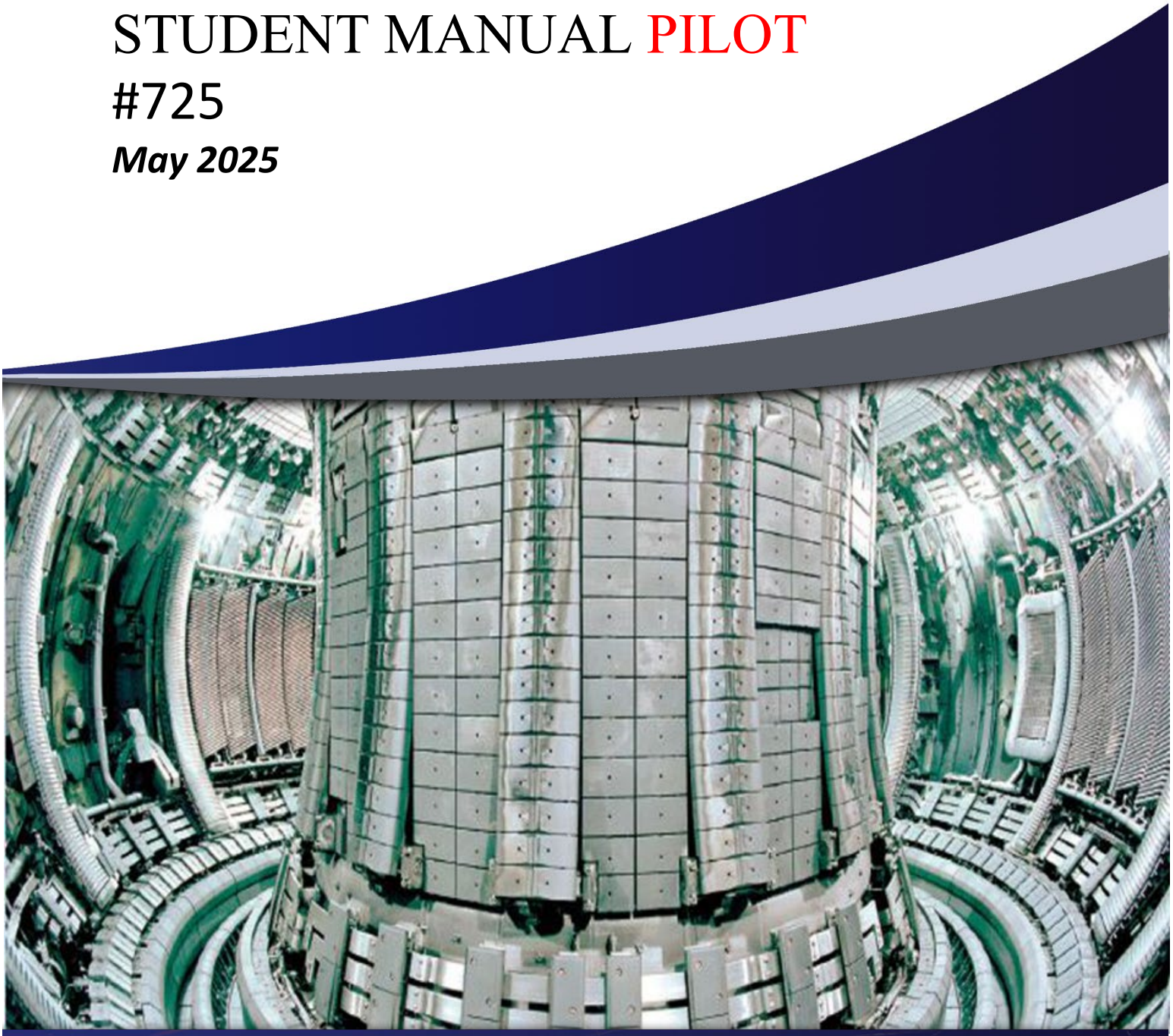
Los Alamos
NATIONAL LABORATORY

BERYLLIUM WORKER LIVE

STUDENT MANUAL PILOT

#725

May 2025



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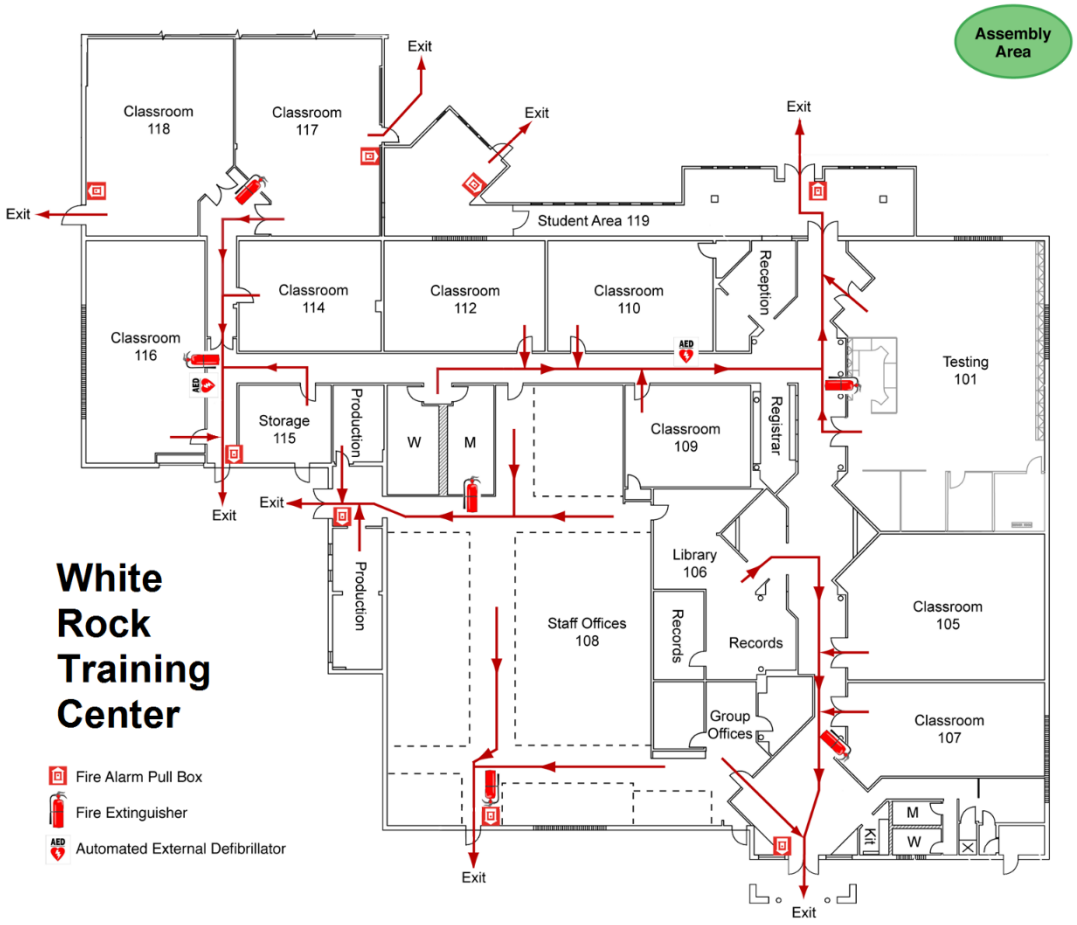

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Beryllium Worker Live #725
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Los Alamos NATIONAL LABORATORY

BERYLLIUM WORKER LIVE

STUDENT MANUAL

Cover image: Beryllium-lined interior of the Joint European Torus reactor built for research into fusion-based power (*European Fusion Development Agreement*).

Introduction and Orientation

Course Overview, Purpose, Objectives

Overview

Beryllium is a metal that has many industrial and laboratory uses. Unfortunately, workplace exposure to beryllium can cause adverse health effects in some people. In a small percentage of cases, exposure may lead to chronic beryllium disease (CBD). There is no cure for CBD, and it can seriously affect health and quality of life.

The Department of Energy (DOE) requires Los Alamos National Laboratory (LANL) to provide beryllium-associated workers with information and controls to minimize exposure and medical surveillance to monitor status. This course will tell you about the regulations that govern beryllium, the risks of working with beryllium, the controls used to reduce those risks, and the medical surveillance options offered to beryllium-associated workers.

Purpose

Upon successful completion of this course, participants will be informed how to access the CBDPP be aware of the contents including beryllium hazards and controls, and potential health risks associated with beryllium and beryllium contamination.

Objectives

After completing this course, you will be able to recognize:

- properties, forms, and uses of beryllium in the workplace, and operations that can increase your risk of exposure to beryllium;
- terms and definitions used in the LANL Chronic Beryllium Disease Prevention Program (CBDPP);
- routes of entry and health effects from workplace exposure to beryllium;
- answers to common questions about beryllium sensitization and chronic beryllium disease (CBD);
- documents that affect the use of beryllium in the workplace, and responsibilities of persons who perform or support beryllium work at LANL;
- beryllium exposure limits and types of beryllium sampling in the workplace;
- types of beryllium areas at LANL, and requirements for the release of beryllium materials and release of areas from contamination concerns;
- elements of LANL beryllium medical surveillance and medical removal programs;
- controls for minimizing exposures to beryllium; and
- resources and contacts if you have questions or concerns about beryllium.

Target Audience

Beryllium workers must complete this course before assignment to beryllium-related duties. A beryllium worker is a worker with potential exposure to airborne beryllium, who currently works with or around beryllium on a regular basis, or who is assigned job duties that are expected to include work with or around beryllium (with potential exposure to airborne beryllium) when his or her services are needed.

Such workers may include scientists, engineers, technicians, crafts workers, maintenance workers, custodial workers, management, workers who store beryllium, and support staff.

Authorized Beryllium Workers must be enrolled in and remain complete in Training Curriculum 117, *Beryllium Worker Training Requirements.*

Program Owner

This course was developed under the direction and technical oversight of the Industrial Safety and Hygiene Group (ISH), the functional program owner for this training.

Training Requirements and Course Limitations

Initial training – Training Curriculum 117, *Beryllium Worker Training Requirements*, which includes course #725 *Beryllium Worker Live* and course #25418 *Chemical Hazard Communication Live*.

Refresher training – Beryllium workers must complete *Beryllium Worker Refresher Self-Study* (#21784) or repeat the live course every two years. Hazard Communication training must be completed in accordance with Curriculum 4261, *Authorized Chemical Workers.*

This course does not:

- address every type of hazard or control that may be associated with beryllium work at LANL.
- address site-, facility-, or job-specific training for area(s) where beryllium is used or stored.
- enroll attendees in beryllium medical surveillance.
- authorize beryllium workers to perform work.

The responsible line manager (RLM) must ensure that each worker whom they manage has all required training and authorization for his or her work.

Registration and Attendance

To receive credit, all participants must attend and actively participate in the course, and sign the attendance roster for the course in ink.

Delivery Methods

Course delivery consists of lecture and presentation, group discussion, and participant activities.

Evaluation Strategy

Participants will be evaluated through classroom discussions and participant activities.

The instructor will use oral questioning during the presentation of each module and observation of activity completion to assess participants' mastery of the material. Problem areas identified during questioning will be reviewed in further detail.

Administrative Details

The instructor will use this portion of the course for introductions and to familiarize participants with facility safety and convenience features, the location of the facility's designated break area(s), and any additional resources or equipment available.

Participants must adhere to all safety requirements during training sessions. They should see their instructor immediately if they have any questions or concerns about safety.

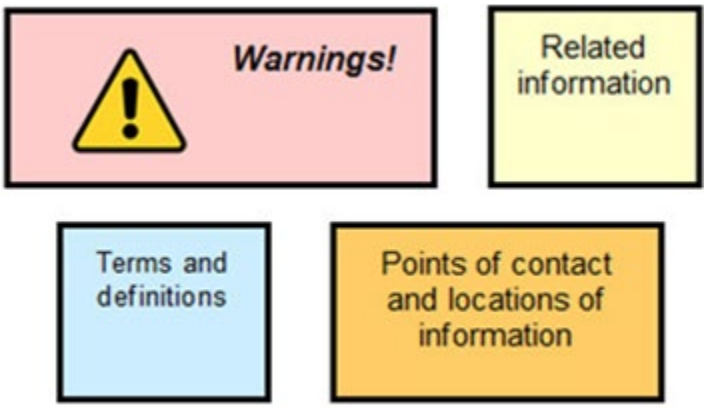
Top left: Elemental beryllium cylinder
Bottom left: Beryllium-copper alloy wrenches showing BeCu markings
Right: CuBe Fingerstock (1.3% beryllium)

Acronyms

ABD	**acute beryllium disease**
ACGIH	**American Conference of Governmental Industrial Hygienists**
AIHA	**American Industrial Hygiene Association**
AL	**action level**
ALDESHQ	**Associate Laboratory Director, Environment, Safety, Health, and Quality**
ANSI	**American National Standards Institute**
BAL	**bronchoalveolar lavage**
Be-LPT	**beryllium-induced lymphocyte proliferation test**
BA-OI	**Beryllium Area-Otherwise Inventoried**
BeS	**beryllium sensitized**
BTF	**Beryllium Technology Facility**
CBD	**chronic beryllium disease**
CBDPP	**Chronic Beryllium Disease Prevention Program (P101-21)**
CFR	**Code of Federal Regulations**
CT	**computed tomography**
CTS	**Comprehensive Tracking System**
D&D	**Decontamination and Decommissioning**
DOE	**Department of Energy**
EEOICP	**Energy Employees Occupational Illness Compensation Program**
ERMP	**exposure Reduction and Minimization Plan**
FOD	**facility operations director**
HEPA	**high-efficiency particulate air**
IARC	**International Agency for Research on Cancer**
ISH	**Industrial Safety and Hygiene (LANL)**
IWD	**integrated work document**
LANL	**Los Alamos National Laboratory**
LEV	**local exhaust ventilation**
LIBS	**laser induced breakdown spectroscopy**
LIHSM	**Laboratory Industrial Hygiene and Safety Manual**

NASA	**National Aeronautics and Space Administration**
NIOSH	**National Institute for Occupational Safety and Health**
NNSA	**National Nuclear Security Administration**
OH-DO	**Occupational Health Division**
OSHA	**Occupational Safety and Health Administration**
PEL	**permissible exposure limit**
PPE	**personal protective equipment**
QIHSP	**Qualified Industrial Hygiene and Safety Professional**
RCRA	**Resource Conservation and Recovery Act**
RLM	**responsible line manager**
SOMD	**site occupational medical director**
STEL	**short term exposure limit**
TLV	**threshold limit value**
TWA	**time-weighted average**
WMC	**waste management coordinator**

Units of Measure			
In symbols	In words	Meaning	Applies to
0.2 µg/m^3	0.2 micrograms per cubic meter	2 tenths of a millionth of a gram in a volume equal to 1m wide x 1m deep x 1m high	Air: personal or area
0.2 µg/100cm^2	0.2 micrograms per 100 square centimeters	2 tenths of a millionth of a gram on a surface area 10 cm x 10 cm.	Surfaces



Information is provided in color-boxes throughout this course as shown at the left.

Glossary

*See LANL Definition of Terms or P101-21, Chronic Beryllium Disease Prevention Program, for detailed definitions and examples.

Beryllium Terms and Definitions*—PERSONNEL	
authorized worker	A person with the needed skills, knowledge, and training to perform a specific operation or activity correctly and safely. An authorized worker must be designated by their RLM or supervisor and must be current in the training required for the beryllium operation being performed. If performing an activity with potential exposure to airborne beryllium, an authorized worker must also be a beryllium worker.
beryllium worker	A worker with potential exposure to airborne beryllium, who currently works with or around beryllium on a regular basis, or who is assigned job duties that are expected to include work with or around beryllium (with potential exposure to airborne beryllium) when his or her services are needed. Beryllium workers must complete beryllium worker training and be enrolled in the beryllium medical surveillance program.
beryllium-associated worker	A current LANL worker who was or who currently is exposed or potentially exposed to airborne beryllium at a DOE facility. Includes: • beryllium workers • past beryllium workers • workers with signs and symptoms of beryllium exposure • workers who are receiving medical removal protection benefits • any other workers enrolled in LANL's beryllium medical surveillance program
beryllium awareness level worker	A worker who is involved in a beryllium operation or who must enter a designated beryllium area, but who does not require beryllium worker status. This includes workers who may encounter beryllium contamination or use beryllium alloy tools on a regular basis, but where a qualified industrial hygiene and safety professional (QIHSP) does not expect exposure to airborne beryllium.
Beryllium sensitized (BeS)	After exposure to beryllium, a worker whose immune system recognizes beryllium and responds adversely. Workers who are sensitized to beryllium have a higher risk of developing CBD.
Beryllium susceptible	Before exposure to beryllium, a worker who is genetically more likely to become sensitized to beryllium if exposed. Most workers are not susceptible to beryllium.
qualified industrial hygiene and safety professional (QIHSP)	A person within OSH division who meets the LANL qualification requirements to perform beryllium hazard assessments or, if a subcontractor, has equivalent knowledge or experience as approved by OSH-ISH.
visitor	A non-LANL employee or a LANL employee who is not an authorized beryllium worker.

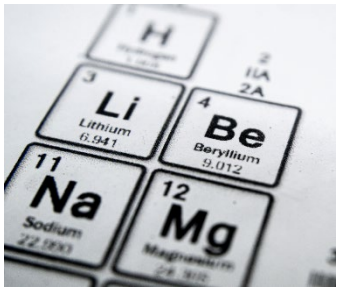
Beryllium Terms and Definitions* —GENERAL TERMS AND EXPOSURE LIMITS	
accessible surfaces	Surfaces that can be touched, contacted, or disturbed during normal, routine operations in a work area. Examples include surfaces of furniture or equipment; walls and facility structure surfaces less than 8 feet above routinely accessed walking/working surfaces; and easily opened enclosures or equipment cabinets.
action level	The concentration of airborne beryllium that, if met or exceeded, requires additional worker protections in Regulated Beryllium Areas. The DOE action level (AL) for airborne beryllium is 0.2 µg/m^3, 8-hr time-weighted average (TWA).
beryllium	Elemental beryllium, and any beryllium compound or alloy containing at least 0.1% beryllium that may be released as an airborne particulate.
beryllium article	An item formed to a specific shape or design during manufacture that under normal conditions of use or handling does not release or otherwise result in exposure to airborne beryllium, and is unlikely to spread beryllium contamination to adjacent or nearby work area surfaces.
beryllium item	An object, device or material made of beryllium or containing accessible beryllium, including any beryllium compound or alloy containing at least 0.1% beryllium by weight and that does not meet the definition of a beryllium article.
beryllium-contaminated item	A non-beryllium object or device with measurable removable beryllium surface contamination above 0.2µg/100 cm^2, or a beryllium item or article with loose surface contamination likely to spread beryllium contamination to work area surfaces.
beryllium operation	Any activity or process involving the handling, processing, fabrication, storage, or disposal of beryllium where there is a reasonable potential for exposure to airborne beryllium or for the spread of beryllium contamination to work area surfaces.
beryllium release	The process for the movement of beryllium items or potential beryllium-contaminated items to other areas within LANL or other areas off-site.
designated installed beryllium containing material	Known or suspect beryllium-containing material (typically beryllium copper alloy) used for electro-magnetic shielding, electrical continuity, or sealing of doors or other openings to Faraday cages, shielded rooms, screen rooms, equipment or similar installations.
permissible exposure limit (PEL)	The allowable limit to which workers may be exposed to an airborne chemical substance. The beryllium PEL is 0.2 µg/m^3, 8-hr TWA.
surface sample trigger level	the level of beryllium surface contamination at which corrective measures are initiated or implemented.

