified beryllium-affected cases that had been retested had an initial abnormal or borderline abnormal BeLPT result in years other than 2007, but follow-up BeLPTs did not confirm the original abnormal. Six individuals had an initial abnormal in 2006, two in 2005 and one each in 2004 and 2001 that were not confirmed until 2007. As the result of increased beryllium surveillance testing for participants, previous abnormal BeLPTs were confirmed in 2007. If these 10 cases had been confirmed in the same year as the initial abnormal BeLPT an alternate sensitivity model regarding the 2007 increase might have been seen (**Attachment 2**) with the *de novo* identification of 8 cases rather than 18. Bolded numbers indicate the changes in beryllium-affected case numbers by year, if these cases were attributed to the year in which the first abnormal test occurred. Correspondingly, the number of beryllium-affected cases in 2006, 2005, 2004, and 2001 would have increased by a total of 10.

Figure 2 shows the cumulative number of beryllium-affected cases by year and the cumulative number of LLNL employees tested by year. The cases are presented based upon the date that the abnormal BeLPT was confirmed (solid blue line). **Figure 2** also shows the change in the cumulative number of individuals found beryllium-affected in 2007, if the cases were attributed to the year of the first abnormal result (dashed red line). The dashed red line also shows a normal increase in beryllium-affected cases as the number of new beryllium surveillance participants increased and the retesting of individuals with previous normal or unconfirmed abnormal occurs. The large increase seen in the 2007 beryllium-affected rate appears to have been the result of a number of inter-related factors including the increased frequency of BeLPTs, new testing enrollment, and repeat testing especially for those who had a previous unconfirmed abnormal BeLPT result.

Figure 2



- Did the 2007 increase in the beryllium sensitivity/concern incidence result from a single exposure pathway, e.g., building, activity, or a group of employees?

No. Based on the data collected it appears that the increase in the beryllium-affected incidence rate was the result of a combination of factors as previously described.

- Are there populations (by job category, work location, or other parameter) that should be considered Beryllium Associated Workers or Beryllium Workers?

  Based on the analysis of the data, it is suggested that the Crafts and Trades, and Technician functional job categories should be reviewed for inclusion in the Beryllium Associated Workers classification. In addition, Waste Processing should be reviewed for classification for inclusion in the Beryllium Workers classification.

- Were any beryllium exposure incidents identified that have resulted or may result in the identification of beryllium-affected cases?

  As part of an on-going beryllium baseline inventory facility characterization survey at LLNL, beryllium contamination was found in a known beryllium work area. On elevated surfaces in Building 321C NC Shop, contamination levels, which were higher than previously encountered and above the release criterion of 0.2 µg/100 cm^2 were detected. Contamination above the release level was found in 83 of 1,107 samples taken in Building 321C. Sample measurements ranged from 0.2 to 3.1 µg/100 cm^2. In July 2007, additional sampling was performed that further characterized the extent of the legacy beryllium contamination. Levels during this sampling ranged from 0.2 to 56 µg/100 cm^2. Surface contamination in these operational areas may pose a potential pathway for employee exposure not previously identified and communicated through the work control process. From 2002 through 2007, as part of the Engineering Technology Center Upgrade Project, LLNL crafts and trades personnel, as well as laborers, and subcontractors had opportunity for indirect or incidental exposure to beryllium. While potential exposures may be attributed to this event, it is not possible to definitively attribute beryllium sensitization to the Upgrade Project or to other discrete exposure events for the LLNL workers. There are other possible exposure factors such as alternate work activities, uncertainties about time course of exposures, etc., that make such determinations impossible. However, three subcontractors affiliated with the Upgrade Project were identified as beryllium-affected cases.

- Were machinists and mechanical technicians a high percentage of the HSD identified beryllium-affected cases? What about technicians as a group? What was the time sequence?

Machinists accounted for 11 (24%) and mechanical technicians accounted for 4 (9%) of the 46 identified beryllium-affected cases. The first beryllium-affected machinist began employment at LLNL in October 1977, was first tested in March 1999, shortly after HSD began using the BeLPT, and had a first abnormal BeLPT result as the result of repeat testing in May 2001.

As a group, technicians (chemical, electronics, engineering, hydrodynamics, mechanical, waste operations) accounted for 17 (37%) of the 46 HSD identified beryllium-affected cases. The first beryllium-affected mechanical technician began employment at LLNL in July 1965, was first tested in February 2000, and had a first abnormal BeLPT result on an initial test in February 2000. The first reported beryllium exposure occurred in the aforementioned mechanical technician, who also was the first technician identified with an abnormal BeLPT result.

- Was waste processing a high percentage of the HSD identified beryllium-affected cases? What was the time sequence?

  Waste processing accounted for 4 (9%) of the 46 identified beryllium-affected cases. The first beryllium-affected waste processor began employment at LLNL in November 1991, was first tested in November 2006, and had a first abnormal BeLPT result following repeat testing in January 2007.

- Did work in the B321C NC Shop or Waste Complex by technicians account for a significant portion of the beryllium-affected population?

