NEEDS ASSESSMENT FOR SCREENING FORMER NTS WORKERS FOR BERYLLIUM EXPOSURE

1. Introduction

Beryllium is a very strong, lightweight metal ideal for use in the nuclear industry due to its ability to withstand high temperatures and to act as a thermal conductor. It was used in a variety of settings at the Nevada Test Site: in reflectors surrounding the reactor cores of nuclear devices, in x-ray permeable windows, in copper-alloy switches for experiments placed in a tunnel's line-of-sight pipe, in flanges which mounted cable within the line-of-sight pipe, and in rocket fuel as an aid to impulse control. When ground, manufactured, machined, modified, heated, or combusted in fuel, beryllium dust and fumes are highly toxic to the respiratory system.

There is no known "safe limit" for exposure to beryllium. The current OSHA permissible exposure limit (PEL), adopted in 1971, is 2.0 mcg/m3. DOE in recent rulemaking [10 CFR 850, Chronic Beryllium Disease Prevention Program (CBDPP)] instituted a 0.2mcg/m3 action level that triggers certain workplace precautions and control measures. Further, DOE is requiring its contractors and any covered DOE employers to establish exposure reduction and minimization measures in their CBDPPs, designed to reduce potential exposure to levels below the action level.

The major health problems associated with beryllium exposure are beryllium sensitization and acute and chronic beryllium disease. While the acute form of the disease is rare today, cases of chronic beryllium disease continue to be diagnosed in worker populations at DOE sites and in private industry. It is estimated that beryllium sensitization occurs at a rate of 1-7% in those exposed, with an onset of symptoms ranging from a few months from the time of exposure to as many as 40 years. Sensitization to beryllium can be determined through a blood test known as the Beryllium Lymphocyte Proliferation Test (BeLPT). Due to the routine use of beryllium at NTS in several high-risk applications, we believe that a significant number of former workers may have become sensitized and are at risk for developing chronic beryllium disease and possibly lung

cancer. This report details the nature and extent of beryllium use and exposure at NTS, and estimates the burden of health effects resulting from work with beryllium metal and its alloys.

2. Sources of Information/Methodology

The nature and extent of beryllium exposure at NTS was derived from five key sources: REECO industrial hygiene data spanning the years 1954-1992; EG+G industrial hygiene data from 1966-1992; DOE OpenNet citations, obtained online, from DOE-Nevada, and Los Alamos National Laboratories (LANL); interviews with knowledgeable individuals conducted both in person and by telephone; and focus groups conducted with former NTS employees in Las Vegas.

Industrial hygiene data:

REECO Industrial hygiene data establishes that beryllium was present at the NTS and that exposure may have occurred in a number of different venues. Beryllium sampling was performed throughout the NTS complex. In 1954 and again in 1962-3, sampling records indicate the presence of beryllium in area 5 at the Sugar and Kay bunkers. Sampling records from line-of-sight pipe in U16A tunnel in 1962-63, as well as sampling records from E, N, and U tunnels in area 12 during 1968-9, illustrate the presence of beryllium in the post-shot environment. Nuclear Rocket Development Station (NRDS) records from 1962-1977 include sampling performed in a variety of locations, including the engine stands, test cells, and assembly/disassembly buildings in areas 25 and 26 (also known as 400 and 401). These records illustrate ongoing concern regarding beryllium exposure from machining operations, fuel burn-up, assembly/disassembly, tunnel and shaft re-entry, and work in and around the underground line-of-sight pipe. EG+G sampling records from 1966-1992 show similar concern for beryllium exposure resulting from machining operations. A detailed description of the areas evaluated and sampling data is presented below in section 3.A., "History of Beryllium Use".

DOE OpenNet database:

A search of DOE's OpenNet database yielded 130 citations potentially relevant to beryllium exposure at NTS. Approximately half of these citations were useful in confirming the presence of beryllium in fuel during the NRDS era, as well as for other uses. Experiments involving beryllium on other sites, such as the Enewetak Atoll in the South Pacific, were also described, and proved helpful in illustrating exposure to beryllium from combusted fuel, which was also an exposure at NRDS.

Interviews with workers:

Interviews were conducted with both former and current NTS employees, including industrial hygienists, laborers, operators, miners, "tunnel-walkers", machinists, electricians, security guards, custodians, Rad-Safe personnel, and pipefitters. Persons were chosen for interviews based on relevant eras and locations of work.

3. Extent of Beryllium Hazard at NTS

A. History of Beryllium Use at NTS

While beryllium was never manufactured at NTS, it was used in a variety of applications with exposure occurring in a number of settings. Beryllium was ground, machined, modified, cut, lathed, heated, combusted in fuel, dispersed underground during nuclear blasts, and dispersed with explosives above ground at NTS.