Beryllium Terms and Definitions* —AREA TYPES	
designated beryllium area	Any of the five beryllium areas defined by a graded approach based on risk of exposure. The five areas are (in order of increasing hazard): • beryllium storage area • inaccessible beryllium contamination area • accessible beryllium contamination area • airborne beryllium area • regulated beryllium area
beryllium storage area	A location where beryllium is stored that is outside of a contaminated designated beryllium area.
inaccessible beryllium contamination area	A location in which there is surface beryllium contamination greater than 0.2 µg/100 cm^2 on inaccessible facility surfaces. Airborne beryllium would not be expected under normal conditions.
accessible beryllium contamination area	A location with beryllium contamination from current or former beryllium operations on accessible facility surfaces that is greater than 0.2 µg/100 cm^2. Airborne beryllium would not be expected under normal conditions.
airborne beryllium area	A location where there is measurable or a reasonable potential for measurable levels of airborne beryllium (≥0.3 µg/m^3) for ongoing activities at that location.
regulated beryllium area	A beryllium area in which the airborne level of beryllium exceeds, or can reasonably be expected to exceed, the action level of 0.2 µg/m^3.
beryllium areas-otherwise inventoried	Operational areas where beryllium may be handled or encountered (but that do not meet the definition of a designated beryllium area), some areas with installed beryllium containing materials, and some former operational areas.
beryllium buffer zone	An administratively controlled, posted area that serves as an intermediate area to help prevent the spread of beryllium contamination and to limit the potential for exposure to workers who are not beryllium workers.

*See LANL Definition of Terms or P101-21, Chronic Beryllium Disease Prevention Program, for detailed definitions and examples.

Approximately two-thirds of the world's beryllium supply originates in the USA. UGS, 2020
Beryllium is primarily mined at the Spor Mountain site in Utah in the form of the mineral bertrandite.
Beryllium tuff from Utah (*left and right)*

Module 1



Properties, Forms, and Uses of Beryllium

Module Objectives

After completing this module, you will be able to recognize:

- *properties, forms, and uses of beryllium;*
- *operations at LANL that could result in exposure to beryllium; and*
- *who might be exposed to beryllium.*

Golden beryl, morganite, and emerald are variations of beryl in crystalline form.

Beryllium ore is mined as the minerals beryl and bertrandite. In pure crystalline form, beryl is considered a gemstone, more commonly known as aquamarine (sea blue), morganite (pink), heliodor (greenish-yellow), or emerald (green).

Metal ID	Atomic Weight (amu)	Melting point (°C)	Density (g/cm³)	Young's modulus (stiffness) (GPa)	Specific Heat (J/g·°C)
Aluminum	27	660	2.70	70	0.904
Beryllium	**9**	**1287**	**1.85**	**287**	**1.82**
Chromium	52	1907	7.19	279	0.448
Copper	64	1085	8.96	130	0.384
Gold	197	1064	19.3	78	0.129
Iron	56	1538	7.87	211	0.449
Magnesium	24	650	1.74	45	1.02
Manganese	55	1246	7.47	198	0.479

Properties, Forms, and Uses of Beryllium

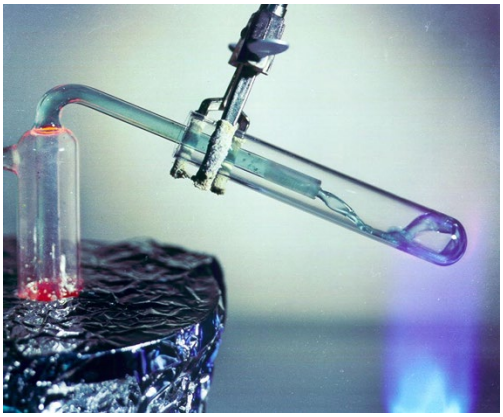
Properties of Beryllium
light weight and low density - second lightest metal after lithium; low density, 1/3 less dense than Al
stiffness (rigidity)- more rigid than steel; can withstand great force before bending
high melting point- (2340°F) compared to other metals; holds its shape over a wide temperature range
high heat-absorption capacity - a pound of beryllium will absorb almost as much heat as 5 pounds of copper
non-magnetic and non-sparking – Be is alloyed with copper to make durable, non-sparking tools
good electrical insulator (as beryllium oxide)- high thermal conductivity, used in semiconductor parts
Other properties: • lowest thermal neutron-absorption cross section of any metal • high permeability (transparency) to x-rays (as BeO) • can be machined to close tolerances

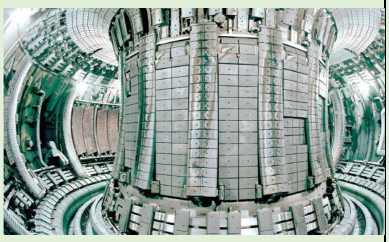
Above: Non-sparking beryllium copper wrench (*NGK Berylco*).

Right: mirror base for JWST (*NASA*)

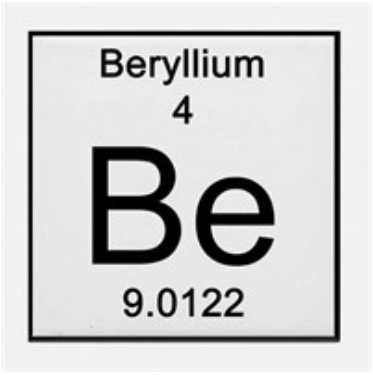
Left - The prototype NASA 1kW Kilopower nuclear reactor for use in space and on other planets has a beryllium oxide radial neutron reflector (*NASA*).

Right - FLiBe is a molten salt made from a mixture of lithium fluoride (LiF) and beryllium fluoride (BeF_2). It is both a nuclear reactor coolant and solvent for fissile material (*Oak Ridge National Laboratory*).



Forms and Uses of Beryllium			
Form	**Use***	**Image 1**	**Image 2**
Beryllium metal	Used in aerospace, structural, and nuclear applications.		
Beryllium alloys	Created to increase the hardness, strength, electrical conductivity, and/or the resistance to wear of the resulting alloy.		
Beryllium oxide (BeO)	Used in some ceramic components of electronics and electrical equipment to draw heat away from other circuit components.		
Beryllium salts	Used as an analytical standard, in the Be-LPT blood test, and to aid certain chemical reactions (such as a catalyst).		

*See next page for more beryllium uses



Uses of Beryllium		
medical lasers	precision tools	spacecraft windshield frames
air bag triggers	engines	clock/watch gears & springs
nuclear triggers	cell phones	mirrors (space telescope)
missile guidance	golf clubs	sprinkler system springs
heat exchanger tubes	gyroscopes	aircraft brake components
non-sparking tools	x-ray windows	inertial guidance systems
space shuttle brakes	bicycle frames	neutron moderators in nuclear reactors
camera shutters	dental bridges	electronic relays & switches
fishing rods	satellites	integrated circuit substrates

Warning! *Exposure to beryllium is also a concern during support activities such as maintenance, construction, housekeeping, waste management, repair, environmental restoration, sampling, inspections, emergency response, decontamination, demolition, and decommissioning.*

Beryllium Operations at LANL

Beryllium operations are performed at LANL in support of weapons research, stockpile stewardship, energy research, reactor technology, and materials science. Currently major beryllium operations (machining, destructive testing, etc.) are regularly conducted in four technical areas, including the Beryllium Technology Facility (BTF). Smaller operations (parts handling, storage, sample analysis, etc.) are conducted at multiple technical areas. Examples of beryllium operations at LANL are listed below.

Beryllium operations were performed at ~20 LANL technical areas between 1948 and 1980.

Beryllium Operations at LANL - Current and Past		
alloy development	joining and coating	plasma spray
beryllium machining	laser ablation	powder operations
beryllium storage	materials research and development	radiography
beryllium welding	metallography	sample preparation
bioscience research	molten salt research	target fabrication
chemical analysis	nondestructive and destructive testing	vapor deposition
foundry operations	outdoor operations	waste processing
hydrodynamic testing	parts assembly and inspection	x-ray sensor assembly

Not all beryllium activities take place in a ***designated beryllium area***, since not all work with beryllium creates the potential for airborne exposure to beryllium or the presence of beryllium contamination on facility surfaces. Examples include handling of packaged waste, assembly operations, and storage of beryllium articles.

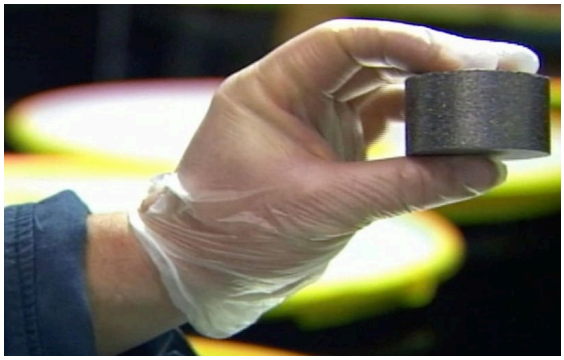
LANL maintains an inventory of locations with beryllium operations and/or beryllium contamination at LANL.

A LANL beryllium machinist works at a lathe. Local exhaust ventilation (LEV) is used to minimize operator exposure to airborne beryllium. A respirator is worn during new or modified operations until sampling shows that controls are adequate.

OSHA estimated that approximately 62,000 workers are potentially exposed to beryllium in approximately 7,300 establishments in the United States, including approximately 12,000 workers the construction and shipyard industries. https://www.osha.gov/beryllium

Activities that May Expose Personnel to Beryllium			
abrasive blasting	drilling	machining	brazing
alloy processing	lapping	melting	brushing
deburring	cutting	turning	milling
target fabrication	grinding	polishing	buffing
explosives testing	heat treating	sanding	casting
coolant management	honing	sawing	welding
maintenance and housekeeping in beryllium areas			laser cutting

Left: Beryllium alloy tools Right: Elemental beryllium cylinder



Using Beryllium Alloy Tools:

When feasible, use of beryllium alloy tools should be eliminated. If use of beryllium alloy tools is required:

- Use in conformance with a work document (Integrated Work Document [IWD] or equivalent)
- Segregate and store separately from other tools.
- Protect the tools from surface abrasion or damage.
- Wear gloves to prevent skin exposure when handling beryllium alloy tools unless otherwise specified by a QIHSP.
- Avoid using visibly corroded or damaged tools.
- Dispose of visibly corroded or damaged tools by contacting the local waste management coordinator. Label toolboxes clearly as containing beryllium alloy tools using a Beryllium Danger Label.
- Minimize tool contact with work surfaces to prevent contamination spread.
- Keep tools and toolboxes clean and dry to prevent corrosion.
- Do not modify (grind, polish, cut, etc.) the tools.
- Clean the tools and toolboxes using wet methods or LANL-approved High-Efficiency Particulate Air (HEPA) vacuum systems.
- Ensure toolboxes with tools are included in the LANL Beryllium Area Inventory when being used for storage.

Who Might Be Exposed to Beryllium?

LANL personnel who perform operations with beryllium, such as machining, welding, chemical analysis, and destructive testing of beryllium parts or materials have a potential for direct exposure to beryllium. These workers handle beryllium parts or material and are involved in activities that can generate beryllium dust.

Support work or maintenance personnel who enter posted beryllium areas to perform work, such as custodians, inspectors, skilled craft workers, supervisors, have a potential for indirect exposure to beryllium. Although they do not work directly with beryllium, they may disturb settled beryllium dust in the course of performing their work, or otherwise encounter airborne beryllium when they enter a beryllium area.

Personnel who do not work with beryllium or work in beryllium areas could have an incidental exposure to beryllium. This could occur from a spill or unintended release of beryllium, failure of control equipment, unauthorized entry into a beryllium area, or encountering beryllium contamination on work surfaces, equipment, or materials. Such an exposure is possible, but not likely, as controls are designed to prevent such an exposure. Failure to follow beryllium program requirements is the most likely cause for an incidental exposure.

Glossary Review:

Personnel (pg 8)	General Terms (pg 9)	Designated Beryllium Area (pg 10)
Beryllium worker	Beryllium	5 types of Designated Beryllium Areas
Beryllium-associated worker	Beryllium operation	Beryllium area- otherwise inventoried
	Beryllium article	
	Beryllium item	

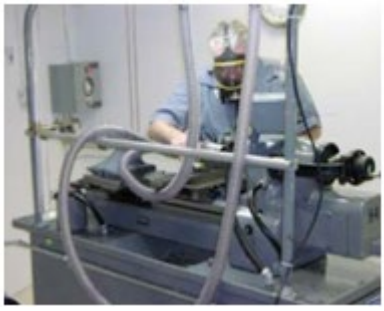
Module 1 Self-Assessment:

Use the glossary and information from Module 1 to match the term in with the letter of the corresponding image. One of the images corresponds to two different terms.

A

Term	Letter
Beryllium article	
Beryllium operation	
Beryllium release	
Property of beryllium	
Form of beryllium	

B



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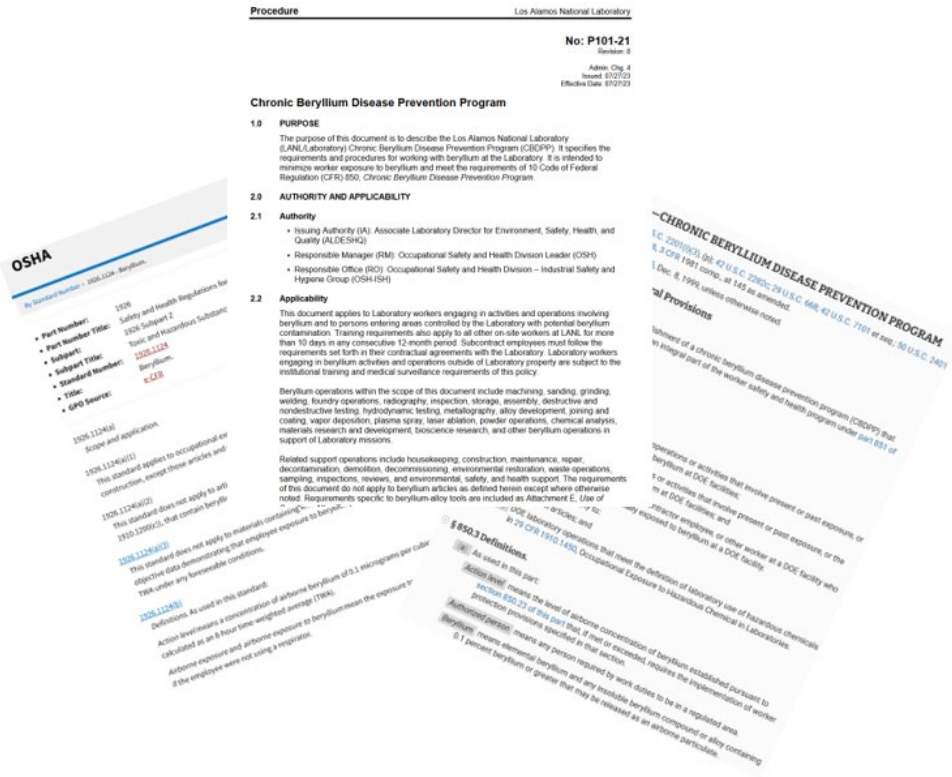


Module 2

Beryllium Regulations

Module Objectives

After completing this module, you will be able to recognize:

- documents and standards that address beryllium work
- roles and responsibilities of persons who perform or support beryllium work at LANL
- beryllium exposure limits
- types of designated beryllium areas at LANL

Beryllium Documents and Standards

Documents and standards that address exposures to beryllium in the workplace include

- 10 CFR 850, the DOE Beryllium Rule,
- 29 CFR 1910.1024, *Beryllium*, from the Occupational Safety and Health Administration (OSHA), and
- P101-21, the LANL *Chronic Beryllium Disease Prevention Program* (CBDPP).

10 CFR 850, The DOE Beryllium Rule

The DOE beryllium rule (10 CFR 850) was enacted in Dec 1999 and is designed to reduce the occurrence of CBD among personnel at DOE facilities. The methods to achieve this goal include:

- limiting the number of workers who are exposed to beryllium,
- minimizing exposure levels of workers who are exposed to beryllium,
- improving training and communication about the hazards of beryllium,
- implementing controls that prevent the release of beryllium into the workplace, and
- establishing medical surveillance to monitor the health of exposed workers and ensure early detection that makes early treatment of disease possible.

29 CFR 1910.1024, Beryllium

In 2018, the PEL for beryllium was lowered by a factor of 10, from 2.0µg/m^3 to 0.2µg/m^3 as a time-weighted average (TWA) in accordance with 29 CFR 1910.1024. 10 CFR 850 specifies compliance with the OSHA PEL, but not the entire OSHA beryllium regulation. However, by complying with 10 CFR 850 and the LANL specific CBDPP, control measures are implemented at LANL that provide similar (or in some cases greater) protection than the OSHA regulation.

P101-21, the LANL Chronic Beryllium Disease Prevention Program (CBDPP)

The LANL CBDPP (P101-21) provides requirements and guidance that help to control worker exposure to beryllium (and prevent beryllium sensitization and disease). The goal of P101-21 is to minimize worker exposure to beryllium and meet the requirements of 10 CFR 850 by specifying the requirements and procedures for working with beryllium at LANL. Some of the areas addressed in P101-21 are listed in the table below.

P101-21 also addresses medical surveillance, medical and medical removal (see Module 5) and workplace beryllium controls (see Module 6).

P101-21 Chronic Beryllium Disease Prevention Program
https://policy.lanl.gov/apex/special/policy/documents/P101-21

P101-21 also specifies responsibilities for the Occupational Safety and Health Division (OSH) and Occupational Medicine (OM).

P101-21 addresses
Roles & responsibilities
Exposure limits
Designated beryllium areas
Beryllium sampling, including air sampling, surface sampling & surface trigger levels
Release of beryllium materials and areas

You can access P101-21 from the LANL Policies homepage or Beryllium homepage.

Roles and Responsibilities

P101-21 specifies responsibilities for persons who perform or support beryllium work at LANL. Key responsibilities of FODs, RLMs, QIHSPs, beryllium workers, and visitors are shown below. A complete list of responsibilities is found in P101-21.

Facilities Operations Directors (FODs)*

- Ensure new and or modified facilities will have sufficient controls to meet regulations and requirements and eliminate or minimize exposures from beryllium operations.
- Establish and post beryllium areas as recommended by the QIHSP, and restrict access to authorized workers.
- Ensure hygiene facilities are available for work involving Regulated Beryllium Areas.

*within their area of responsibility.

Responsible Line Managers (RLMs)*

- Ensure workers have the required training, qualifications, and medical surveillance, if any, before authorizing them to perform work.
- Ensure beryllium operations are evaluated by a QIHSP.
- Minimize beryllium exposure levels and the number of workers exposed to beryllium.
- Ensure beryllium-associated workers are offered beryllium medical surveillance.
- Ensure resources are available to implement the requirements of P101-21.
- Ensure high-efficiency particulate air (HEPA) vacuums and negative air machines (NAMs) used for beryllium cleanup or capture are HEPA tested.

HEPA vacuums and NAMs must be tested in accordance with P101-16, *Industrial Ventilation (non-HVACR).*

*within their area of responsibility.

Qualified Industrial Hygiene and Safety Professional (QIHSP)

- Identify designated beryllium areas, and identify activities with potential for exposure to airborne beryllium or the potential to spread beryllium contamination.
- Perform or direct hazard assessments for beryllium operations, and evaluate beryllium air and surface sampling results.
- Recommend controls, including required PPE, for beryllium operations.

Beryllium Workers

- Complete a beryllium worker questionnaire upon initial assignment to beryllium work.
- Complete and maintain required knowledge, skills, and training.
- Follow approved work control documents, perform work safely, and use Pause/Stop Work as needed.

P101-18, *Procedure for Pause/Stop Work*, specifies criteria for pausing, stopping, and restarting work at LANL.

Visiting Beryllium Workers

- Attend necessary training or briefings, participate in personal beryllium sampling as requested, and remain with a designated escort when in a beryllium area.

Visitors who are Authorized Beryllium Workers from sites that comply with 10 CFR 850 may be considered Authorized Beryllium Workers while at LANL. See P101-21.