  Yes. In addition to the 11 machinists and the 2 waste processing personnel, 9 technicians worked for varying amounts of time in B321C NC Shop or the Waste Complex.

- Did work in the B321C NC Shop or Waste Complex account for a significant portion of the HSD identified beryllium-affected cases?

- Yes. The greatest frequency of beryllium-affected employees (29 of 46) reported some level of work activity in B321C NC Shop. Fourteen of the 46 beryllium-affected cases reported having worked in one of the Waste Complex buildings (B513, B514, B625, B695).

3.2 The LLNL BMSP

- What was the LLNL BMSP? How were the former LLNL employees recruited and how is that different from recruitment for the LLNL beryllium surveillance program? How many former employees were screened?

  Between 1998 and 2003, the DOE in cooperation with ORISE, conducted the voluntary BMSP for former employees of several DOE Sites, including LLNL. The BMSP was initiated to detect possible long-term health effects of exposure to beryllium and beryllium alloys. Beginning in late 1998 and continuing through 2000, more than 10,000 former LLNL workers were invited to participate in the LLNL BMSP through a direct mail campaign. Participation in the LLNL BMSP was on a voluntary basis. The potential for exposure to beryllium was determined by the former LLNL employee and was the basis for participation, but no LLNL employee was refused participation in the BMSP. During the BMSP, 1,804 former LLNL employees received at least an initial test for beryllium sensitivity. Of this group 61 individuals were identified as beryllium-affected (55 beryllium sensitized, 6 beryllium concern), and 8 from the beryllium-affected group were identified with some level of chronic beryllium disease. Participation in the LLNL beryllium surveillance program is through a more managed selection process and is based upon an employee's present or past opportunity for exposure to beryllium. Since 1998, 1,007 individuals have participated in the LLNL beryllium surveillance program. Of this group 46 have been identified as beryllium-affected, and 3 from the affected group were identified with some level of chronic beryllium disease.

- What are the differences and similarities between the LLNL BMSP beryllium-affected cases identified between 1999 and 2003, the LLNL HSD identified beryllium-affected cases identified between 1998 and 2009, and the BU-UCSF FWP participants who received testing between 2007 and 2009?

  The BMSP beryllium-affected former workers who received testing between 1999 and 2003, the 46 beryllium-affected cases identified by LLNL HSD's beryllium surveillance program, and the BU-UCSF FWP LLNL beryllium-affected workers who received testing between 2007 and 2009 showed distinct differences in job category distributions. The differences, although partially the result of the selection process for participation in each surveillance program, demonstrated that other types of jobs could be included in the LLNL beryllium surveillance program. Employees either incidentally or indirectly exposed to beryllium comprised a significant portion of the BMSP beryllium-affected population, while the current employee group was comprised of more individuals with direct and indirect exposure potential (**Figure 3**). Job categories with a significant difference in the portion of BMSP versus the LLNL HSD's identified beryllium-affected

group are shown with percentages for each respective job category. Only limited information regarding buildings worked was collected for the BMSP population.

The BMSP beryllium-affected group was comprised of former employees who worked at LLNL prior to the implementation of the LLNL CBDPP in 2001. As mentioned in the preceding paragraph, individuals in this group were more likely to have an opportunity for incidental and indirect exposure to beryllium, but since no industrial hygiene beryllium air sampling data is available for the BMSP group this reasoning is based solely on subjective reasoning. The HSD beryllium-affected group had a longer mean employment at LLNL than those identified through the BMSP (17.7 years versus 15.8 years). The prevalence rate of beryllium-affected cases (beryllium sensitized plus beryllium concern) for the BMSP group was 61/1,804 (3.38%) versus 46/1,007 (4.57%) for the employees identified by LLNL's HSD.

The earliest initial exposure to beryllium at LLNL for the BMSP beryllium-affected group and for the LLNL HSD identified beryllium-affected group was reported to have occurred in 1953 and 1958, respectively (**Attachment 4**). First exposure years were reported by 45 of the 61 members of the BMSP group and by 43 of 46 members of the HSD identified employee group. The potential for direct exposure to beryllium was significantly greater in the HSD identified beryllium-affected group with 15 of 46 (33%) who reported machining beryllium or waste processing versus 6 of 61 (10%) in the BMSP group. Work (at any level or for any duration) in a building that had some type of beryllium activity was reported by 45 of the 46 (98%) HSD identified beryllium-affected employees, but by only 13 of the 61 (21%) BMSP individuals. The buildings worked in for the HSD identified and the BMSP beryllium-affected individuals are shown **Attachment 3a** and **3b**, respectively. **Figure 4** shows the distribution of the 15 buildings/facilities worked in most commonly identified by the LLNL HSD beryllium-affected population overlaid with those most commonly worked in by the BMSP beryllium-affected population. The data for all buildings noted by workers from the BMSP and the HSD current worker programs are shown in **Attachments 3a** and **3b**. The distribution of facilities worked in between the two populations varies significantly. These data clearly indicate that a high percentage of employees from the HSD identified beryllium-affected group worked in buildings where an opportunity for exposure to beryllium was present. The BMSP identified beryllium-affected group did not show the same frequency of work in these same buildings. There may be several explanations for this finding.