Visitors / Non-Beryllium Workers

- May visit Designated Beryllium Areas during non-operational periods as long as a QIHSP working with the host organization has determined there is no reasonable potential for airborne beryllium exposure during the visit.
- Must receive a documented briefing that addresses beryllium hazards, site-specific controls, PPE, and emergency procedures.

LANL workers with potential for beryllium exposure at other sites must follow additional P101-21 requirements.

Beryllium Exposure Limits

LANL uses the airborne exposure limits from 10 CFR 850 (shown below), but efforts are made to keep airborne levels as low as practical and to keep surfaces as clean as practical.

Airborne beryllium at the AL/PEL of 0.2 µg/m^3 cannot be seen, smelled, or tasted.

Other Exposure Limits

The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for beryllium is **0.05 µg/m^3** (inhalable). The Occupational Safety and Health Administration (OSHA) AL for airborne beryllium of **0.1 µg/m^3 (8-hour TWA)**, and the Short-Term Exposure Limit (STEL) for beryllium is **2.0 µg/m^3** over a 15-minute sampling period. In 2018, the OSHA PEL was lowered and became the same as the DOE action level of **0.2 µg/m^3** for an 8-hour TWA. DOE facilities are not required to use the ACGIH beryllium TLV or the OSHA beryllium AL or STEL.

Airborne Exposure Limits	
Action Level (AL)	0.2 µg/m^3, 8-hour time weighted average (TWA)
Permissible Exposure Limit (PEL)	0.2 µg/m^3, 8-hour TWA

Minimizing Exposures in Your Workplace

Although the airborne exposure limits for beryllium may be protective enough for most workers, no exposure limit is guaranteed to provide everyone with full protection from potential beryllium health effects. In addition, skin exposure to beryllium dusts, powders, solutions, or compounds may cause adverse health effects. Most occupational health professionals believe that minimizing the amount of airborne and dermal exposure to beryllium reduces a worker's risk of developing adverse beryllium health effects. At LANL, only Authorized Beryllium Workers may perform activities or enter areas where measurable airborne beryllium (≥ 0.03 µg/m^3) is anticipated.

Designated Beryllium Areas

The five types of Designated Beryllium Areas at LANL are shown in the table below.

LANL Designated Beryllium Areas			
Area	**Acronym**	**Beryllium Contaminated?**	**Airborne Beryllium?**
Beryllium Storage Area	BSA	No	No
Inaccessible Beryllium Contamination Area	IBCA	Yes*	No
Accessible Beryllium Contamination Area	ABCA	Yes	No
Airborne Beryllium Area	ABA	Yes	Yes, below AL
Regulated Beryllium Area	RBA	Yes	Yes, may be above AL
*Contamination limited to inaccessible surfaces Beryllium items may be stored in all of the designated beryllium areas.			

Each Designated Beryllium Area has specific requirements, which often differ from area to area. However, requirements that apply to all or nearly all designated beryllium areas include the following:

- Defined boundaries
- Postings
- Access control
- Exposure monitoring
- Periodic surface sampling
- Housekeeping

Designated Beryllium Area postings, access control, and housekeeping requirements are found in Module 6.

Other areas identified in P101-21 include Non-Beryllium Areas, Inaccessible Be Areas, & Beryllium Areas-Otherwise Inventoried.

Glovebox work with beryllium in support of a European effort to prove the feasibility of fusion as a large-scale and carbon-free source of energy.

Module 2 Self-Assessment

1. Which of the **3** main documents that address Beryllium in the workplace is:

a. specific to work at LANL? _____

b. also called “The Beryllium Rule”? _____

c. an OSHA regulation? _____

2. The action level (AL) for airborne beryllium in the workplace is _____

3. What do the letters PP represent in CBDPP?

_____

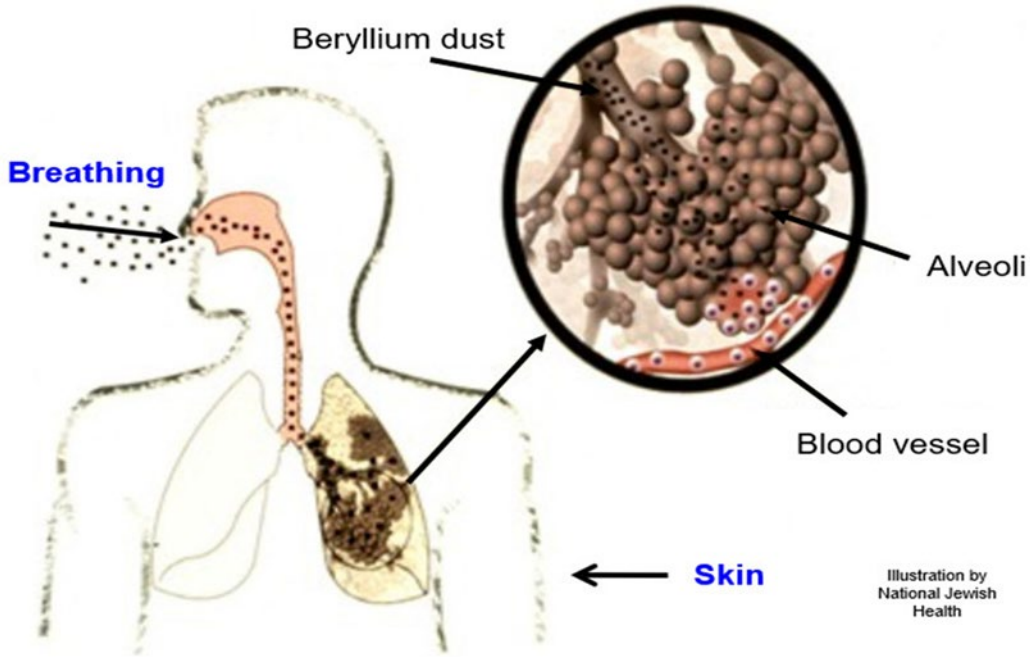
4. Most and least restrictive of LANL Designated Beryllium Areas:

Most _____

Least_____

5. Who at LANL performs hazard assessments, recommends controls, and identifies required PPE for Beryllium operations? _____

Module 3



Beryllium Health Effects

Module Objectives

After completing this module, you will be able to recognize:

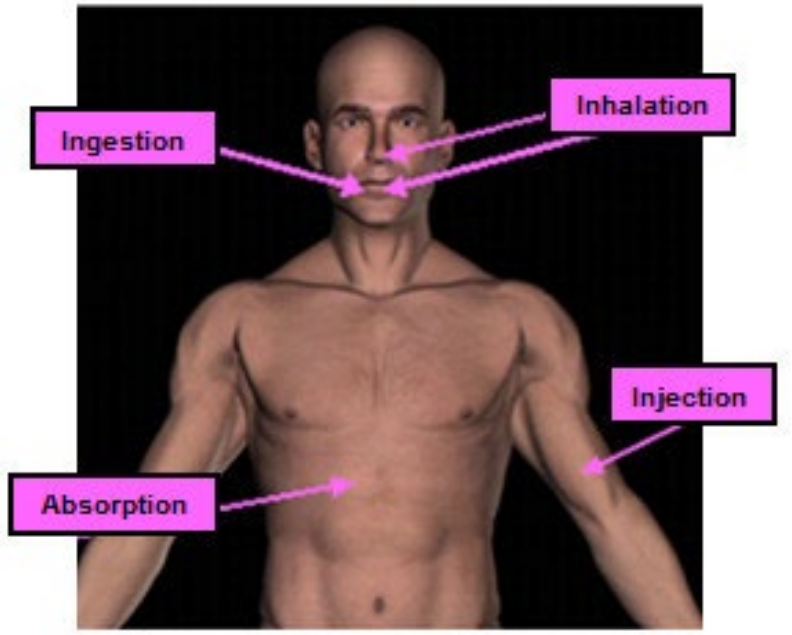
- routes of entry by which beryllium can enter the body;
- acute and chronic health effects from exposure to beryllium; and
- the answers to commonly asked questions about beryllium sensitization and CBD.

Beryllium is found at low levels in most soils and does not appear to cause adverse health effects. This may be from the low amounts of the beryllium and/or the chemical form of the beryllium. However, some workers exposed to beryllium while at work have an increased risk of developing CBD—chronic beryllium disease.

Routes of Entry

Beryllium can enter the body through any of four pathways: skin contact (absorption), swallowing (ingestion), breathing (inhalation), or piercing (injection). Examples of these routes are

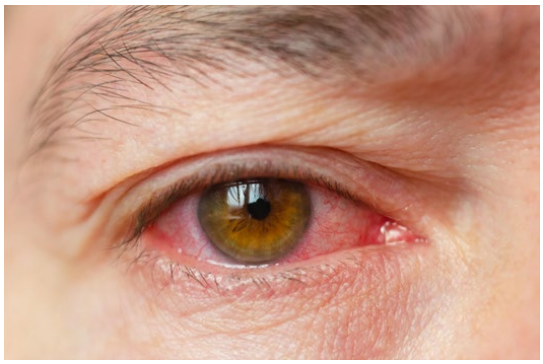
- skin contact or contact of open cuts with soluble beryllium compounds or beryllium powders (absorption),
- eating or drinking where beryllium particles are present (ingestion),
- breathing air that contains particles of beryllium (inhalation), or
- piercing by a tool contaminated with beryllium (injection).



Although beryllium can enter your body through ingestion (swallowing), beryllium is not generally considered an ingestion hazard.

Skin or Eye Contact

Water-soluble beryllium compounds such as beryllium salts may cause rashes or irritation if you get them on your skin. Both water-soluble and water-insoluble beryllium materials can irritate your eyes. Skin contact may indirectly lead to inhalation if contaminated hands/gloves touch or are brought in close contact with the mouth or nose. Current studies are investigating whether skin contact leads to the development of dermatitis and/or sensitization.



Examples of beryllium salts include beryllium chloride, beryllium sulfate, and beryllium nitrate.

Open Cuts and Wounds

Beryllium can also enter your body through open cuts and wounds. Wounds contaminated with beryllium may form granulomas.

Granulomas are small areas of chronic inflammation that do not heal properly and often result in a permanent scar. The granulomas at right were caused by beryllium and may involve an immune response that is like an allergic reaction. Nonallergic granulomas are more common and represent the skin's response to implanted foreign materials such as splinters, plant spines, and silica.

Skin granulomas caused by beryllium.

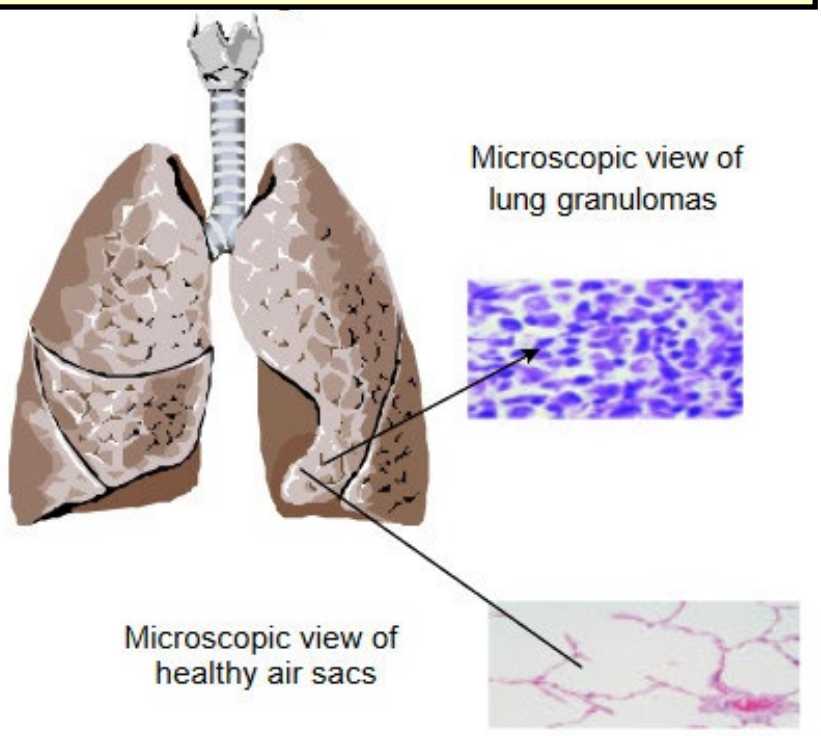
Clean any wound contaminated with beryllium immediately and then go to Occupational Medicine (OH-DO). The wound will usually heal normally once the beryllium is removed.

Granulomas caused by beryllium can also occur in the lung.

Research has shown that sub-micrometer particles could enter intact human skin with mechanical motion and that mice could be sensitized to beryllium salts applied to their ear skin (*Tinkle 2003*).

Inhalation

Inhalation of airborne beryllium is the route of entry of most concern. Airborne particles that are small enough to travel deep into the lungs can cause acute beryllium disease (ABD) or chronic beryllium disease (CBD). Inhaled beryllium particles are trapped in the lungs. The body's immune system attacks the particles and this causes inflammation and scarring. The damaged areas of the lung do not effectively exchange oxygen and carbon dioxide. Lung damage progresses over time, even if exposure to airborne beryllium is stopped.



Health Effects from Beryllium Exposure

Acute Beryllium Disease (ABD)

In the 1940s, doctors discovered that some personnel working in areas with high concentrations of airborne beryllium developed symptoms that resembled pneumonia. ABD may result from a short-term, high-level exposure to airborne beryllium. Symptoms, which appear within days or weeks, may include:

- coughing,
- burning and pain in the chest, and
- shortness of breath.

In the past, ABD was known as chemical pneumonia. Studies of workers from the 1940s and 1950s who had chemical pneumonia after a beryllium exposure suggest that such an episode can lead to CBD later in life.

Recovery from ABD often takes from a week to six months, although symptoms may reappear. Today, improved workplace controls make it unlikely that anyone working in beryllium operations will be exposed to concentrations high enough to cause ABD, but accidents do happen. You should be aware of the hazard.

Chronic Beryllium Disease (CBD)

CBD is an incurable disease that can result from the inhalation of airborne beryllium. CBD is mainly a lung disease, but it may also affect other organs such as the lymph nodes, skin, spleen, liver, kidneys, and heart.

The average time from the first beryllium exposure to the onset of symptoms of CBD is about 10–15 years. In some people, health effects have appeared within less time after exposure; in other people health effects may take as long as 30 years to appear. This delay or "latency" means you can be exposed to beryllium today and not suffer any health effects for many years.

Common Questions & Answers About Beryllium Sensitization and CBD

What are the Main Risk Factors for CBD?

Workers who currently perform or in the past have performed beryllium activities are at an increased risk of developing CBD. Factors that increase the risk of developing CBD include particle size, amount of exposure, and individual susceptibility.

Particle size. When people breathe, airborne particles smaller than 10 micrometers in diameter are more likely to travel deep into the lung and become trapped than are larger particles. Beryllium work that produces large amounts of small particles (such as machining) increases the risk for both inhalation and skin exposure.

A 10-micrometer (10 µm) particle is 10 millionths of a meter in diameter. In comparison, the diameter of a human hair ranges from 50–150 µm.

Exposure amount. The amount of exposure depends on the

- concentration of airborne beryllium to which you are exposed,
- length of time you are exposed, and
- possibility of dermal exposure from beryllium-contaminated surfaces.

Individual susceptibility. **Individual susceptibility is the main factor in determining if a person will develop CBD.** Beryllium is different from many workplace health hazards because there are relatively few people who are susceptible to it. *"Susceptible" people who are exposed to beryllium and develop an allergic reaction become "sensitized."* (While beryllium sensitivity is not exactly an allergy, the comparison helps explain why some people respond to beryllium and others do not.)

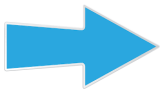
Susceptible - before exposure, you are more likely to become sensitized to beryllium if exposed.

Sensitized - after exposure, your immune system recognizes beryllium and responds adversely.

Most workers are not susceptible to beryllium and will never become sensitized nor develop CBD. However, some workers appear to be very susceptible to beryllium, and low levels of exposure may cause them to become sensitized and possibly develop CBD. Beryllium sensitization typically develops within a year after exposure; however, it may develop long after exposure to beryllium ends.

Beryllium controls must address both inhalation and skin contact.

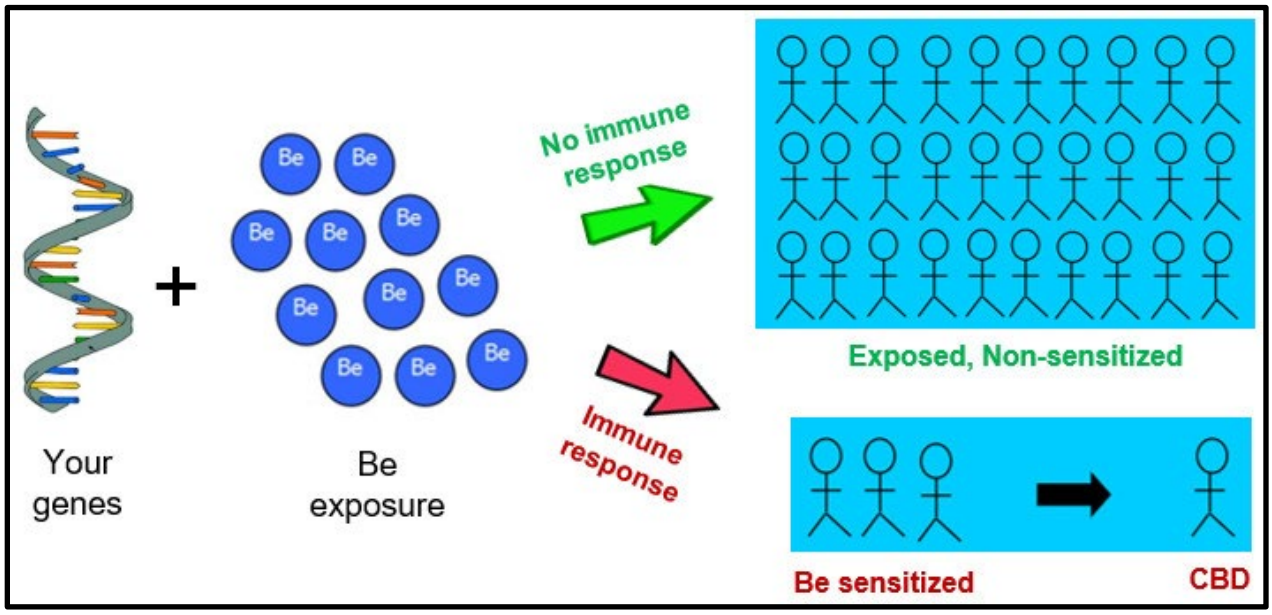
Although rare, CBD has been found in office workers and others who were only known to have had a brief, casual exposure to beryllium.



For beryllium-associated workers, the risk of beryllium sensitization continues after beryllium work ends.

Being sensitized to beryllium does not necessarily mean that a worker will develop CBD but it does put the worker in a higher risk group. Because no sure method exists for predicting which workers are susceptible to beryllium, LANL assumes that all workers may be susceptible to beryllium and protects them accordingly.

Possible outcomes after exposure to beryllium ~~in the workplace~~.



According to the diagram, what is the most likely outcome after exposure to beryllium in the workplace?

How Can I Tell if I'm Sensitized to Beryllium?

The beryllium lymphocyte proliferation test (Be-LPT) is used to diagnose beryllium sensitization. Federal regulation requires offering this test to all workers enrolled in the beryllium medical surveillance program. The test involves testing cells from a blood sample with beryllium and checking the cells for a response in the form of rapid growth (proliferation). If the cells respond, the test result is reported as abnormal or "LPT-positive."

A **lymphocyte** is a white blood cell that supports the body's defenses.

The Be-LPT is voluntary, and you are NOT required to take it. *If you decide to have the test, you must sign a consent form.*

Repeat positive Be-LPTs indicate that a worker has been exposed to beryllium and has become sensitized. That is, the worker's immune system is responding to beryllium. Having the Be-LPT will not cause you to become sensitized but it will suggest whether you have a higher risk of developing CBD.