Figure 3

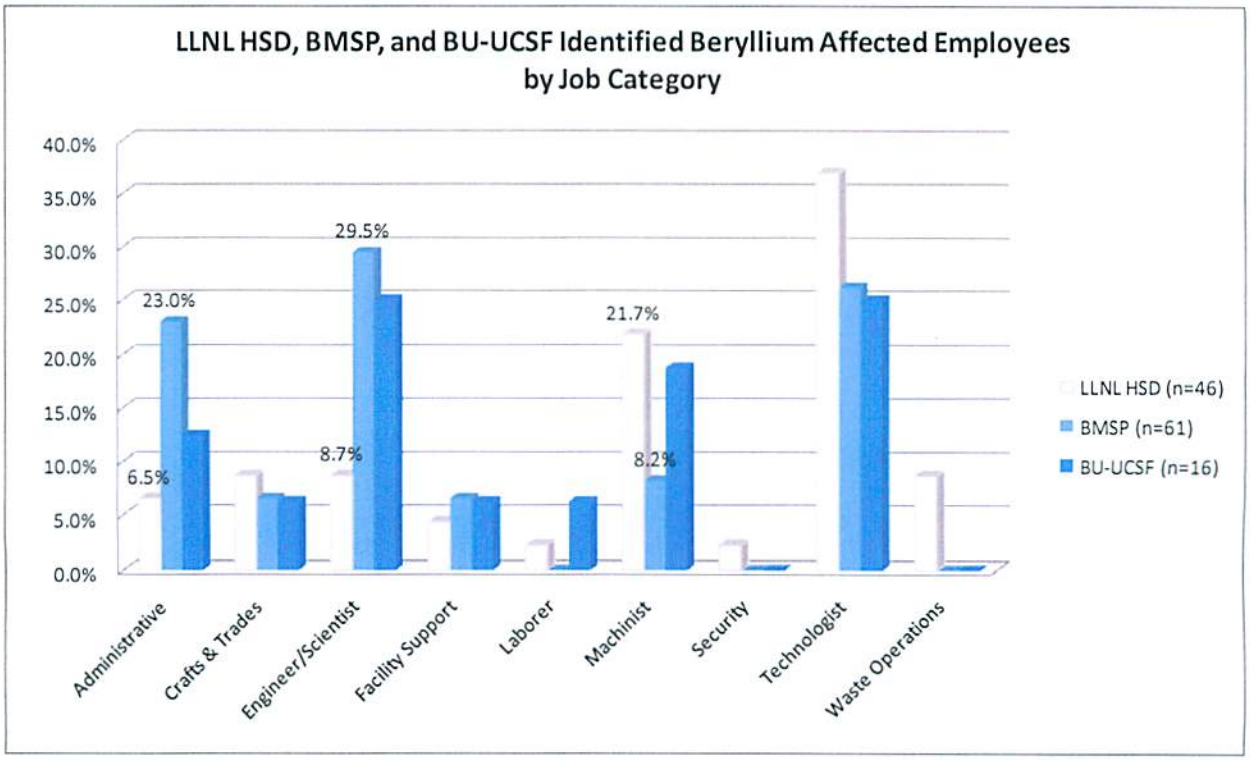
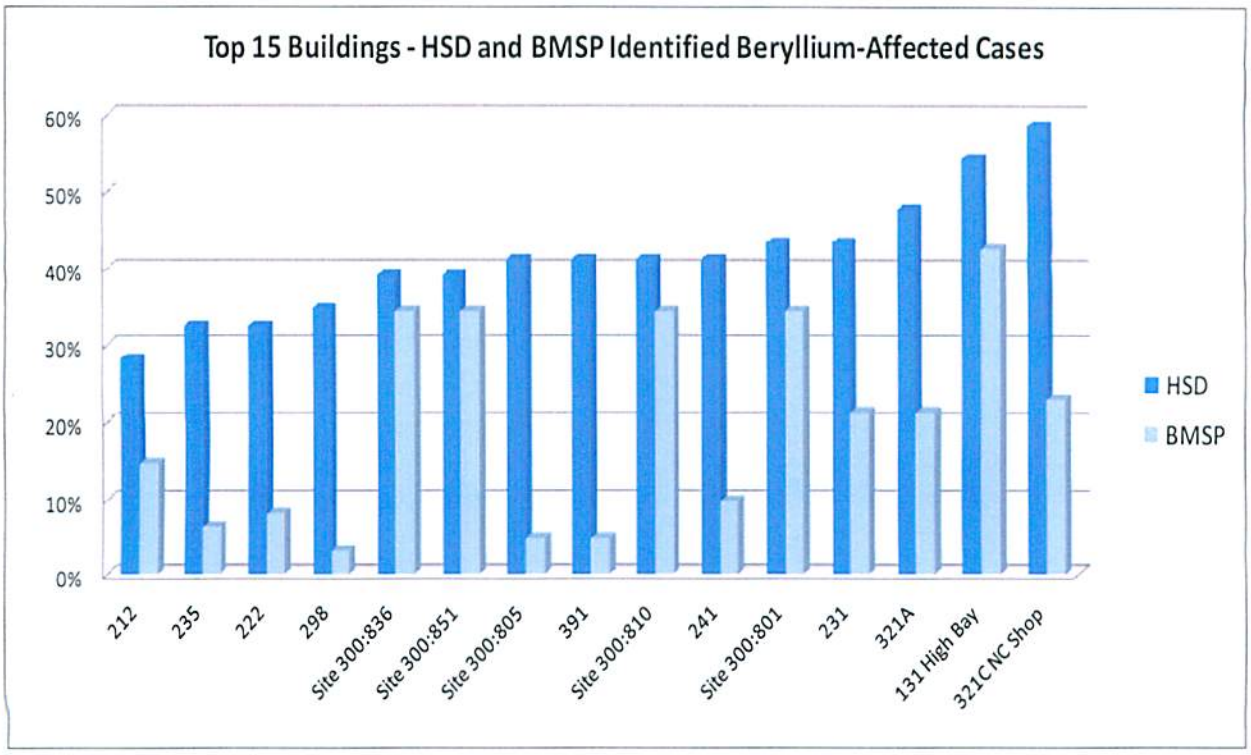