Note: A positive Be-LPT does not always mean a person has CBD or will develop CBD.

A blood sample is drawn for a Be-LPT. A worker will NOT become sensitized or develop CBD from having a Be-LPT performed.

How Reliable is the Be-LPT?

The Be-LPT helps identify people with a higher risk of developing CBD. The Be-LPT is not a perfect tool, but at this time it is the best tool available for medical surveillance of workers exposed to beryllium in the workplace.

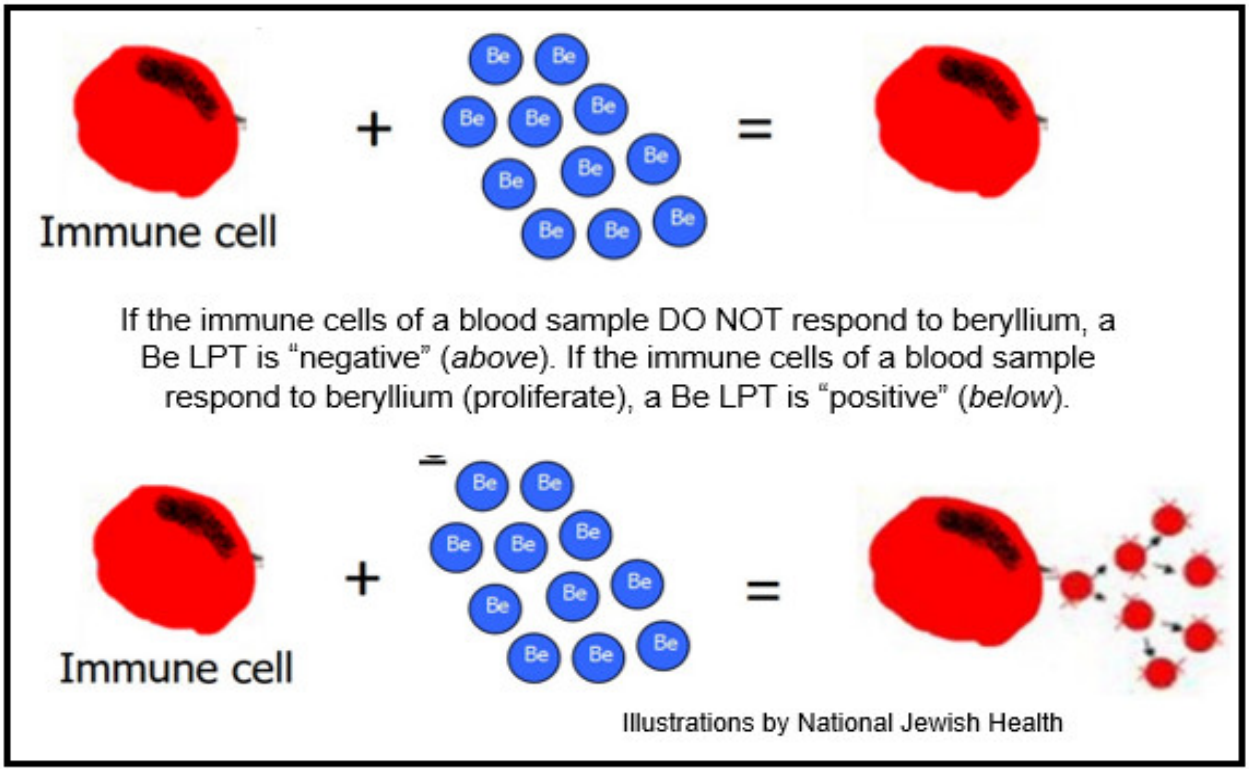
A 2004 study* of 12,194 current and former DOE workers found that the false positive rate for the Be-LPT averaged only 1.09%. This rate is widely considered acceptable for a test. The same research indicated false negative rates ranging from 25–38%. This rate is higher than is desirable for a screening test. However, repeating this test on a regular basis (every one to three years, depending on when medical surveillance is offered) increases the chances of identifying a worker who is truly beryllium sensitized.

*A.W., Stange, F.J. Furman, D.E. Hilmas, "The Beryllium Lymphocyte Proliferation Test: Relevant Issues in Beryllium Health Surveillance", *American Journal of Industrial Medicine*, 46: 453-462, (2004).

A **false positive** indicates an abnormal value (LPT-positive) when the person tested is actually normal (LPT-negative). In other words, a false positive concludes that someone is sensitized to beryllium when he/she is not sensitized.

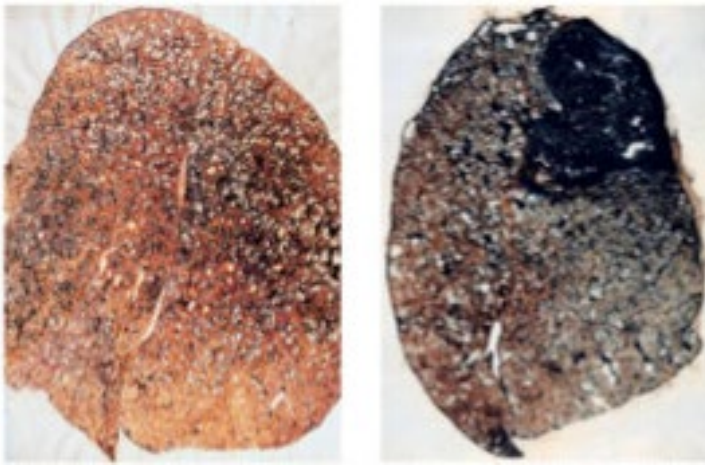
A **false negative** indicates a normal value (LPT-negative) when the person tested is actually abnormal (LPT-positive). In other words, a false negative concludes that someone is not sensitized to beryllium when he/she actually is sensitized.

The Beryllium Lymphocyte Proliferation Test (Be-LPT)



How Does CBD Develop and Progress?

When a person breathes in beryllium some of the beryllium particles they inhale are trapped in their lungs. In a sensitized person, the body's attempts to protect itself from beryllium particles can actually hurt the lungs by causing inflammation and scarring, and this damage will disturb normal breathing. The damaged areas of the lungs no longer exchange oxygen and carbon dioxide as well as they should, and this reduced exchange makes it harder for the body to get all of the oxygen it



Normal lung (*left*); beryllium-exposed lung (*right*).

CBD typically progresses slowly. The extent of symptoms and the course of the disease can differ greatly from person to person. Some persons have mild symptoms; others have periods of flare-ups followed by periods of improvement. Some persons are stable for many years and then show a rapid decline. Because CBD disturbs the ability to breathe, supplemental oxygen may be needed to protect against heart damage that may occur because of low oxygen levels.

CBD negatively affects the quality of life and increases the risk of premature death.

What Are the Symptoms of CBD?

CBD is mainly a disease of the lungs with signs and symptoms much like other diseases that affect the lungs and breathing. Signs of CBD may include

- shortness of breath with walking, climbing stairs, or other physical activity,
- a dry cough that will not go away,
- coughing up blood,
- fatigue,
- chest and joint pain,
- rapid heart rate,
- loss of appetite, and
- fevers and night sweats.

DO NOT WAIT until your next scheduled physical examination to report suspected symptoms.

What Are My Chances of Becoming Sensitized or Getting CBD?

Consider the data shown in the table below, collected during a study of participants in the Rocky Flats Beryllium Health Surveillance Program, prior to the enactment of the DOE Beryllium Rule in 1999. The study showed that depending on the type of work a person is doing, 3–10% of workers exposed to beryllium may become sensitized. Historically, 2–9% of workers exposed to beryllium have developed CBD. The figure 9% includes jobs such as machining, where the risk of exposure is greater.

A study of 5173 workers in the Rocky Flats Beryllium Health Surveillance Program found 154 cases of beryllium sensitization and 81 cases of CBD.

This data on percentages of workers becoming sensitized or getting CBD is based on decades-old research, which was carried out before the DOE beryllium rule existed. With the current requirements for controls and work practices, we can expect rates of sensitization and disease to be far lower today. The historical level of sensitization and disease is what led the DOE to develop the beryllium rule (10 CFR 850).

Studies suggest better housekeeping leads to fewer cases of sensitization and/or disease.

Sensitization and CBD by Job Type

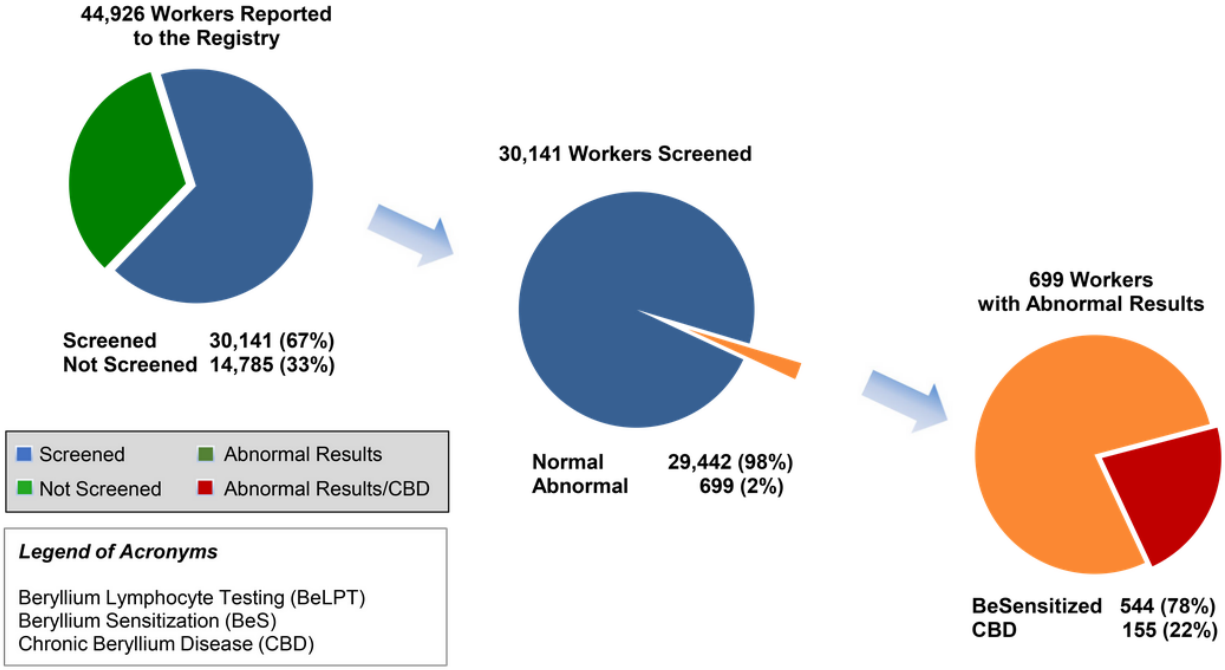
Job Type	Percent with Sensitization	Percent with CBD
Beryllium machinist	11.94	8.46
Nuclear machinist	10.81	8.11
General machinist	5.66	2.60
Construction trades	9.95	2.62
Laborer	5.59	2.69
Crafts and trades	4.75	2.06
Facilities support	4.56	1.75
Custodial	5.64	2.96
Decontamination	7.64	4.46
Radiation technician	6.65	2.31
Health physics	11.90	4.76
Administrative	4.35	1.29

From A. W. Stange, et. al., "Beryllium Sensitization and Chronic Beryllium Disease at a Former Nuclear Weapons Facility," *Applied Occupational and Environmental Hygiene* 16(3): 405-417, 2001.

Data entered in the Beryllium Associated Worker Registry (BAWR) from 2002-2021 shows 1.8% of the 30,141 screened workers were beryllium sensitized (BeS), and 0.5% of screened workers were diagnosed with CBD. Of the 155 workers diagnosed with CBD within DOE, 5.2% (8 diagnoses) were reported by LANL workers, or approximately 0.2% of those screened at LANL in the same time period.

(see next page)

Number and Percent Proportion of Workers Undergoing BeLPT Testing, and Yielding Abnormal BeS or CBD Results (n=44,926) (2002–2021) *

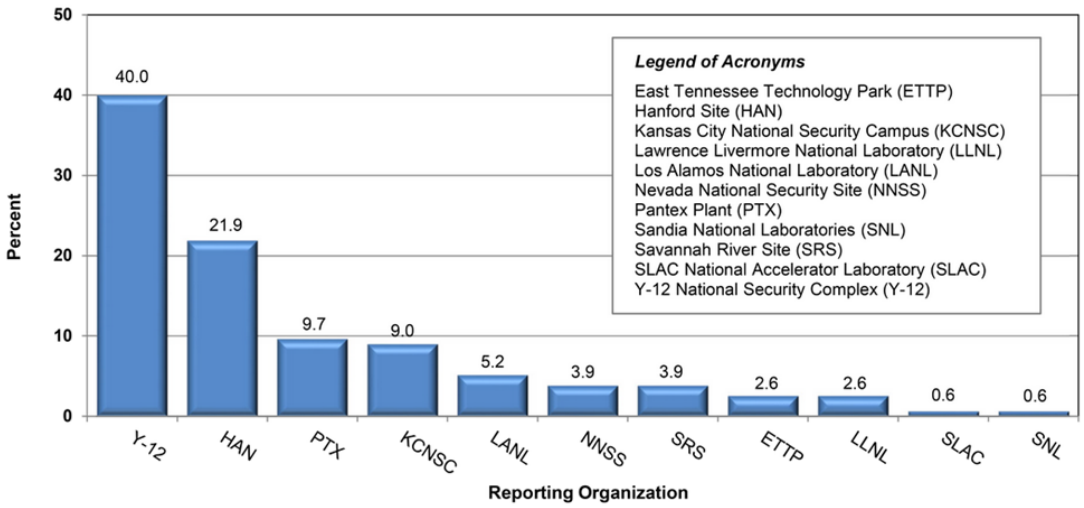


This figure depicts the numbers and percentages across the U.S. Department of Energy (DOE) complex of workers screened using the BeLPT and among those workers having abnormal results, how many are sensitized or have developed CBD. Comparison with previous years' reports show that these DOE-wide percentage distributions have remained consistent.

*Some reporting organizations have provided data that predate the 2002 start date of the registry.

https://oriseapps.orau.gov/BAWR/DashboardsReports.aspx

Percent Proportion of Workers Diagnosed as CBD by Reporting Organization (n=155) (2002–2021) *

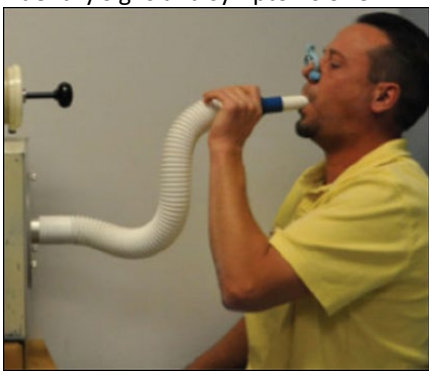


How Can I Tell if I Have CBD?

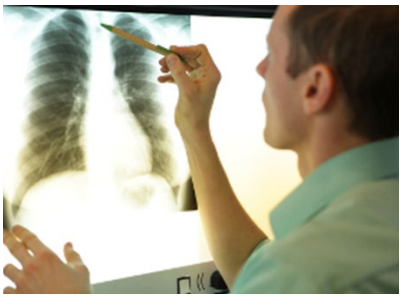
The Be-LPT can help doctors tell CBD apart from other diseases with similar symptoms and may help them detect CBD earlier. Other methods used to diagnose CBD include:

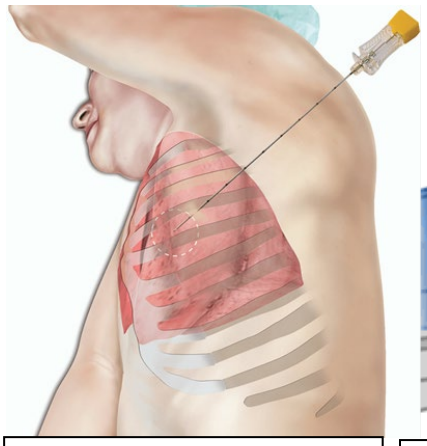
- a review of your occupational/medical history to see if signs or symptoms of CBD are present,
- a bronchoalveolar lavage (BAL) in which a Be-LPT is done on a sample of lymphocyte cells washed from the lung,
- a biopsy in which a small piece of lung tissue is removed and examined under a microscope for signs of disease,
- breathing (pulmonary function) tests to detect any decreased lung function,
- an examination with a stethoscope for possible abnormal breathing sounds (called rales),
- a chest x-ray to detect abnormalities in the lungs,
- a low dose computed tomography (CT) scan.

Above: A review of your history to identify signs and symptoms of CBD.

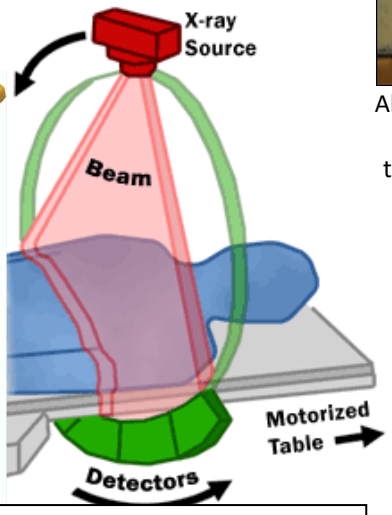


Above: Repeated pulmonary function tests can track lung function over time. Below: A chest x-ray can show abnormalities in the lungs





A biopsy can be done on a small piece of lung tissue



A CT scan uses x-rays to display a cross section of your body.

Is Beryllium a Carcinogen?

A **carcinogen** is a substance capable of causing cancer in living tissue.

Medical studies suggest that inhalation of beryllium particles may cause lung cancer. While the evidence is not completely conclusive, it is strong enough for several agencies to consider beryllium a carcinogen. The following agencies consider beryllium a confirmed carcinogen:

- the Occupational Safety and Health Administration (OSHA)
- International Agency for Research on Cancer (IARC)
- ACGIH (formerly the American Conference of Governmental Industrial Hygienists)

Studies have shown an increased risk of lung cancer among beryllium-exposed workers.

Is CBD Curable or Treatable?

Treatment improves a condition and improves the patient's quality of life.

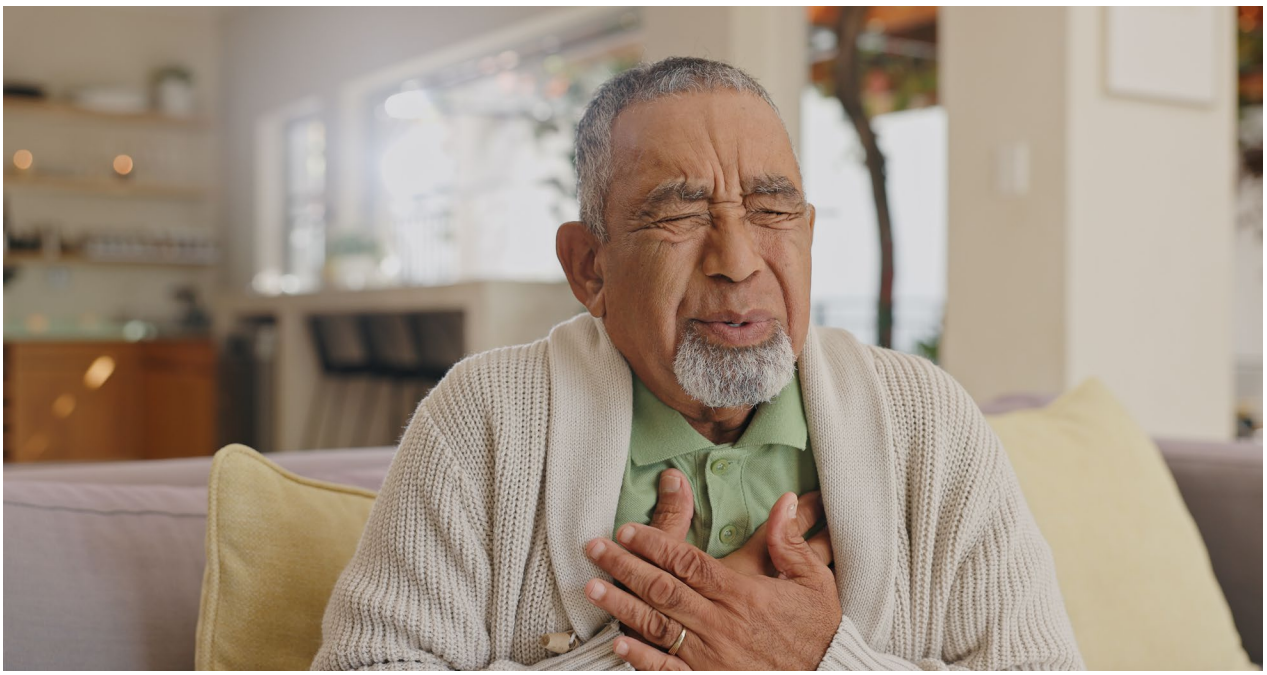
A **cure** completely removes the disease from the patient.