Figure 4



There was a significant difference between the types of facilities in which the HSD and the BMSP identified beryllium-affected populations worked. The first facility type was not identified in the legacy inventory and poses a beryllium exposure risk to current/recent LLNL workers. The legacy inventory was required by DOE in 10 CFR 850, which was promulgated in the early 2000s. The second type of facility, which presented a risk of exposure to former LLNL workers, has been either decontaminated or demolished and no longer poses an exposure risk to more current/recent workers. This analysis provides important information, but is complicated by the following factors:

- Facilities for both groups were self-identified and may or may not have housed beryllium activities or had legacy beryllium contamination.
- The presence of an individual in a facility does not necessarily indicate exposure to airborne or surface beryllium.
- Given that most individuals at LLNL have visited or worked in a number of different facilities over time, a substantial number of buildings may have been spuriously identified during the interview process.
- Since LLNL facilities have been renumbered, most recently in the 1970s, numbers reported by the two populations may not be directly comparable.
- LLNL facilities were "owned" by programmatic organizations until 2008. Under this model, workers tended to spend most of their careers in their line organization's facilities. Therefore, employees may have reported working in all programmatic organization owned facilities instead of individual ones, e.g. machinists may have identified all of the Engineering-owned facilities as a location where they worked.
- Site 300 facilities in general, such as 801, 804, 805, 810, 826, 834, 836, and 851, are highly represented in the BMSP beryllium-affected population. Site 300 was the site of extensive open-air explosive testing of beryllium components in the past, an activity with a known potential for beryllium exposure. Site 300 facilities tend to be small, single-use buildings, so the identification of multiple buildings among a single set of workers is not surprising.

- Is the frequency of facilities worked in similar between the LLNL BMSP and the LLNL HSD beryllium-affected worker populations? Are there facilities identified only in one group of beryllium-affected workers?

  No. The buildings that the BMSP and the LLNL HSD beryllium-affected populations reported working in were very much the same. However, the distribution of facilities worked in by the BMSP and the LLNL HSD beryllium-affected populations varied significantly. The building distributions clearly indicated that a higher percentage of employees from the HSD identified beryllium-affected group worked in buildings where

a significant opportunity for exposure to beryllium was present, e.g., B321C NC Shop, B222, B235, B241, and B298.

No. There were no LLNL buildings/facilities where only one beryllium-affected group reported work activities.

4.0 Discussion

Beryllium has been used at LLNL since its inception in 1952. Because of the potential health concerns associated with exposure to beryllium, to address DOE's efforts to reduce the number of workers exposed to beryllium, to minimize the levels of beryllium exposure, and to ensure early detection of beryllium-related disease, in 2001 LLNL established the Chronic Beryllium Disease Prevention Program (CBDPP). As of March 31, 2009, 1,007 current workers have been tested for beryllium sensitivity using the BeLPT, 33 individuals have been identified as beryllium sensitized (two abnormal BeLPTs) and another 13 identified as beryllium concern (one abnormal and at least one borderline abnormal BeLPT). Timelines for the 46 HSD identified beryllium-affected cases help to illustrate the diversity of this group with respect to dates of hire (as subcontractors and as LLNL employees), length of LLNL employment, buildings worked in and resultant recurring opportunities for beryllium exposure, participation in the HSD beryllium surveillance program, and the identification of the first abnormal BeLPT (***Appendix 1***).

4.1 1998- 2009 LLNL Beryllium-Affected Cases

From 1998 through March 31, 2009, LLNL HSD identified 22 individuals as beryllium-affected as the result of an abnormal result on an initial BeLPT, and 24 individuals as beryllium-affected through periodic BeLPTs. A review of these 46 cases resulted in the following observations:

- One individual, who was diagnosed with beryllium sensitivity and CBD, previously worked as a machinist at Rocky Flats between 1982 and 1988. Interviews with the individual indicated a potential for beryllium exposure between 1985 and 1986 at Rocky Flats; however, BeLPT testing conducted in May 1992 under the BMSP returned normal results. The individual reported that additional beryllium exposure occurred during his early employment at LLNL as a subcontractor.
- Three beryllium-affected employees had no evidence of a LLNL occupational history with a clear potential for incidental, indirect and/or direct beryllium exposure. However, interview based information did indicate the potential for legacy beryllium exposure for these three cases. All three cases reported having been in buildings where legacy beryllium might be present. Work (at any level or for any duration) in a building that had some type of beryllium activity was reported by 43 of the 46 (93%) HSD identified beryllium-affected employees.
- The first reported potential beryllium exposure occurred prior to 2001 in 29 of the 46 cases, but as early as 1958 for one case.
- Twenty-four cases involved machining or working with machine tools that resulted in direct or indirect exposure to beryllium.

- Machinists and technicians accounted for 27 (59%) of the 46 identified beryllium-affected cases.
- Waste processing accounted for 4 (9%) of the 46 identified beryllium-affected cases.
- With a few exceptions (n=3) the beryllium-affected cases were associated in some way with LLNL buildings in which beryllium use was known, including the B321C NC Shop, B131 High Bay, B231, B241, and Site 300 bunkers. Beryllium exposure associated with work in B695 (RHWM) was also identified, but the population that worked in this building was smaller than many other buildings.
- Employees who worked in B321C NC Shop or the Waste Complex (n=34) accounted for a significant portion of the beryllium-affected population (74%).
- Employees who did not work in B321C NC Shop or the Waste Complex (n=12) represented the remainder of the beryllium-affected cases (26%).
- The increase seen in beryllium sensitivity/concern identification in 2007 was based on several inter-related factors, and was not the result of any one factor.

Questionnaire data and medical records were used to identify 79 LLNL buildings/facilities in which the 46 beryllium-affected employees had worked. Of these 79 buildings/facilities, 32 had been identified on the beryllium baseline inventory performed by Industrial Hygiene. In addition, some of these buildings/facilities were identified as having legacy beryllium contamination and were not classified as beryllium buildings. LLNL might consider verifying whether or not the remaining facilities may have had beryllium operations. Other buildings listed by employees do not necessarily reflect that beryllium activities occurred in these buildings, but were merely listed as a location where employees worked while at LLNL. The potential for some employees to have been exposed to beryllium while visiting or working at other DOE facilities or while employed at another company can certainly not be ruled out.

The building frequencies for the 46 beryllium-affected individuals are shown in **Attachment 3a**. Of the 46 beryllium-affected employees, 24 reported hands on work with beryllium. It is interesting to note that Building 321C NC Shop, the LLNL building with the history of the most beryllium work, was also the building with the greatest reported frequency for work by the current employee beryllium-affected group. Twenty-three of the 46 reported working in the Building 321C NC Shop, and an additional three individuals had transitory activities in the Building 321C NC shop. All of the current beryllium-affected individuals reported working in and/or having transitory activities in at least one of the buildings listed by Hazards Control as having had beryllium operations, past or present. Buildings 391, 241, and 131 High Bay, as well as the Site 300 bunkers were also identified by a significant portion of the beryllium-affected group. Consideration for increased enrollment and participation in the LLNL beryllium surveillance program by individuals who spend time in or work in beryllium designated LLNL buildings is suggested. Due to the occupational diversity of the beryllium-affected population, i.e., the buildings and areas in which they worked, the years of

employment, and the job functions, no apparent common factor(s) can be associated with the identified increase in beryllium sensitivity/concern seen in 2007 through 2009.

It is worthy to note that LLNL populations with indirect or incidental exposure to beryllium were identified as being beryllium-affected. This provides some indication that employees who have the potential for any level of exposure to beryllium should be offered participation in the LLNL beryllium surveillance program. This also indicates that additional beryllium-affected individuals might be identified in the current LLNL employee population, if more individuals from incidentally or indirectly exposed job function categories were provided the opportunity to participate in the LLNL beryllium surveillance program. To control incidental beryllium exposure, known beryllium buildings at LLNL whether presently operating or in legacy status should be characterized for the presence of surface or airborne beryllium contamination. Buildings that are identified as having beryllium contamination should be beryllium decontaminated before work activities of any type are continued without the use of appropriate personal protective equipment. Management at all levels should encourage employee participation in the LLNL beryllium health surveillance program.

4.2 Comparison Summary: LLNL BMSP and LLNL HSD Identified Beryllium-Affected Cases

The prevalence rate of beryllium-affected cases (beryllium sensitized plus beryllium concern) for the BMSP group was 61/1,804 (3.38%) versus 46/1,007 (4.57%) for the employees identified by LLNL's HSD.