CBD can't be cured but it can be treated. Treatment works better when the disease is found early, and is usually based on the worker's overall health and medical history. Currently, the treatment for CBD that shows the best results is steroids. Steroids are used to suppress the immune system, slowing the buildup of scar tissue and delaying permanent lung damage. Steroids do not work for everyone and may cause side effects including

- irritability;
- greater susceptibility to, and slower healing of, infections;
- calcium loss from the bones;
- higher blood cholesterol;
- negative effects on the reproductive systems of both males and females; and
- fluid retention, which can worsen heart or kidney disease.

Although steroids can slow the course of CBD they will not stop it. Persons who can't take steroids or for whom steroids do not work may continue to lose lung function. As breathing becomes more difficult, their activities and lifestyles may become more limited (similar to people with emphysema). It is far better to prevent CBD by controlling exposures than to try to treat its symptoms.

Prednisone is a steroid commonly prescribed to patients with CBD.



Module 3 Self-assessment

1. Regarding beryllium exposure, what is the route of entry of primary concern?

   _____

2. The part of the body mainly affected by CBD is _____

3. Three main risk factors for developing CBD are:
   a. _____
   b. _____
   c. _____

4. On average, the time from initial beryllium exposure to the development of symptoms of CBD is: (circle one)

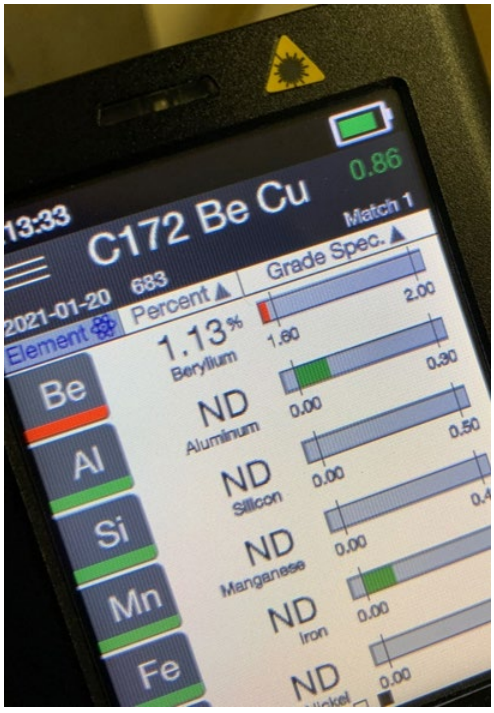
   6-12 months 1 -3 -years 10- 15 years 30-50 years

5. Currently, there is not a test that indicates susceptibility to beryllium. What test can be used to indicate beryllium sensitization?

   _____

6. CBD is incurable. What can be used to treat CBD by slowing the progress of the disease?

   _____



Module 4

Monitoring Beryllium in the Workplace

Module Objectives

After completing this module, you will be able to recognize:

- types of beryllium sampling in the workplace, including air sampling, surface sampling, and surface trigger levels;
- requirements for release of beryllium materials and areas; and
- beryllium sampling limitations and research.

Beryllium Sampling in the Workplace

Air and surface sampling are used to determine the chance for beryllium exposure or beryllium contamination in and around designated beryllium areas. Samples must be collected under the guidance of a qualified industrial hygiene and safety professional (QIHSP).

Procedures for beryllium sampling are found in the LANL *Laboratory Industrial Hygiene and Safety Manual* and as required by P101-21.

Air Sampling

Air samples are collected to measure the airborne concentration of beryllium in the work area. A pump draws air through a filter, and beryllium particles are trapped on the filter. After the sample is collected the filter is sent to an accredited laboratory for analysis. The two types of air sampling are personal and area sampling.

Personal sampling pump with collection device in breathing zone (*left*); area sampler (*below*).

Personal Sampling

Personal air samples are collected near the worker's breathing zone and are used to estimate individual exposures to airborne beryllium.

Area Sampling

Area samples of the work area may be collected close to a particular operation and/or in the general room location. They are often high-volume samplers that allow airborne beryllium to be detected at very low levels.

Use of Sampling Data

Data collected from personal and area air sampling help answer the following questions:

- What jobs or operations are producing airborne beryllium?

To how much airborne beryllium are

- individual workers exposed?
- Are there opportunities to reduce exposures?
- What level of respiratory protection, if any, does the job require?
- How well are the controls working?

Airborne Beryllium Detected during Abrasive Blasting Operations

On two separate occasions at the Oak Ridge National Laboratory, air sampling during abrasive blasting operations indicated airborne beryllium concentrations that exceeded the DOE action level. Subsequent samples of paint, mortar, terra cotta block, and blasting agent were collected. Analysis of the bulk materials revealed that beryllium was present in concentrations ranging from 0.2 to 1.2 µg/g (ppm). The concentration of beryllium in these materials was consistent with the concentration of beryllium in the natural soils at Oak Ridge. In general, routine controls for other hazards involved in abrasive blasting operations should keep the potential for beryllium exposure controlled as well.

DOE NNSA Lessons Learned Y-2003-OR-BWXTY12-0602

Surface Sampling

Surface sampling methods are addressed in the Laboratory Industrial Hygiene and Safety Manual (LIHSM).

Surface sampling is used to determine the amount of removable beryllium dust on a surface. Surface samples are collected from locations

- within and near designated beryllium areas;
- where beryllium contamination may exist from past operations; and
- on other work area surfaces if there is potential beryllium contamination above trigger levels.

Surface sampling is usually performed by wiping a moistened filter paper or wipe over a surface area of known size. The filter paper/wipe is sent to a certified laboratory for analysis or analyzed "in-house" by LANL.

Surface sampling helps determine

- areas and equipment with beryllium contamination;
- the effectiveness of controls (especially housekeeping and decontamination efforts);
- if airborne beryllium has been present (current or past) and settled onto surfaces;
- if beryllium has spread into non-beryllium areas;
- what personal protective equipment (PPE), if any, is required; and
- if items can be released.

At LANL, approximately 4000 samples are collected and analyzed per year.

Some surfaces in designated beryllium areas (such as within hoods or vessels or on normally inaccessible surfaces) may exceed trigger levels when approved by a QIHSP.

Surface Sample Trigger Levels

Surface sample trigger levels are the beryllium surface contamination levels at which corrective actions are taken. Required actions depend on the amount of surface contamination and the type of area, as shown in the table below.

Refer to P101-21(section 4.6), your QIHSP, or your work control documents for the specific action(s) to take based on surface sample trigger levels.

Surface sample trigger levels apply to surface cleanliness, but do not necessarily indicate an airborne beryllium exposure hazard. However, disturbed, removable beryllium dust can become re-suspended into the air, creating a potential inhalation hazard.

Surface Sample Trigger Levels & Required Actions	
Accessible Beryllium Contamination, Airborne Beryllium, Regulated Beryllium Areas & Designated Installed Beryllium-Containing Materials	
Trigger Level µg/100 cm^2	**Actions Required**
<3.0	• No corrective action required.
3.0 to 10.0	• Further evaluate source of contamination, potential exposure, housekeeping, and controls. • A QIHSP and the FOD and/or RLM will determine if work should be stopped. • Clean to below 3.0 µg/100 cm^2
>10.0	In addition to actions for 3.0 - 10.0 µg/100 cm^2(above) • Stop operations that could result in worker exposure to airborne beryllium or or spread surface contamination • Determine needed corrective actions and clean to below 3.0 µg/100 cm^2 • RLM and QIHSP approval required for restart
Non-Beryllium Areas, Beryllium Storage Areas, Inaccessible Be Areas, & Beryllium Areas-Otherwise Inventoried	
Trigger Level µg/100 cm^2	**Actions Required**
<0.2	• No corrective action required.
0.2 to 3.0	• Further evaluate source of contamination and potential exposure • A QIHSP and the FOD and/or RLM will determine if work should be stopped. • Clean to below 0.2 µg/100 cm^2 or post as a beryllium area
>3.0	• Stop operations that create or spread airborne or surface contamination • Further evaluate source of contamination and controls • Determine future use of area and post accordingly

Release of Beryllium Materials and Areas

Releases of beryllium or potentially beryllium contaminated items or areas must be performed and documented under direction of a QIHSP. Areas must be correctly posted and inventoried. Items must have release forms and correct labels. Form 2120, *Beryllium Release Form*, is used to document the release of beryllium materials.

If an item is in a contaminated Designated Beryllium Area or has been used for a beryllium operation, it is considered potentially beryllium contaminated, and must meet specific release requirements. In general, release of beryllium materials is as follows:

1. Begin Form 2120
2. Determine release type and follow the requirements based on type of release
3. Decontaminate and sample, as needed
4. Package and label, following any site-specific requirements.
5. Obtain written confirmation that the recipient understands beryllium hazards and will use controls to prevent exposure.
6. Complete from 2120 and release material.

Form 2120 is accessible through the LANL homepage under "Forms Center".

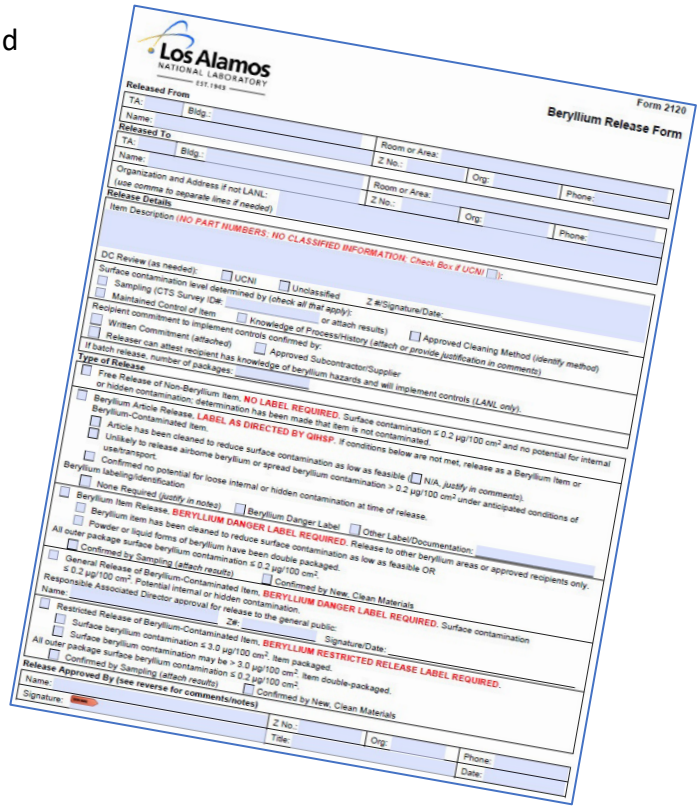
Release types are shown on the next page.

Signs and labels used for release of beryllium and beryllium-contaminated items or areas are shown in Module 6.

A release form might not be required for transfers of items between LANL beryllium areas if a QIHSP determines that suitable procedures are in place.

Items under constant control of a worker that have no potential for contamination (such as a pen or eyeglasses that did not contact workplace surfaces) may be removed without forms or labels.

The removal of packaged waste, beryllium alloys for recycling, and contaminated laundry from a designated beryllium area is not considered a beryllium release, however, removal of such items must follow applicable LANL requirements.


Los Alamos NATIONAL LABORATORY

Form 2120

Beryllium Release Form

Released From

Released To

Release Details

Item Description (NO PART NUMBERS. NO CLASSIFIED INFORMATION. Check Box if UCNI)

Type of Release

Release Approved By (see reverse for comments/notes)

Release of Be Materials & Areas		
Release Type	**Applies to . . .**	**Surface Contamination Levels and Labeling**
Free release of non-beryllium items	Items not made of beryllium with no potential for internal, entrapped, or other inaccessible beryllium contamination.	Removable contamination ≤0.2 µg/100 cm^2. No label required. Form 2120 required.
Release of beryllium articles	Items made of beryllium which meet the definition of beryllium articles that have been used in beryllium-contaminated areas but have no potential for loose internal or hidden contamination at the time of release.	No loose beryllium contamination which could release airborne beryllium or spread contamination > 0.2 µg/100 cm^2. No label needed unless required by a QIHSP.
Release of beryllium items	Items made of beryllium that have been cleaned to remove loose particles (when feasible).	Removable contamination on outer packaging ≤ 0.2 µg/100 cm^2. Beryllium Danger Label required.
General release of beryllium-contaminated items	items with potential for internal, entrapped, or other internal contamination, to be released to the general public*, or another LANL area, or DOE facility for nonberyllium use.	Removable contamination on accessible surfaces ≤0.2 µg/100 cm^2. May have internal or hidden beryllium contamination on inaccessible surfaces. Beryllium Danger Label required.
Restricted release of beryllium-contaminated items	items with beryllium contamination on accessible surfaces which are to be released to another beryllium facility.	Removable contamination on accessible item surfaces ≤3.0 µg/100 cm^2 and removable contamination on outer packaging ≤0.2 µg/100 cm^2. Beryllium Restricted Release Label required.
Release of facilities, work areas, or environmental sites	Former and current beryllium operation areas.	Removable contamination on facility surfaces ≤0.2 µg/100 cm^2; requires sampling plan developed by a QIHSP.

**Release of beryllium-contaminated items to the general public is strongly discouraged and requires special approval.*

Beryllium article - an item formed to a specific shape or design during manufacture that under normal conditions of use or handling does not release or otherwise result in exposure to airborne beryllium, and is unlikely to spread beryllium contamination to adjacent or nearby work area surfaces.
Beryllium item - an object, device or material made of beryllium or containing accessible beryllium, including any beryllium compound or alloy containing at least 0.1% beryllium by weight and that does not meet the definition of a beryllium article.
Beryllium-contaminated item - a non-beryllium object or device with measurable removable beryllium surface contamination above 0.2µg/100 cm^2, or a beryllium item or article with loose surface contamination likely to spread beryllium contamination to work area surfaces.

An item ceases to be an article when it is subjected to any processes or conditions that could result in the release of airborne beryllium particles or the spread of beryllium contamination above trigger levels. This includes excessive oxidation over time, which may become airborne or spread to other surfaces during handling.

Sampling Limitations & Research

Sampling Limitations

- Beryllium dust on a surface may be removable or fixed. When performing surface sampling, only removable beryllium is collected for analysis. Surface sampling with swipes will not collect beryllium that is sealed beneath paint, embedded in building materials, or otherwise difficult to remove. This can affect hazard evaluation for remodeling or demolition work.

Heavy contamination on a surface may result in airborne beryllium if the surface is disturbed.

- Air sampling and surface sampling generally have no direct correlation. Swipe sample results do not accurately predict the amount of airborne beryllium levels, and air sampling results do not accurately predict of the amount of surface contamination. Surface contamination may indicate that previously airborne beryllium dust has settled, but can't be used to predict current airborne beryllium levels.
- Surface and air sampling results are not available in real-time. Results are usually available within days of collection, but this delay means that results cannot be used for immediate evaluation. Therefore, personnel must continue to use required controls (such as a respirator) until the results of the samples are received and a QIHSP determines that less stringent controls may be used.

At present, LANL uses a fluorometric procedure for the near real-time analysis of some surface samples. This gives relatively fast but preliminary results. Accredited laboratory analysis is required when monitoring worker exposures or performing release sampling.

Sampling Research

Currently, a handheld tool using Laser Induced Breakdown Spectroscopy (LIBS) may be used to determine if metal objects meet the DOE definition of beryllium (contain ≥ 0.1% beryllium). However, there are currently no commercial direct-reading instruments available for real-time airborne beryllium monitoring or reliable quantification of surface contamination. Research continues on the use of a LIBS for these purposes. Eventually, LIBS or a similar method may be able to offer real-time or near-real-time monitoring so that analytical results can be obtained immediately or shortly after sample collection.

Handheld LIBS Research

A recent study looked at the analysis of Be on solid surfaces using a handheld LIBS (HH LIBS). Solutions with known concentrations of beryllium were deposited on filters and then measured with an HH LIBS. A calibration curve was developed that successfully identified the amount of beryllium on filters containing from 0.5 and 5.0 µg when compared with known laboratory analytical techniques. Though still in development, this technology could help determine quantities of beryllium surface contamination on a real-time or near real-time basis.

Handheld LIBS (*SciApps*)

-paraphrased from B.T Manard study in *Analytical Methods,* Issue 6, 2019.

Note: OSH-ISH has developed a screening tool to assess whether surface beryllium is from manmade sources or native soils. This tool is a spreadsheet which uses equations based on soil sampling performed site-wide and ratios of beryllium to other metals closely correlated to beryllium in LANL soils. The OSH-ISH beryllium program lead may be consulted regarding use of this tool.

More information about access to exposure records is on page 53

Access to Sampling (Exposure) Results

You have a right to know your personal sampling results. Notification of personal monitoring results must be provided to the worker within 10 working days of receipt of the analytical results. If the results indicate that your exposure is at or above the beryllium AL, a description of any corrective action taken to reduce your exposure below the AL must be included. The Site Occupational Medical Director (SOMD) is also notified of personal air monitoring results above the action level.

Beryllium in Electrical Component in Crane Power System

On some cranes, the collector shoes that slide along the electrical bus bars to transfer electrical power to bridge cranes may be made of a copper/2%-beryllium alloy. As the collector shoes slide along the bus bar, there is wear over time from oxidation, friction, and arcing. This can result in the collection of beryllium-containing dust on bus bar and collector shoe surfaces.

At a DOE facility, sampling on bus bar surfaces of one crane indicated removable beryllium ranging from 3.7 to 10 µg/100 cm^2. Subsequent sampling indicated no detectable airborne beryllium and no surface contamination over the release criteria on any adjacent surfaces. Before maintenance is performed near bus bars and collector shoes, the type of collector shoes should be checked to see if they are made with a beryllium-containing alloy.

DOE Lessons Learned 2003-RL-PNNL-0001

Module 4 Self-Assessment

1. List two types of beryllium air sampling: _____ and _____

2. Which form is used to document a beryllium release? _____

3. What is the surface sample trigger level for which “No corrective action is required” for:

   a. a **regulated** beryllium area? _____ µg/100 cm^2

   b. accessible surfaces in a room with an **inaccessible** beryllium area (such as a space above the ceiling)? _____ µg/100 cm^2

Module 5

Beryllium Medical Surveillance

Module Objectives

After completing this module, you will be able to recognize:

- elements of the LANL beryllium medical surveillance program,
- elements of the beryllium medical removal program,
- retention requirements for beryllium medical records and your right to access medical records, and
- counseling and support services available for beryllium medical concerns.