The BMSP beryllium-affected former workers who received testing between 1999 and 2003, showed distinct differences in job category and building distributions when compared to the HSD identified beryllium-affected cases. The selection process for participation in these two beryllium surveillance programs resulted in these differences in the distribution, but helped to illustrate that other types of jobs could be included in the LLNL beryllium surveillance program. HSD identified beryllium-affected cases had a greater portion of beryllium exposures attributable to direct or indirect exposure, while the BMSP exposures had a greater portion either incidentally or indirectly exposed. If more current LLNL employees from other job categories were provided the opportunity to participate in the LLNL beryllium surveillance program, additional beryllium-affected cases might be identified. It is important to recognize that in both the HSD and BMSP beryllium-affected populations, individuals with indirect or incidental exposure to beryllium were identified. This is especially true for the BMSP population, and is a good indicator that employees who have the potential for exposure to beryllium should be offered participation in the LLNL HSD beryllium surveillance program.

5.0 Issues for Consideration

The following opinions and suggestions are based on the information obtained through interviews of current and former LLNL employees who were identified as having beryllium sensitization, beryllium concern, and/or CBD (BMSP and HSD identified), and based on conversations with LLNL HSD and Industrial Hygiene personnel.

What do LLNL employees need to know?

Employees regardless of their job function need to know that exposure to beryllium at any level may lead to beryllium sensitivity and/or CBD. The beryllium values established under 10 CFR 850 ("action level" of 0.2 µg/m^3 for airborne beryllium, "permissible exposure limit" for airborne beryllium of 2.0 µg/m^3, surface contamination "release level" of 0.2 µg/100 cm^2, and for beryllium work areas a "housekeeping level" of 3.0 µg/100 cm^2) should be used as guidelines for ensuring a safe workplace, not as absolute values of protection. The beryllium exposure values provided under 10 CFR 850 are based on best subjective reasoning, and were not intended to be considered as absolute with regards to safety and potential health effects from beryllium. At present no one knows what levels of beryllium exposure are safe and what levels can result in the development of beryllium sensitivity and/or CBD. Again, based on LLNL sensitized employee interviews, a repeated complaint was that employees who have direct contact with beryllium were not always cautious with respect to beryllium contamination of their workplace. Employees' inability to follow protocols and procedures when working with beryllium, and in maintaining clean work environments can lead to cross-contamination and to preventable beryllium exposures. Under 10 CFR 850 beryllium surveillance testing is available to any employee who believes they were exposed to beryllium at any DOE Site, and employees who are identified as beryllium-affected have two-years of medical removal protection benefits.

What do LLNL managers need to know?

Managers need to recognize the same things as employees only to a greater extent, i.e., anyone exposed to beryllium may develop beryllium sensitivity and/or CBD. Managers need to encourage their employees who have a potential for exposure to beryllium to participate in the LLNL beryllium surveillance program, and provide support to employees who are identified as being beryllium-affected. Several interviewed LLNL employees reported that management had discouraged participation in the LLNL beryllium surveillance program. The LLNL CBDPP policy is to provide a BeLPT to any employee who believes that they have been exposed to beryllium.

How do LLNL employees feel about the process of medical surveillance and screening for beryllium sensitization?

For the most part, interviewed employees were very complimentary of the LLNL beryllium surveillance program and HSD personnel. However, a number of LLNL active employees believe that the LLNL beryllium surveillance program is not necessary. This belief does not appear to be as great as it was two to three years ago, but the belief is still prevalent among current employees. The primary reason that was reported for non-participation in the LLNL beryllium surveillance program is the belief that an abnormal BeLPT could result in the employee losing their specific job or employment at LLNL. The second reason for non-participation was that enrolling in the beryllium surveillance program could result in the loss of the employee's specific job or employment at LLNL. The third reason for non-participation was that employees with abnormal BeLPT results might lose their ability to obtain health and/or life insurance.

What improvements could be made in the LLNL beryllium safety program?

Most LLNL employees remain concerned about beryllium and the potential implications of beryllium surveillance. All levels of management at LLNL need to become proactive in identifying possible sources of beryllium, limiting beryllium exposures in the workplace, and stopping work activities if they believe or their employees believe that a beryllium exposure could occur. Managers need to encourage their employees to enroll in the LLNL beryllium surveillance program and to actively participate through periodic serial health surveillance screening. Managers in beryllium areas need to provide opportunities for employees to learn more about the potential health effects associated with beryllium and ways to prevent beryllium exposure. Efforts need to be made to increase the amount of or the availability of beryllium training materials to managers and to employees.

The LLNL Human Resources needs to work with LLNL HSD to provide newly identified beryllium-affected employees with information regarding their continued employability at LLNL. Human Resources might consider appointing a beryllium-affected/CBD advocate who is knowledgeable regarding beryllium sensitivity/CBD, can work with management on the employee's behalf to accommodate beryllium work restrictions, and to comply with the medical removal protection benefits under 10 CFR 850.