Beryllium Medical Surveillance at LANL

Beryllium medical surveillance must be available for beryllium-associated workers, including subcontractors as set forth in their subcontracts. The overall goals of medical surveillance are to:

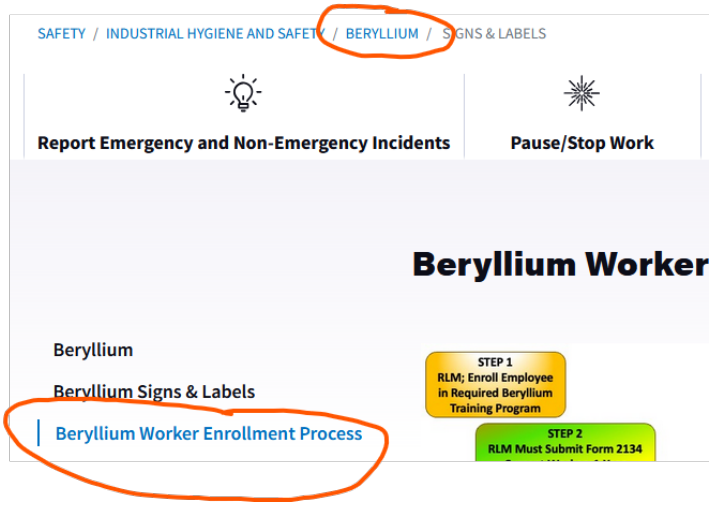
- monitor the health of exposed workers, and
- identify as soon as possible any adverse health effects from exposure to beryllium.

The LANL beryllium medical surveillance program:

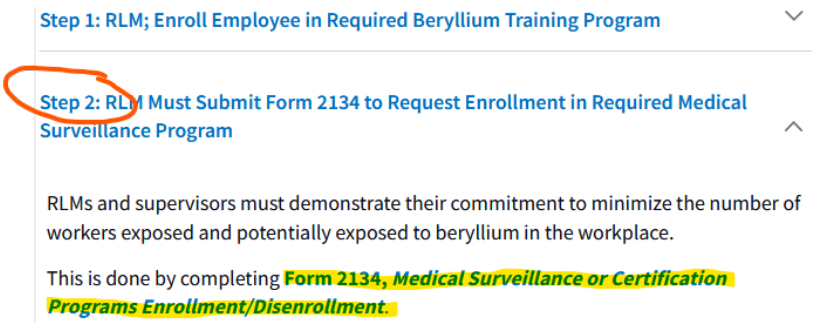
- identifies workers at higher risk of adverse health effects from exposure to beryllium;
- links health outcomes to beryllium tasks, workplace conditions, and exposure data to identify risks and take actions to prevent disease associated with beryllium;
- makes possible the early treatment of disease associated with beryllium; and
- allows for removing affected workers from further exposure to beryllium.

LANL workers with potential exposure to airborne beryllium (either current or past) may take part in the LANL beryllium medical surveillance program. During enrollment, a beryllium questionnaire is completed in which you will be asked about current and past exposures to beryllium.

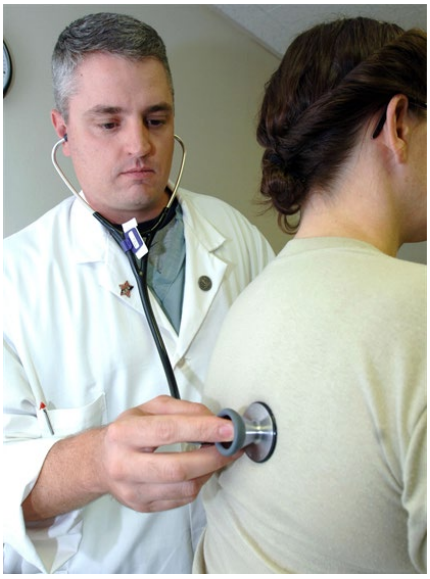
Personnel newly assigned to work with beryllium are generally identified by their supervisor using Form 2134, Medical Surveillance or Certification Programs Enrollment/Disenrollment Form, and receive an email from ISH requesting completion of the questionnaire. If you think you are currently doing work that may expose you to beryllium or may have been exposed in the past (even if at another site), complete a beryllium questionnaire.



This questionnaire is available on the LANL beryllium homepage.



Enrollment in the beryllium medical surveillance program is required for all beryllium associated workers, but participation in specific medical evaluations is voluntary. Beryllium workers are encouraged, but not required, to participate in medical evaluations even after they stop working in a beryllium area. Workers may refuse any or all medical surveillance tests. Workers who decline beryllium medical surveillance may change their mind and accept it at a later date. There is no cost to the worker for this service.



The medical evaluation must offer

- a detailed medical and work history,
- a questionnaire about respiratory symptoms,
- a physical examination,
- a pulmonary (lung) function test,
- a chest x-ray,
- a Be-LPT, and
- any other tests determined by the physician to be necessary to evaluate beryllium-related health effects.

Periodic medical evaluations are offered each year for current beryllium workers and every three years for past beryllium workers who are no longer exposed to airborne beryllium. An optional declination statement is provided at the time medical surveillance is offered. If you elect not to participate in medical surveillance, return the declination statement to OccMed.

Worker receiving physical exam (*above*); Worker performing a pulmonary function test (*below*).

Chest x-rays are offered every five years. Emergency medical evaluations are available to any worker in the event of a beryllium emergency.

After a beryllium medical evaluation, a written medical opinion and recommendations must be provided to the beryllium worker or the beryllium-associated worker within 10 working days of receipt of all results. Workers may designate a second physician to review results, or conduct tests the second physician feels are necessary.

If you think you have symptoms of CBD, seek medical attention immediately. **Do not wait** until your next scheduled physical examination. Contact OM at 505-667-0660.

Value of Medical Surveillance

Medical surveillance can identify persons at increased risk for developing beryllium health effects. Any worker diagnosed with beryllium sensitization (BeS) may decide whether or not to continue working with beryllium. Since beryllium-sensitized workers have a higher risk of developing CBD, they will continue to be offered medical surveillance as well as additional diagnostic examinations by medical specialists.

LANL workers receive follow-up evaluations from specialists at National Jewish Health in Denver, CO, one of the leading respiratory hospitals in the nation.

If a worker is identified as beryllium sensitized, a worker's compensation case is initiated with the Department of Labor. This allows the worker to receive follow-up medical evaluations under the Energy Employees Occupational Illness Compensation Program (EEOICP). Workers diagnosed with CBD are eligible for compensation under the EEOICP.

You can contact the Energy Employees Compensation Resource Center in Espanola, NM, at (866) 272-3622.

Periodic medical surveillance helps medical professionals make a definitive diagnosis, which helps them suggest the best treatment. Once a definitive diagnosis has been made, medical professionals are better able to provide

Definitive diagnosis—a decision based on tests made by one or more medical professionals that a specific medical condition exists.

- information on the cause and progress of the disease,
- guidance on recommended treatment,
- information to establish eligibility for workers' compensation insurance, and
- guidance on recommended work restrictions to minimize further exposure.

Early treatment slows the progress of CBD in some people but will not stop the process entirely.

Left - Review of medical evaluation results (*National Jewish Health*); *Right* - The Oak Ridge Institute for Science and Education (ORISE) maintains the Beryllium-Associated Worker Registry for the DOE.

See 29 CFR 1910.1027(l)(13)

Medical Removal

Beryllium-associated workers diagnosed with beryllium sensitization or CBD are offered medical removal from work involving beryllium. Stopping further exposure to beryllium may help prevent sensitization from developing into CBD or may slow the progression of CBD. As part of medical removal,

- workers with beryllium sensitization or CBD are offered removal to a comparable job;
- the job must be one for which they are qualified or can be trained in a short period and where beryllium exposures are as low as possible and never exceed the AL;
- normal earnings, seniority, and other rights will remain the same for up to two years;
- if a comparable job is not available, normal benefits must be provided until a comparable job becomes available or for two years, whichever comes first; and
- retraining for other jobs is also available.

Medical removal for beryllium-associated workers diagnosed with beryllium sensitization or CBD is recommended but it is not required. All beryllium-associated workers will be advised of the benefits of removal and the risk of continued exposure to beryllium. They will be given the opportunity to have any questions concerning medical removal answered. Even if medical removal is recommended, the worker may still choose to continue working in his or her present position.

Medical Records

At LANL, records are kept by LANL for the duration of the worker's employment and then for 75 years thereafter. All work-related records must remain confidential as required by the CBDPP. This means that records sent to other parties must not contain names, social security numbers, or any other means of identifying individuals, unless a worker gives specific written permission. Medical information generated by the CBDPP must be kept confidential.

OccMed collects data on current and past beryllium workers at LANL, which includes the following information:

- a unique identifier (not traceable to any worker),
- date of birth,
- gender,
- site,
- job history,
- medical screening test results,
- exposure measurements, and
- results of specialized medical evaluations.

Data is sent to the DOE Office of Epidemiologic Studies in an effort to link occupational exposures and work conditions with health outcomes. Collecting and evaluating this type of data from across the DOE Complex may allow for a better understanding of CBD and the conditions that lead to its development. Understanding the disease is a key to preventing it.

Access to Exposure and Medical Records

Every worker has the right to examine and copy their exposure records and medical records. A worker may authorize another person or organization to access such records (such as a physician or a union representative). A copy of the record must be provided at no cost to the worker or representative.

If a worker or representative asks for access to a record, the employer must provide the record in a reasonable time, place, and manner. If the employer can't provide the record within 15 working days, the employer must explain why and inform the worker when the record will be available. The employer may require information such as dates and locations where the employee worked during the period in question.

When access to employee medical records is requested, a physician representing the employer may recommend that the employee or designated representative:

1. Consult with the physician for the purposes of reviewing and discussing the records requested,
2. Accept a summary of material facts and opinions in lieu of the records requested, or
3. Accept release of the requested records only to a physician or other designated representative.

Upon an employee's first entering into employment, and at least annually thereafter, each employer shall inform current employees covered by this section of the following:

- The existence, location, and availability of any records covered by this section;
- Who is responsible for maintaining and providing access to records; and
- Each employee's rights of access to these records.

Medical surveillance records must include the worker's name and social security number, a copy of any written medical opinions, and a copy of the information given to the physicians and specialists.

To access your medical records, use the WeCare portal https://wecareportal.lanl.gov/

To access exposure records, contact OSH-ISH Exposure Assessment

More information about access to worker records can be found in 29 CFR 1910.1020(e)".

An Exposure Record may include:
Environmental (workplace) monitoring or measuring of a toxic substance or harmful physical agent, including personal, area, grab, wipe, or other form of sampling,
Biological monitoring results which directly assess the absorption of a toxic substance or harmful physical agent by body systems.

A Medical Record may include:
Questionnaires or histories (including job description and occupational exposures),
The results of medical examinations and laboratory tests (including chest and other X-ray examinations taken for the purposes of establishing a base-line or detecting occupational illness),
Medical opinions, diagnoses, progress notes, and recommendations,
First aid records,
Descriptions of treatments and prescriptions, and
Employee medical complaints.

Counseling and Support Services

Workers who are diagnosed with CBD or have positive Be-LPTs are offered counseling. The counseling program includes physicians, psychologists, QIHSPs, and workers' compensation specialists who will talk to a worker about:

- the risks of continued exposure to beryllium;
- options for medical follow-up and treatment;
- the process for submitting a workers' compensation claim, including information on medical benefits and compensation for lost earnings;
- mental health counseling (if requested);
- medical removal protection benefits; and
- practices and procedures that limit exposure to beryllium.

Additional contact information is on page 76.

Counseling and Support Services		
LANL OccMed	Answers questions about beryllium medical surveillance, medical removal, and health concerns related to beryllium sensitization and disease.	505-667-0660
LANL Employee Assistance Program (EAP)	Provides counseling for personal or work issues that may cause stress, anxiety, or depression.	505-667-7339
LANL beryllium subject matter expert (SME)	Provides information on the LANL CBDPP, beryllium hazards and controls, exposure monitoring, and general beryllium questions.	505-606-0295 or beryllium@lanl.gov.
National Jewish Health	Provides information on CBD, respiratory diseases similar to CBD, and treatment for CBD.	800-423-8891 ext. 1722

Module 5 Self-assessment

1. What is an intended benefit of having a beryllium surveillance program?

   _____

2. Is enrollment in the beryllium medical surveillance program mandatory? _____

   _____

3. Is participation in medical diagnostic tests mandatory? _____

4. Identify two supports/services that become available in the event of a definitive diagnosis of BeS or CBD:

   _____

   _____

5. Is a worker diagnosed with BeS or CBD required to accept medical removal?

   _____

6. List two areas addressed by the formal counseling process for workers diagnosed with BeS or CBD:

   _____

   _____

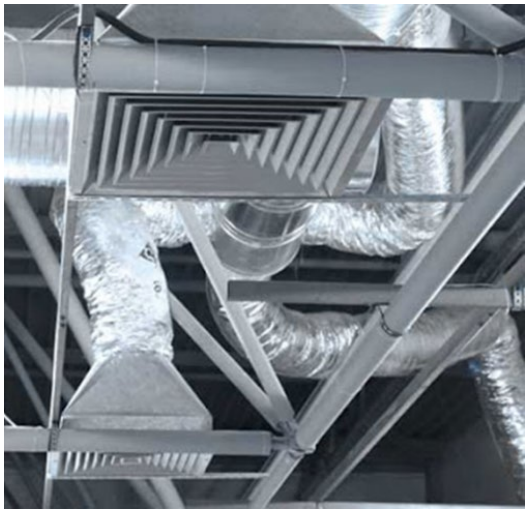
7. List two sources of beryllium counseling and support.

   _____

   _____

8. How long are beryllium medical records kept? _____

Module 6



Beryllium Controls

Module Objectives

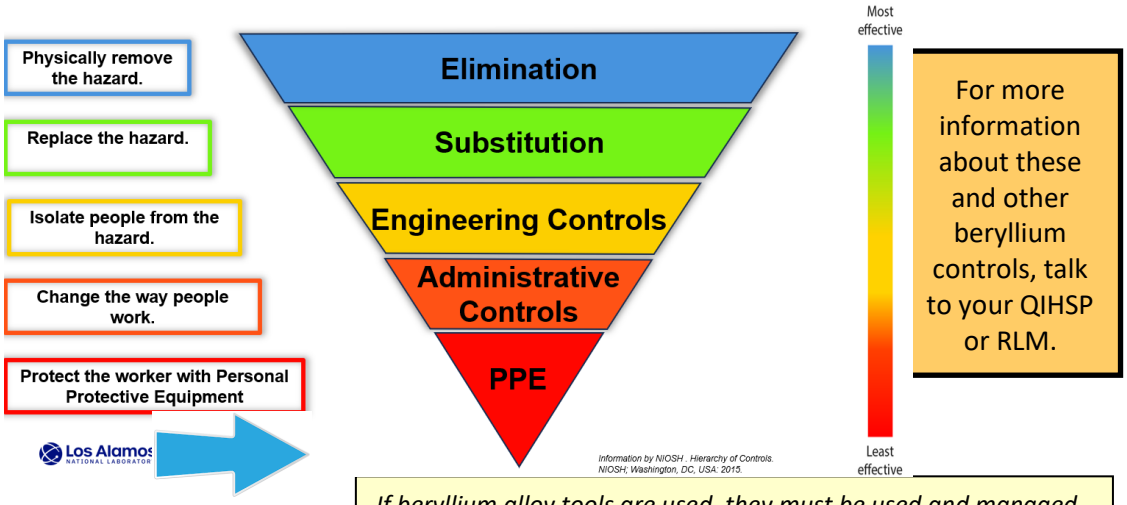
After completing this module, you will be able to recognize:

- examples of substitution and engineering controls for beryllium, including ventilation, wet methods; isolation/containment, and other methods;
- administrative controls for beryllium, including work control documents, access control, safe work practices, housekeeping, hygiene, signs and labels, training, and waste management;
- requirements for the use of personal protective equipment (PPE) used to reduce exposure to beryllium; and
- resources and contacts for questions and concerns about beryllium.

Beryllium Controls

Controls can reduce the possibility of worker exposure to airborne or surface contamination sources of beryllium. Controls used to reduce the risk of beryllium exposure are shown on the following pages in the form of the hierarchy of controls (that is, from the most effective to the least effective). Other controls that are not presented in this manual may be used at your work site.

Hierarchy of Controls



If beryllium alloy tools are used, they must be used and managed according to P101-21, Attachment E, Use of Beryllium Alloy Tools

Elimination and Substitution

Feasible - able to be done or put into practice successfully.

Elimination is the complete removal of a hazard. Because the elimination of beryllium from certain LANL operations is not feasible at this time, beryllium will continue to be used.

Substitution is the replacement of a more hazardous material or process with a less hazardous one. Examples include

- Using aluminum or graphite in place of beryllium when testing a new procedure (before actual operations) or training new workers on existing operations or processes.
- Using “non-sparking” or “spark-resistant” tools made of brass, bronze, Monel metal (copper-nickel alloy), or copper-aluminum alloy as a substitute for copper-beryllium alloy. While the risk of exposure to airborne beryllium is most likely low with the general use of copper-beryllium non-sparking tools, risk may increase when grinding or polishing the tool itself.

F-35 aircraft component using coated metal powders as a substitute for beryllium materials. (*Air Force Research Laboratory*)

Engineering Controls

Engineering controls are mechanical or structural systems used to minimize hazards. For engineering controls to be effective, workers must also use safe work practices (see page 63). Examples of engineering controls are listed at right and shown on the following pages.

Beryllium Engineering Controls	
Type of Control	**Page**
Ventilation	58
Wet methods	59
Isolation / Containment	60
Other engineering controls	61

Engineering controls must be checked and maintained regularly to ensure proper operation.

Ventilation systems must be selected, designed, reviewed, approved, tested, and labeled in accordance with P101-16, *Industrial Ventilation (non-HVACR).*

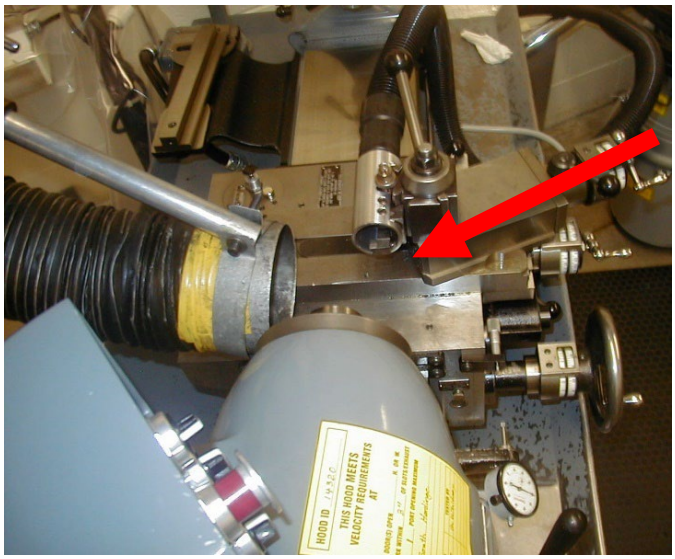
Ventilation

Ventilation reduces the risk of inhaling airborne beryllium by drawing contaminated air away from your breathing zone and out of the work area. Ventilation for beryllium uses high-efficiency filters to prevent the release of beryllium into the outdoor environment. P101-21 requires that operations that create airborne beryllium be controlled with ventilation and/or containment whenever feasible. Two types of ventilation are used to remove airborne beryllium from work areas:

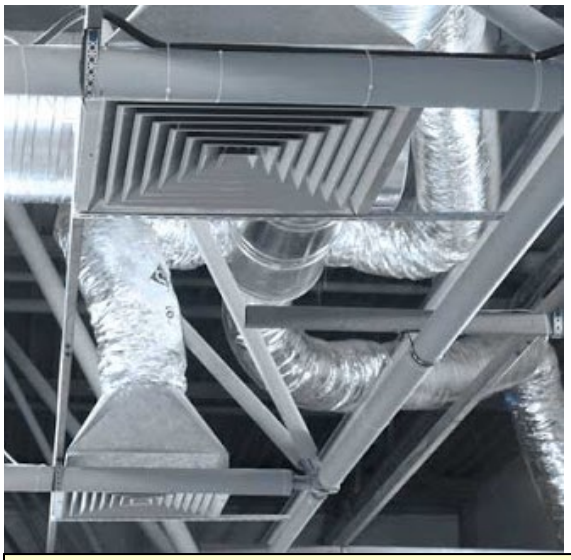
Local exhaust ventilation (LEV) captures airborne beryllium at or very near the source. LEV should be positioned as close as possible to the source and in line with the direction of particle travel (if applicable).