Education/information videos could be made available on the LLNL video and computer networks that provide details about beryllium surveillance, and provides LLNL HSD and Human Resources contact information. Training could be mandatory for all individuals who work in or

have the opportunity for direct or indirect exposure routes, and recommended to all employees who have the potential for incidental contact with beryllium.

Based on the experience gained from the Rocky Flats Closure Project, to limit the additional exposure to beryllium and the development of unknown and incidental exposure beryllium sensitivity cases, buildings at LLNL that have stored beryllium or had beryllium processes of any type need to be fully characterized for beryllium.

Consideration could be given to requiring LLNL employees to wear respirators whose work requires direct exposure to beryllium. Based on data from the Rocky Flats Plant after the initial identification of a chronic beryllium disease case in June 1984, respirator use was made mandatory for all beryllium workers (beryllium machinists, beryllium toll crib attendants, beryllium waste workers, etc.) beginning in 1986. The surveillance data for Rocky Flats showed a significant reduction in the annual rate of beryllium sensitivity for employees hired after respirator use became mandatory compared with those hired before 1986.

Improved work-control management of LLNL subcontractors, students, and visiting professors might prove beneficial with regards to the potential for beryllium exposure.

Attachment 1 Lawrence Livermore National Laboratory, Beryllium Surveillance Interview-Survey

Name of Individual:_____ Title/Job Classification:_____
Organization:_____ Primary Facility Affiliation: B_____ (From _____ to _____)
Interview Date: _____ (Interview format: Personal Phone Email Site Visit)
Employment Status: Current _____ Former_____ Retiree _____ Subcontractor _____

1. What job responsibilities and/or programs/projects have you worked on while at LLNL and the date you began each? What specific activities did you perform in each job? Describe the building/room number.

	1	2	3	4
Program/Project				
Job Responsibilities				
Specific Activities				
Buildings/Room No.				
Dates				

2. While at LLNL did you ever work directly (hands-on) with beryllium?
   a. Yes _____ If yes, first known beryllium exposure - Date: _____/_____/_____
   b. No _____
3. If "Yes" to 2, what was the activity? _____
4. If "No" to 2, did you ever work in an area at LLNL where beryllium was present?
   a. Yes _____ If yes, potential incidental beryllium exposure - Date: _____/_____/_____
   b. No _____
5. If "Yes" to 2 or 4, provide legacy or current beryllium facilities [work in (W) or transient (T)] at LLNL?

								Other Bldg.	W-T
B121		B212		B262		B343			
B131HB		B222		B298 – Target Fab		B391			
B154		B231		B321A					
B174		B233V		B321C – NC Shop		RHWM: 513, 514, 625, 695			
B175		B235		B322					
B179		B241 – Pluto Project		B327		Site 300: 801, 805, 810, 836, 851			
B190		B253		B329					
B194		B255		B332					

6. Have you worked at another DOE Site(s)? (Include LLNL work-related visits to other DOE Sites.)
   a. Yes _____ If yes, between what dates (years) - _____-_____, _____-_____, _____-_____
   b. No _____ Site(s) _____, _____, _____
7. If "Yes" to question 6, did you have the opportunity for exposure to beryllium while at the Site(s) provided in 6b?
   a. Yes _____ If yes, at what Site(s) _____, _____, _____
      i. Direct (hands-on) _____ ii. Potential incidental beryllium exposure _____
   b. No _____

Attachment 1 Lawrence Livermore National Laboratory, Beryllium Surveillance Interview-Survey

8. Other than at a DOE Site, have you ever worked with beryllium or have you ever worked where beryllium was present?
   a. Yes _____ If yes, company/institution name - _____
   b. No _____

9. Were you involved in doing routine facilities maintenance, repair, inspections, or custodial work in LLNL areas that may have been beryllium-contaminated?
   a. Yes _____
   b. No _____

10. Was PPE utilized for work activities or in the LLNL area where you worked (e.g. respirator, gloves, etc.)?
   a. Yes _____
   b. No _____

11. Were you involved in any LLNL incident when you might have been exposed to beryllium?
   a. Yes _____
   b. No _____

SIGNATURES

Bill Stange, Ph.D. _____ Date: ____/____/____

_____ _____ Date: ____/____/____

Please Print Your Name ***Signature***

Attachment 2 Beryllium Sensitization Resulting from Initial and Repeat BeLPTs

Year	No. Initially Tested	No. Repeat Tested	Beryllium Sensitivity Initial Abnormal BeLPTs	Beryllium Sensitivity Repeat Abnormal BeLPTs
1992	1	0	0	0
1997	0	1	0	1
1998	28	0	2	0
1999	42	2	0	0
2000	46	3	2	0
2001	166	58	2	2
2002	111	58	0	0
2003	91	69	1	0
2004	19	104	0	0
2005	39	81	0	0
2006	52	65	0	2
2007	58	109	6	12
2008	185	83	5	4
2009	169	16	4	3

Attachment 3 Beryllium Sensitization: by Date of Confirmational BeLPT : by Date of First Abnormal BeLPT*