Dilution ventilation is used to reduce the concentration of airborne beryllium in the work area. Dilution ventilation is often used to create negative pressure in Airborne Beryllium Areas, Regulated Beryllium Areas, and change rooms to reduce movement of airborne beryllium into clean areas.

Left: Example of a typical dilution ventilation vent.

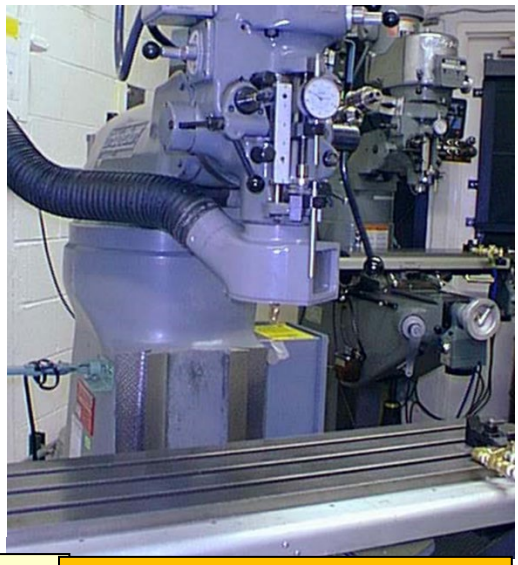


If you think a ventilation control is not working correctly, inform your RLM or QIHSP immediately. Do not try to modify ventilation systems or equipment yourself.



Left – dilution ventilation

Right – LEV on a milling machine.



Dilution ventilation uses air changes within an area to keep airborne beryllium below certain levels. Dilution ventilation may be used with LEV to control airborne beryllium but should not be used as the sole means of controlling airborne beryllium.

Ventilation: Fume Hoods Self-Study (#48002) presents requirements and best practices for the use of ventilation at LANL.

Wet Methods

Wet methods use liquids to entrap particles and reduce the number that become airborne. The surface of the part or the tool may be flooded with a stream of liquid, or the entire operation may be submerged in liquid. Wet methods are often used for work such as machining, drilling, grinding, and polishing.

Though effective, wet methods do have limitations. If liquids are applied with too much force or the operation splashes the liquid, fine droplets containing beryllium particles can become airborne and move about on air currents. An example of this is the spray from a bottle of household cleaner floating back into the face of the user. In addition, liquids that dry on surfaces can leave behind beryllium particles that could later become airborne.

Machining lubricant/coolant should be changed or cleaned regularly to reduce the build-up of fine particles, which may become airborne with repeated use.

Avoid excessive splashing of lubricants onto floor areas or operators' clothing.

If you have questions about when to use wet methods or what type of wetting solution to use, talk to your QIHSP or RLM.

Above:
Wet methods used while machining beryllium reduce but do not eliminate airborne beryllium particulates.

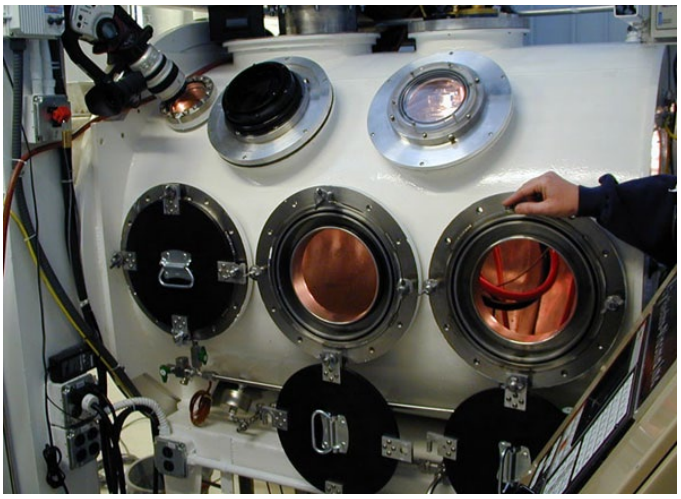
Isolation / Containment

Isolation is used to limit exposure to beryllium and control the spread of contamination. Enclosure is the total or near-total containment of a work operation and is one way to isolate an activity. Examples of enclosures include chambers and glove boxes. Routine beryllium operations that can be enclosed include machining, grinding, buffing, casting, and melting. Glove bags or temporary negative pressure enclosures can be used to isolate nonroutine activities such as maintenance.

Enclosure is often used together with local exhaust ventilation. While enclosures can be very effective, they may not be feasible for all operations. The use of enclosures can sometimes shift exposure hazards from daily operators to the workers who perform cleaning and maintenance.

Enclosure and containment are types of isolation.

Isolation can also be achieved through timing, however this is an administrative control. For example, maintenance can be scheduled at times when few workers are in the area, or visitors may be allowed in beryllium areas only during nonoperational periods.



Examples of isolation: Plasma spray chamber where beryllium is applied (above left); Multi-port glovebox used to sort beryllium contaminated items (above right); LANL Beryllium Technology Facility (below).

Other Engineering Controls to reduce worker exposure to beryllium are listed below.

- Use pellets instead of powders to reduce generation of airborne beryllium during transfer or in case of spill. [This may also be considered substitution.]
- Use non-porous materials for work surfaces to make decontamination more effective and reduce beryllium contamination levels on surfaces with which workers are likely to contact.


If possible, use pellets instead of powders. Non-porous work surfaces can be cleaned more effectively.

- Automate work procedures that are repetitive or that generate significant amounts of airborne beryllium to reduce the numbers of workers exposed.


- Use remote viewing with voice communication to allow personnel to observe/direct/comment upon activities without being directly exposed.
- Access control engineering controls may include electronic badge readers, coded electronic locks, and/ or physical barriers (see also page 62).
- Hygiene facility engineering controls may include hand and face washing facilities, lunch and break areas, showers, areas for donning and doffing PPE, collection and storage of contaminated PPE, and storage of personal items and clean PPE. Hygiene facilities enab good hygiene practices (see also page 65).
- Housekeeping engineering controls may include HEPA filter vacuums (see also page 64)

Other engineering controls include remote viewing of beryllium operations (*above*); HEPA vacuum (*lower left*); changing room and showers (*below*).

Administrative Controls

Administrative controls are efforts to change behavior to prevent or reduce your exposure to a hazard. Administrative controls that may be used to reduce worker exposure to beryllium are listed in the table on the right and shown on the following pages.

Beryllium Administrative Controls	
Type of Control	**Page**
work control documents	
access control	
safe work practices	
housekeeping	
hygiene	
signs and labels	
training	
waste management	

For administrative controls to be effective, they must be recognized by workers and used by workers.

Work Control Documents

Before beryllium operations are performed, a QIHSP must perform a hazard assessment of the operation. Controls identified during the assessment should be incorporated into work control documents such as Integrated Work Documents (IWDs). IWDs are approved written plans or procedures used for the consistent control of hazards to an acceptable level of risk. If work control documents cannot be followed as written, work must be paused or stopped until the process is reviewed, revised as needed, and re-approved.

If a beryllium operation has a reasonable potential for significant release of beryllium or exposure to emergency responders, the work control document must include emergency shutdown procedures.

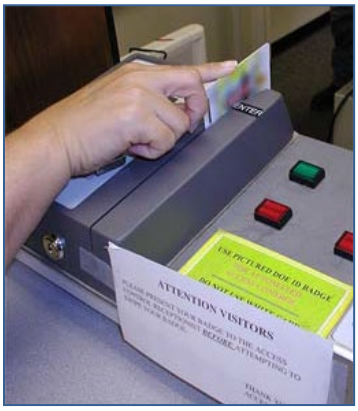
P101-18, *Procedure for Pause/Stop Work*, specifies criteria for pausing, stopping, and restarting work at LANL.

Access Control

Access control helps to ensure that only authorized personnel enter beryllium areas. Access control also alerts unauthorized personnel that the area has restricted or conditional entry.

Access control that depends on worker compliance, such as a sign-in log, is an administrative control. Access control at LANL uses many engineered controls such as badge readers, physical barriers, and locks.

Designated beryllium areas each have specific access control requirements. Know the access control requirements before you enter or escort anyone else into one of these areas.



Electronic badge readers are an example of access control.

Only authorized Beryllium Workers are permitted to enter Airborne Beryllium Areas or Regulated Beryllium Areas while a beryllium operation is being performed.

Safe Work Practices

Safe work practices are administrative controls that help reduce worker exposures and the spread of contamination. Safe work practice requirements and guidance address work in beryllium areas, personal hygiene when working with beryllium and when leaving beryllium areas, housekeeping, and beryllium storage. Follow these safe work practices in beryllium areas:

- Enter designated beryllium areas only if authorized and only when required.
- Verify that controls are operating properly before beginning work.
- Use the smallest amount of beryllium possible.
- Use gloves recommended by your QIHSP when handling beryllium or beryllium-containing items.
- Do not lie or sit on potentially contaminated workbenches.
- When leaving any type of beryllium area, doff outer protective clothing and place in a designated labeled container or clean in a manner which will prevent beryllium particles from becoming airborne or contaminating nearby surfaces.

Safe work practices that apply to the storage of beryllium include the following:

- Package beryllium in a way that safely contains the material, prevents skin or airborne exposure, and prevents the spread of contamination.
- Place a Danger Beryllium Label and identifying information on the package where it is clearly visible.
- Keep outer package surfaces clean (below the surface sample trigger levels shown on page __ of this manual).

P101-21 identifies specific requirements for beryllium posting, packaging, labeling, and storage.

NIOSH Case Study – Non-Beryllium Worker Diagnosed with CBD

Two years after starting work at a beryllium-using facility, a secretary was moved to an area in which beryllium laboratory testing had been done years earlier. One year later, her work area was renovated, including opening the ventilation duct work. She developed skin problems, including itching and raised lesions, which she believed were due to the dust from renovation. Five months after renovation, she had an abnormal Be-LPT blood test which was confirmed the following month. She was then evaluated for CBD. No granulomas were found in lung biopsy samples, but her lung lymphocytes (obtained through lavage) were elevated (22%). Testing of her lung lavage cells did not indicate lung sensitization. She left work the following year. A second medical evaluation, 16 months after the first, found granulomas in the biopsy samples and further elevation of lung lavage lymphocytes (36%). At that time she was diagnosed with CBD.

Paraphrased from NIOSH Pub. No. 2011–107, February 2011.

Housekeeping

Good housekeeping keeps surface contamination and potential beryllium exposures as low as practical. Use the following housekeeping practices to prevent or minimize the spread of beryllium dust from one work area to another:

1. Ensure all housekeeping equipment used for beryllium cleanup or decontamination is labeled and dedicated to beryllium use.
2. Whenever possible, clean equipment used for beryllium work before maintenance or repair is performed.
3. Use a HEPA vacuum or wet methods to reduce dust during cleanup and do not allow wet processes to dry before cleaning.
4. Store mops in clean water after use.
5. NEVER use forceful sprays on beryllium-contaminated surfaces.
6. NEVER use compressed air or dry sweeping for cleaning, unless within a completely enclosed system.
7. Avoid wiping or cleaning surfaces so that particles become airborne and enter your breathing zone (such as from wiping surfaces that are above your head).

When using rags and liquid spray cleaners, spray the liquid directly on the rag, NOT on the surface to be cleaned. This helps prevent beryllium particles from becoming airborne from the force of the spray.

If reusing a rag for cleaning, avoid shaking or snapping the rag before reuse, as such actions can create airborne beryllium.

Before using a HEPA vacuum at LANL, ensure the certification sticker is current (indicating it has passed performance testing) and inspect the HEPA vacuum as required by P101-16, *Industrial Ventilation (non-HVACR).* If the inspection date is past, DO NOT use the vacuum!

Equipment / Item Cleaning

When machined, some beryllium items may retain a coating of loose particles that were not removed by LEV. Oxidation of the surface may also form removable particles. Removing loose beryllium particles that build up during operations reduces the potential for such particles to become airborne or spread contamination at a later time.

Cleaning methods include wet wiping, enclosed cleaners, ultrasonic baths, and HEPA-filtered vacuuming. In some cases, pickling is used to remove the oxide layer with an acid bath. Pickling often requires LEV to control airborne beryllium and other health hazards created when gases that form bubbles within acid tanks rise to the surface of the tank and burst.

Hygiene

Use the following hygiene practices in Accessible Beryllium Contamination Areas, Airborne Beryllium Areas, and Regulated Beryllium Areas:

Hygiene uses conditions or practices that help to maintain health and prevent disease, especially through cleanliness.

1. DO NOT eat, drink, or chew tobacco or gum; apply cosmetics, lotions, ointments, or lip balm; bite fingernails; or put items such as pencils into your mouth.
2. DO NOT enter Regulated Beryllium Areas with jewelry, personal clothing, or other personal items.
3. Avoid scratching or picking at your skin, and try not to touch your face with your hands or gloves.
4. Workers with open cuts, wounds or skin abrasions must have initial approval by OM before entry.
5. Cover open cuts, wounds, or abrasions with a bandage or dressing. Hands with cuts, wounds or abrasions must also be covered by an impermeable glove and must remain covered during the entire time in the area.
6. Wash hands after leaving beryllium areas and before starting other tasks.
7. NEVER enter lunch- or break-areas wearing protective work clothing with potential beryllium contamination.
8. Leave LANL-provided work clothes at work to prevent exposing family members to beryllium contamination.

P101-21 permits a QIHSP to allow re-hydration [drinking] to avoid heat stress if the beryllium exposure risk is acceptable.

Family members who come into contact with a beryllium worker's contaminated personal clothing or other items may become sensitized and develop CBD.

In regulated beryllium areas, workers MUST:

- be provided with clean changing rooms, hand-washing facilities, and shower facilities.
- shower at the end of the work shift and before donning personal clothing or leaving LANL property.

Workers with open cuts or wounds must have initial approval by OM. Open cuts and wounds must be covered with a bandage or dressing.

Beryllium Contamination Study – published 1999

Evaluation of potential take-home beryllium exposures was conducted by measuring surface concentrations in vehicles and on hands of workers at a (non-LANL) beryllium machine shop. Results of wipe samples taken from 61 workers showed that many workers had beryllium on their hands when they left work. Workers' vehicles were also found to have beryllium contamination, with the highest levels found on the floor of the driver's side of the vehicle. Results of the study are shown in the table below.

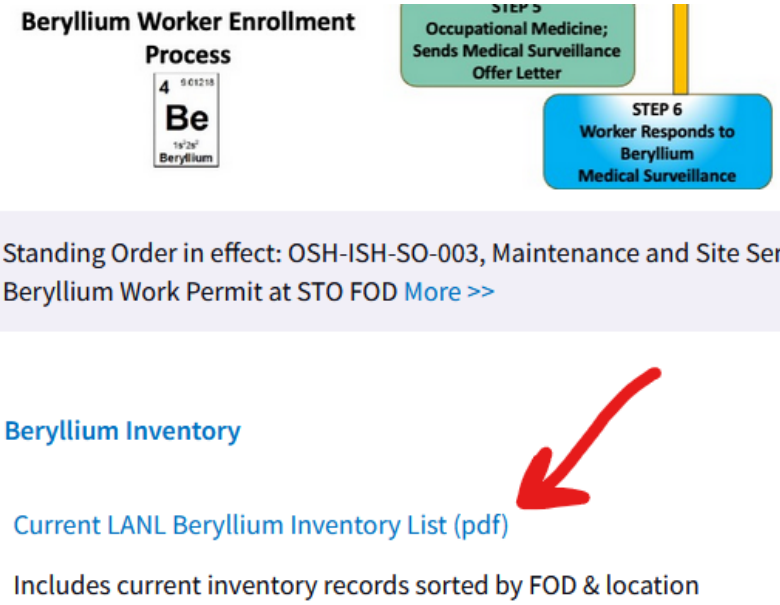
Photo- national Jewish Health

Location	Levels of Beryllium	
	Average (µg/100 cm^2)	Maximum (µg/100 cm^2)
Steering wheel	0.25	5.3
Driver's seat	0.26	15.9
Driver's floor	2.05	76.9
Driver's armrest	0.48	39.7
Passenger's seat	0.18	7.5
Passenger's floor	0.53	25.2

Sanderson, W. T. (1999). Beryllium Contamination Inside Vehicles of Machine Shop Workers. *Applied Occupational and Environmental Hygiene*, *14*(4), 223–230. https://doi.org/10.1080/104732299302990

LANL Beryllium Inventory

To find the link to the Beryllium Inventory go to the Beryllium home page and scroll to below the Medical Surveillance enrollment information. Click Current LANL Beryllium Inventory List (pdf)

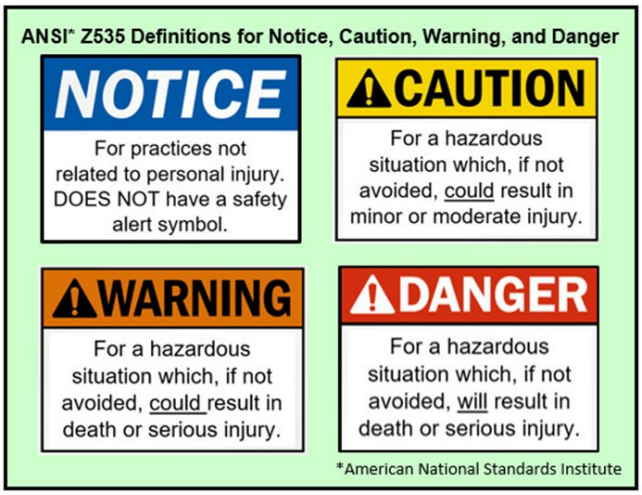


OSH-ISH maintains an institutional beryllium inventory. This inventory identifies the locations of beryllium operations, designated beryllium areas, and former beryllium areas. Beryllium operations and areas that are repurposed, demolished, transferred, cleaned and/or released that are not included in the current inventory listing are retained as archived records in the inventory. Some posted areas, such as temporary beryllium areas, may not appear on the inventory list.

Notify your QIHSP or the LANL Beryllium Program Lead if you have questions about a particular inventory entry or location, you know of an area where beryllium may have been used or stored in the past, or you know of a new beryllium operation.

Signs and Labels

Approved LANL signs and labels for Designated Beryllium Areas and for beryllium materials are shown on the following pages. See P101-21 Attachment D for additional information.



P101-21 identifies specific requirements for the packaging and labeling of beryllium and the transfer of beryllium items and beryllium-contaminated items.

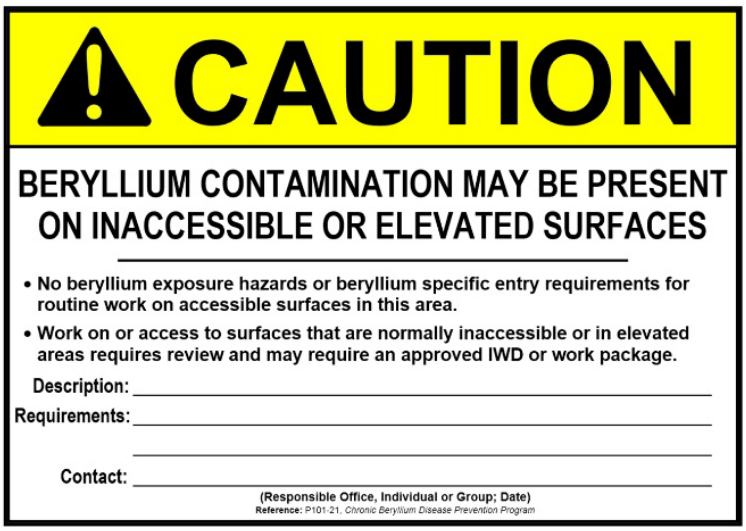
Signs help to prevent inadvertent or unauthorized entry and also remind authorized personnel of safety rules and PPE requirements before they enter. Labels help to prevent beryllium exposure to workers who subsequently handle beryllium materials.