Year	No. Initially Tested	No. Repeat Tested	Beryllium Sensitivity from Initial Abnormal BeLPT	Beryllium Sensitivity from Repeat Abnormal BeLPTs	Beryllium Sensitivity Totals	*Beryllium Sensitivity from Initial Abnormal BeLPT	Beryllium Sensitivity from Repeat Abnormal BeLPTs	*Beryllium Sensitivity Totals
1992	1	0	0	0	0	0	0	0
1997	0	1	0	1	1	0	1	1
1998	28	0	2	0	2	2	0	2
1999	42	2	0	0	0	0	0	0
2000	46	3	2	0	2	2	0	2
2001	166	58	2	2	4	3	2	5
2002	111	58	0	0	0	0	0	0
2003	91	69	1	0	1	1	0	1
2004	19	104	0	0	0	1	0	1
2005	39	81	0	0	0	0	2	2
2006	52	65	0	2	2	2	6	8
2007	58	109	6	12	18	6	2	8
2008	185	83	5	4	9	5	4	9
2009	169	16	4	3	7	4	3	7

Attachment 4a Building Frequencies - 46 HSD Identified Beryllium Affected Cases

Buildings with reported beryllium activity	Machinists & Waste Processors (n=18)	All Other Job Categories (n=28)
121	2	8
131 High Bay	9	16
141		1
154	2	7
175	4	6
212	3	10
222	3	12
231	8	12
233 Vault		4
235	5	10
241	4	15
253	2	8
262		3
298	5	11
321A	11	11
321C NC Shop	15	12
322	4	7
327	5	7
329	5	4
332	7	9
343	4	4
391	7	12
411		3
435	1	
491		1
612		4
695	5	8
854		1
Site 300:801	6	14
Site 300:810	6	13
Site 300:836	6	12
Site 300:851	6	12
Buildings with no reported beryllium activity		
100		1
111		2
113		
115		

Attachment 4a Building Frequencies - 46 HSD Identified Beryllium Affected Cases

117		
148		1
151		1
174	4	8
176	2	
177	1	
179	2	5
190	1	7
194	6	8
198	1	
216		
227		
232		1
239		
243		
251		1
254	1	
255	2	7
261		
271		1
Site 300:805	7	12
311		
314		4
316		1
318		1
321B	1	
331		
339		1
341		
345		
361		1
364		
365		
371	1	
381	2	1
383	6	
412		1
419	1	1
423	1	
431	1	
432	4	
438	1	
439		

Attachment 4a Building Frequencies - 46 HSD Identified Beryllium Affected Cases

442		1
481		
482		1
490		3
511		2
513	5	5
514	5	6
516	2	
517		
531		1
543	1	
551		
571		
596		1
619		2
625	4	5
671		
691	1	
693		1
694		1

Attachment 4b Building Frequencies - 55 BMSP Identified Beryllium Affected Cases

Buildings with reported beryllium activity	Machinists & Waste Processors (n=9)	All Other Job Categories (n=46)
121	1	11
131 High Bay	5	17
141		2
154		3
175		3
212		9
222		4
231	1	10
233 Vault		2
235		3
241	2	3
253		3
262		2
298		2
321A	6	6
321C NC Shop	6	7
322		2
327	1	4
329		2
332	3	8
343		2
391		3
411		
435		
491		
612		
695		2
854		
Site 300:801	3	15
Site 300:810	3	15
Site 300:836	3	15
Site 300:851	3	15
Buildings with no reported beryllium activity		
100		
111		5
113		3
115	1	1

Attachment 4b Building Frequencies - 55 BMSP Identified Beryllium Affected Cases

117		1
148		
151		3
174		3
176		
177		1
179		2
190		2
194		5
198		
216		1
227		1
232		
239	1	
243		2
251		1
254		
255		4
261	1	2
271		
Site 300:805	3	15
311		1
314		
316		
318		
321B		
331		1
339		
341		2
345		1
361		2
364		1
365		1
371		
381		3
383		
412		
419		
423		
431		2
432		
438		
439		1

Attachment 4b Building Frequencies - 55 BMSP Identified Beryllium Affected Cases

442		
481		2
482		1
490		
511		
513		2
514		2
516		1
517		1
531		
543		
551		2
571		1
596		
619		
625		2
671		1
691		
693		
694		

Attachment 5 Year of First Reported Beryllium Exposure

Year of First Beryllium Exposure	HSD Beryllium-Affected LLNL Employees	LLNL BMSP Beryllium-Affected Employees
1953		1
1958	1	2
1960		5
1961		2
1963		2
1964		4
1965		1
1966		3
1969		1
1970	1	2
1971		4
1975		3
1977	2	
1978	1	2
1980	1	2
1981	3	
1982	2	2
1983	1	
1984	1	
1985		1
1986	1	1
1987	4	3
1988	3	1
1992	1	2
1993	2	1
1994	1	
1995	1	
1997	1	
1999	1	
2000	1	
2001	2	
2002	3	
2003	2	
2004	1	
2005	3	
2006	1	
2007	2	