Beryllium Storage Area Sign

For areas where packaged beryllium or beryllium-containing materials are stored. Airborne beryllium or surface contamination is not expected outside of packaging. May be limited to a small area such as box, shelf, cabinet, or portion of a room

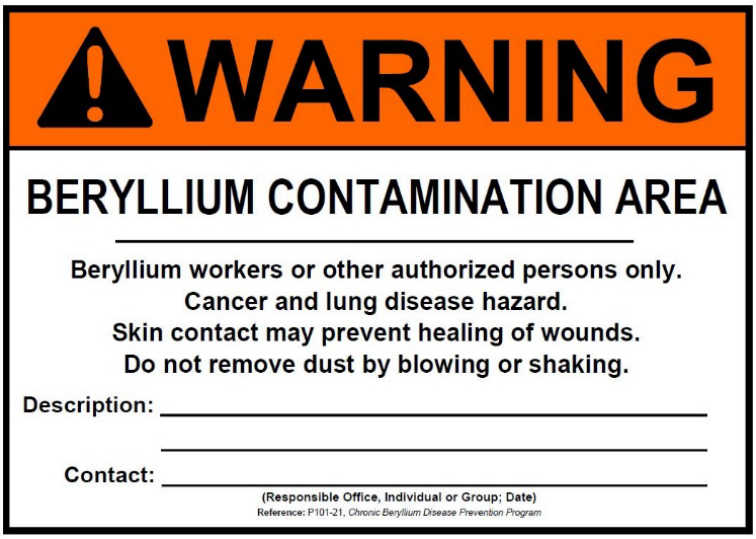
<u>Inaccessible</u> Beryllium Contamination Area Sign

For locations where there is beryllium contamination on inaccessible surfaces, such as under paint, inside exhaust ducts, on elevated beams, etc., that is greater than 0.2 µg/100 cm^2. Airborne beryllium is not expected under normal conditions.



<u>Accessible</u> Beryllium Contamination Area Sign

For areas in which there is beryllium contamination on accessible surfaces greater than 0.2 µg/100 cm^2. Airborne beryllium would not normally be expected. May be limited to a small area such as a shelf, cabinet, or portion of a room.

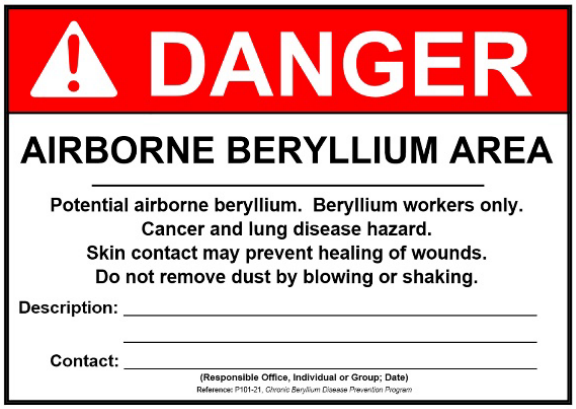


Installed Beryllium-Containing Materials Sign

For designated, installed, beryllium containing materials. This includes worker-occupied or accessed areas (such as shielded rooms, screen rooms, Faraday cages, etc.) where known or suspect beryllium-containing material is used for electromagnetic shielding, electrical continuity, or sealing of doors or other openings.

Airborne Beryllium Area Sign

For areas where beryllium operations take place when there is a risk of measurable levels of beryllium in the air (≥ 0.03 µg/m^3). The area may be limited to a portion of a room, such as a fume hood.



Beryllium Regulated Area Sign

For areas in which beryllium in the air exceeds, or can reasonably be expected to exceed, the action level (≥ 0.2 µg/m3). Respiratory protection is required.

Beryllium Danger Labels
(upper and center right)

Beryllium labels warn workers that items may be made of beryllium, or may be internally or externally contaminated with removable beryllium. Beryllium items and beryllium-contaminated items must be packaged and labeled in accordance with P101-21. Equipment and materials to be released or transferred from beryllium contaminated areas must be appropriately labeled or tagged before release.

Attach one of the labels at right to all packages containing beryllium or beryllium-contaminated materials, in a manner that allows the label to be clearly seen. These labels are also used to label beryllium or beryllium-contaminated items to be released to a nonberyllium area or the general public.

Beryllium Restricted Release Label
(lower right)

Used on potentially beryllium- contaminated items that will be released **only** to another beryllium area, either at LANL or another DOE site. May have internal or hidden contamination. Surface contamination must be $\leq$ 3.0µg/100 cm^2.

Per P101-21, special packaging or handling procedures may be needed for items designated for release with accessible surfaces that cannot be decontaminated below maximum allowable surface contamination limits.

*If an item to be released does not have a release tag or label on it, **DO NOT** release or remove it until you find out why.*

DANGER
CONTAMINATED WITH or CONTAINS BERYLLIUM
DO NOT REMOVE DUST BY BLOWING OR SHAKING
CANCER AND LUNG DISEASE HAZARD
DO NOT GET ON SKIN
Contact: _____
(Responsible Office, Individual or Group; Date)

DANGER
CONTAMINATED WITH or CONTAINS BERYLLIUM
DO NOT REMOVE DUST BY BLOWING OR SHAKING
CANCER AND LUNG DISEASE HAZARD
DO NOT GET ON SKIN
Description (optional): _____
_____
_____
_____
Contact: _____
(Responsible Office, Individual, or Group)
Date: _____

DANGER
CONTAMINATED WITH or CONTAINS BERYLLIUM
DO NOT REMOVE DUST BY BLOWING OR SHAKING
CANCER AND LUNG DISEASE HAZARD
DO NOT GET ON SKIN
RESTRICTED RELEASE
APPROVED FOR USE IN A BERYLLIUM FACILITY ONLY
Accessible surfaces are clean to levels for use in a beryllium facility. Evaluation indicated contamination on accessible surfaces below 3.0 ug/100 cm² upon release.
☐**Check this box if inner packaging is accessible surface.**
(Contamination may exceed 3.0 ug/100 cm² below this surface)
Released: ___/___/___ From: _____
(Date) (Location)
By: _____
(Responsible Office, Individual or Group; Date)

Beryllium Waste Management

Beryllium-containing waste, wastewater, beryllium-contaminated items, and discarded beryllium powder disposed of as waste must be handled in accordance with P409, LANL Waste Management. Disposal requirements include the use of impermeable containers and proper labeling.

The DOE Beryllium Rule 10 CFR 850.32, Waste Disposal

(a) The responsible employer must control the generation of beryllium-containing waste, and beryllium-contaminated equipment and other items that are disposed of as waste, through the application of waste minimization principles.

(b) Beryllium-containing waste, and beryllium-contaminated equipment and other items that are disposed of as waste, must be disposed of in sealed, impermeable bags, containers, or enclosures to prevent the release of beryllium dust during handling and transportation. The bags, containers, and enclosures that are used for disposal of beryllium waste must be labeled according to 850.38.

Your waste management coordinator (WMC) MUST be contacted regarding the handling of any beryllium waste.

Discarded beryllium powder must be managed as a Resource Conservation and Recovery Act (RCRA)-regulated waste.

Right: Waste collection in the LANL Beryllium Technology Facility (BTF) is aided by high velocity LEV, which minimizes the amount of airborne beryllium within the facility created by such activities.

The LANL CBDPP does not specify a beryllium contamination limit for soils, sludges, or waste waters. When beryllium waste is stored in a designated waste storage area in compliance with P409, *LANL Waste Management*, the area is not required to be identified and posted as a designated Beryllium Storage Area. Coordinate with the deployed waste coordinator for beryllium waste packaging, labeling and storage.

Personal Protective Equipment

PPE protects you from exposure to beryllium, helps prevent contamination of personal clothes, and helps to minimize the spread of contamination from the work area. PPE used in beryllium areas may include, but is not limited to: coveralls, modesty garments, respirators, gloves, booties, safety shoes, skullcaps, and protective eyewear.

PPE requirements are determined by a QIHSP. Per P101-21:

- Gloves must be worn when there is potential for direct contact with beryllium or beryllium contamination.
- Where PPE is required, locations for the donning, doffing, cleaning, and/or disposal of PPE must be available.
- PPE required for beryllium is provided by LANL and must remain at the work site to prevent the spread of contamination.

Gloves are required for direct contact with beryllium.

Doffed PPE should be placed, not thrown, into appropriate containers to prevent beryllium dust from becoming airborne. This practice helps prevent the spread of contamination and limits the possibility of exposure of those workers who clean or handle contaminated protective clothing.

Workers who wear PPE for workplace hazards are required by OSHA to know the following:

- when PPE is necessary
- what PPE is necessary
- how to properly don, doff, adjust, and wear PPE
- the limitations of PPE
- the proper care, maintenance, useful life, and disposal of the PPE

Personal Protective Equipment Introduction Self-Study (#28886) addresses many of the OSHA training requirements that must be met before workers can use PPE.

A beryllium worker wears coveralls with booties, taped gloves, and a full-face air-purifying respirator while collecting a surface sample.

Warning! *NEVER remove beryllium from PPE by blowing or shaking.*

P101-6, *Personal Protective Equipment*, addresses PPE selection criteria and requirements for use.

Respirators

A respirator helps protect you from inhaling airborne hazards. Respirator use is required when:

- exposures are at, above, or may exceed the AL,
- there is potential for acute worker exposure,
- a critical control may fail, or
- specified by a QIHSP.

The LANL Respiratory Protection Program (RPP) controls the use of respirators at LANL. To wear a respirator at LANL, you must have a medical evaluation, receive training in the use of respirators, and be properly fit-tested.

Respirators may be required when there is a risk of a spill or unexpected airborne release, when new processes are being evaluated, or when existing processes have been changed.

LANL RPP contact information is on page ___.

Warning! *Dust masks or N-95 type masks are NOT suitable for use in airborne beryllium areas.*

You may request a respirator and PPE if you have concerns about the potential for beryllium exposures below the AL or contact with beryllium contamination.

A Beryllium Area Buffer Zone in the LANL BTF (*left*). The grate on which the worker is standing draws air down and away from the worker, capturing potential contamination. Used booties, lab coats, and overalls are placed in ventilated receptacles (*above*).

Training

LANL requires beryllium training for ALL workers on site. There are three levels of training, and **all workers at LANL must complete at least one level of beryllium training every two years**, as follows:

Workers who complete a higher-level course do not have to complete a lower-level course.

Curriculum is a term for a training plan in which enrolled workers are notified of courses that must be completed to stay current with training requirements.

Beryllium workers may also be enrolled in Curriculum 9416, which tracks both beryllium worker training and enrollment in beryllium worker medical surveillance.

Beryllium Worker Training (Curriculum 117) – The highest level training for personnel with potential exposure to airborne beryllium. This includes those who currently work with or around beryllium on a regular basis and those who perform work in support of beryllium work (such as skilled craft or maintenance) when such services are needed. Courses:

- *Beryllium Worker Live (#725)*
- *Beryllium Worker Refresher Self-Study (#21784)*.

Course #725 must be completed initially, then either #725 or #21784 must be completed every two years.

Beryllium Awareness Training (Curriculum 9360) – Midlevel training for past beryllium workers and other beryllium-associated workers not currently exposed to airborne beryllium. This includes workers who regularly handle beryllium items or beryllium alloy tools, workers who access designated beryllium areas (including storage areas) when there is no potential exposure to airborne beryllium, and escorted visitors to beryllium areas during nonoperational periods. Course:

- *Beryllium Awareness Self-Study (#28340*)

Chemical Hazard Communication Introduction (#25418 initially, then #25418 or #25997 on a 3-year cycle) is also required for those in Curriculum 117 or 9360.

Beryllium General Employee Training (Curriculum 118) – General training for all other on-site workers at LANL, including workers at LANL more than 10 workdays per consecutive 12-month period and workers with unescorted access to LANL facilities containing beryllium operations or beryllium contamination. Courses:

- *Beryllium: General Employee Overview* (#55173)

In addition to the above institutional training, each worker's RLM must ensure that all required facility- or job-specific training is also complete.

Module 6 Self-assessment

1. Provide examples of two engineering controls that can be used to help reduce the risk of worker exposure to airborne beryllium in the workplace.

   _____

   _____

2. Provide examples of two administrative controls that can be used to help reduce the risk of worker exposure to airborne beryllium in the workplace.

   _____

   _____

3. Provide examples of two housekeeping practices keeps surface contamination and potential beryllium exposures as low as practical.

   _____

   _____

4. As part of hygiene practices for some beryllium areas, why are LANL-provided work clothes left at work?

   _____

5. The signal word on an *Accessible Beryllium Contamination Area* sign is _____
6. List two conditions when respirators are required for protection against beryllium.

   _____

   _____

7. Can a respirator be worn during a beryllium activity even if there is no chance of airborne beryllium exceeding the action level? If so, is training required?

   _____

8. Who is the key to protecting other people from exposure to beryllium?

   _____

Resources, Contacts, and References

LANL requirements, training, and points of contact that may affect beryllium operations at LANL are shown below. This list is NOT all-inclusive.

LANL Requirements Documents*	**LANL Institutional Training***
P101-6, *Personal Protective Equipment*	*Personal Protective Equipment Introduction Self-Study (#28886)*
P101-14 *Chemical Management*	*Chemical Hazard Communication Live* (#25418) *Chemical Hazard Communication Self-Study* (#25997)
P101-16, *Industrial Ventilation (non-HVACR)*	*Ventilation: Fume Hoods, LEVs, and HEPA Filtration Systems Self-Study* (#48002)
P101-21, *Chronic Beryllium Disease Prevention Program (CBDPP)*	See page22of this manual
* Additional LANL Requirements documents may apply. * Courses may be required or recommended. Additional Institutional Training may be required.	

LANL Websites and Points of Contact
LANL Policy Documents at https://int.lanl.gov/policy/index.shtml?source=toolkit
LANL Beryllium home page at https://int.lanl.gov/safety/industrial_hygiene_and_safety/beryllium/index.shtml Beryllium Release Form (#2120) https://irm.lanl.gov/forms/Shared/2120.pdf
LANL Industrial Safety and Hygiene (ISH) at 505-606-0295 (Division Office, TA-59, Bldg 3, Rm 107A) or https://int.lanl.gov/safety/industrial_hygiene_and_safety/index.shtml
LANL Occupational Medicine (OM) at 505-667-0660 or http://int.lanl.gov/employees/health-wellness/occupational-medicine/index.shtml Clinic https://int.lanl.gov/employees/occupational-health/medical-services/clinic.shtml Employee Medical Records WeCare Portal Counseling & Support Services - see page 53 of this manual
LANL Respiratory Protection Program (RPP) at respiratorteam@lanl.gov or https://int.lanl.gov/safety/industrial_hygiene_and_safety/ihs-programs/respiratory-protection.shtml
LANL Employee Assistance Program (EAP) at 505-667-7339 or eap@lanl.gov https://int.lanl.gov/employees/occupational-health/behavioral-health/eap.shtml

Other Points of Contact		
DOE Beryllium site	https://www.energy.gov/ehss/chronic-beryllium-disease-prevention-program-10-cfr-850	
DOE EEOICPA Brochure	https://www.dol.gov/sites/dolgov/files/owcp/energy/regs/compliance/brochure/Beryllium_Brochure.pdf	
National Jewish Health Beryllium Program	https://www.nationaljewish.org/programs/prevention/beryllium	1-877-CALL NJH 1-877-225-5654
Division of Energy Employees Occupational Illness Compensation (DEEOIC)	https://www.dol.gov/owcp/energy/	1-866-888-3322
Occupational Illness Compensation Program - Espanola Resource Center		1-866-272-3622

References

P.N. Breysse, "Former Worker Medical Screening Program at Los Alamos National Laboratory: Beryllium Related Activities," at Beryllium Health Effects Symposium, Santa Fe, New Mexico, October 30, 2001.

Cotton, F.A.,G. Wilkinson, C.A Murillo and M. Bochmann *Advanced Inorganic Chemistry*, Sixth Edition, John Wiley & Sons, Inc., (1999),

P. Harber, et al., *Exposure Factors Associated With Chronic Beryllium Disease Development in Beryllium BioBank Participants, J.Occup. & Env. Medicine*, 56(8):852-856, August 2014.

Los Alamos National Laboratory. Procedure P101-21, "Chronic Beryllium Disease Prevention Program," (July 2019).

Los Alamos National Laboratory, Industrial Safety and Hygiene (OSH-ISH) Laboratory Industrial Hygiene and Safety Manual, OSH-LIHSM-29-005, "Chapter 29: Identifying and Evaluating Beryllium Hazards," December 2017.

M.T. Pavlova, et al., *Communicating Health Risks: Working Safely with Beryllium*. U.S. DOE and the Oak Ridge Institute for Science and Education, (December 2000).

W.T. Sanderson, et al., "Beryllium Contamination Inside Vehicles of Machine Shop Workers," *Applied Occupational and Environmental Hygiene*, 14: 223-230, (1999).

A.W., Stange, et al., "Beryllium Sensitization and Chronic Beryllium Disease at a Former Nuclear Weapons Facility," *Applied Occupational and Environmental Hygiene,* 16(3): 405-417, (2001).

A.W., Stange, F.J. Furman, D.E. Hilmas, "The Beryllium Lymphocyte Proliferation Test: Relevant Issues in Beryllium Health Surveillance", *American Journal of Industrial Medicine*, 46: 453-462, (2004).

US Department of Energy "Chronic Beryllium Disease Prevention Program;" 10 CFR 850, Federal Register, vol. 71, no. 27, pp. 6858-6948.

US Department of Energy, "Beryllium Lymphocyte Proliferation Testing (BeLPT)," DOE-SPEC-1142-2001 (April 2001),

US Department of Health and Human Services. Centers for Disease Control. National Institute for Occupational Safety and Health. Report to Congress on Worker's Home Contamination Study. NIOSH No. 95-123. 1995.

US Department of Health and Human Services. Centers for Disease Control. National Institute for Occupational Safety and Health. Preventing Sensitization and Disease from Beryllium Exposure. NIOSH No. 2011–107. 2011.

P. K. Henneberger, et al., Industries in the United States with Airborne Beryllium Exposure and Estimates of the Number of Current Workers Potentially Exposed. *Journal of Occupational and Environmental Hygiene* 1(10), 648-659, (2004).

S. S. Tinkle, et al., Skin as a route of exposure and sensitization in chronic beryllium disease. *Environmental Health Perspectives* 111(9):1202-1208, (2003).

B.T Manard, et al., Investigation of handheld laser induced breakdown spectroscopy (HH LIBS) for the analysis of beryllium on swipe surfaces. *Analytical Methods,* 11, 752, 2019.

https://www.osha.gov/beryllium
https://oriseapps.orau.gov/BAWR/DashboardsReports.aspx

Appendix

A

Self-Assessment Answers: Discuss whether to include answers

Lessons learned/ Case studies:

1. Be contamination in tool room. Found contamination outside tool box, from previous filing and/or drilling that occurred. Lesson: Importance of labeling. Awaiting paragraph and reference from Zeke.

2. For BHSC practioner's guide. Outdoor detonation involving Beryllium. Contamination concern when moving settled material from detonation. (Note: multiple detonations resulting in up to 20ppm in soil from past activity) Awaiting paragraph and reference from Zeke.

3. Be machining room flooded. No contamination outside room. Awaiting paragraph and reference from Zeke.

4. BTF filter change procedure. Awaiting paragraph and reference from Zeke.

5. Exposures associated with vessel clean-out. TA-15 Engineering controls developed. Vacuum system associated with cleaning tools to effectively reduce exposures. Awaiting paragraph and reference from Zeke.

6. Unexpected Be contamination at TA-8. Room previously used for Be machining. Awaiting paragraph and reference from Zeke.