Early Beryllium-Dispersal Experiments

The first documented evidence of beryllium use at the Nevada Test Site, at that time called the Nevada Proving Grounds, was at Kay bunker in area 5 on September 23, 1954. An experiment was conducted which sought to estimate the maximum quantity of beryllium distributed in the environment for any subsequent scheduled experiment (1). Similar experiments were undertaken at a nearby firing site called "Uncle" beginning October 9, 1954. Beryllium content of the firing pit

soil was documented as "significantly high" (the actual results were missing). By November, beryllium "experiments involving polonium" known as the "Teabag" tests (1) took place in this area, at which time the Health Chemistry division wrote that the constant change in experimental sites and firing conditions was making it difficult for their staff to collect the necessary air samples. Whether or not their request for additional staffing was honored is not known. A third program near Kay involving beryllium, known as "Sugar", began in December of that year.

Beryllium in the Nuclear Rocket Development Era

Under joint sponsorship of the Air Force and the Atomic Energy Commission, Project Rover (1955-1972) and Project Pluto (1957-1961) were initiated in the southwest corner of NTS (areas 25 and 26, also known as areas 400 and 401); these areas formed the Nuclear Rocket Development Station (NRDS). These two projects sought to develop reactor technology for a nuclear rocket engine (Rover) and to explore the feasibility of applying heat from nuclear reactors to ramjet engines for low altitude flight (Pluto) (2). Project Rover included the Kiwi, Phoebus, Peewee, and Nuclear Furnace test series, and Project Pluto included the Tory test series. Nuclear reactors and engines were tested extensively at NRDS between 1959 and 1972. Beryllium-containing reflectors, which surround reactor cores and improve their economy, were used in both Rover and Pluto tests. Reflector assembly stands as well as several locations within machine shops at NRDS were often swiped for beryllium, suggesting that these reflectors were modified and/or machined. Temperature-measuring devices known as thermocouples contained beryllium, and appear to have been sampled in the same place, time, and manner as the reflectors. It is believed that reflectors and thermocouples were manufactured at the National Laboratories. Beryllium was also used in rocket fuel for its ability to enhance impulse. Test cells, hot bays, fuel tubes, fuel cans, and decontamination rooms were sampled frequently for beryllium contamination from 1961-1972.

NRDS hosted numerous contractors during its era, and many of their roles changed over time. REECO held the support contract at NRDS until 1963, which included most construction work and general labor needed to set up the tests. Pan American World Services inherited this contract

in 1963, which was expanded to include cryogenic support, photographers, electronic technicians, radiation safety technicians, pipefitters, welders, and machinists. By the mid-1960's, Pan Am's workforce of approximately 700 made it the largest single contractor at NRDS. Westinghouse Astronuclear Laboratories (WANL) was hired as a subcontractor to Aerojet to assist on flight reactor development for the Nuclear Engine for Rocket Vehicle Application (NERVA) program tests. The combined workforce of Aerojet and WANL was approximately 1000, and their tasks included analytical work on reactor cores, engineering, and reactor disassembly. Industrial hygienists were provided by EG+G Energy Measurement, Pan Am, and REECO at various times. Wackenhut provided a security force of approximately 300, all of whom were likely to have been stationed at NRDS at least once.

In June 1965, Project Rover's Phoebus 1A rocket was tested at full power. During shutdown, all of the liquid hydrogen coolant was consumed due to a failed gauge, resulting in overheating and severe core damage (3). The extent of the radioactive hazard and beryllium contamination caused by this accident is unclear, as there is a lack of available detailed information, such as soil, air, or swipe sampling from this year. One worker recalls "that accident in '65...[when] all of us had to pitch in on the clean up, with tongs and suits, so that nobody would go over the radiation limit. Maybe 500 or 600 of us helped out with cleaning this up."

In 1972 Project Rover was terminated, and its operations were shut down almost overnight. Some workers recalled decontaminating and decommissioning the RMAD (Reactor Maintenance Assembly and Disassembly) building in 1973. It appears that the nearby EMAD (Engine Maintenance Assembly and Disassembly) was *not* similarly decontaminated, as there was a flurry of sampling conducted in 1977, finding beryllium swipe samples averaging 5.02 mcg/swipe during one set of sampling and 1.91 mcg/swipe during another. These were taken from the building's hot bays, storage tanks, and other unspecified locations within that facility. Swipe sampling methodology was not detailed in the reports.

Beryllium Exposure in Underground Testing

Throughout NTS's history of underground testing from 1958-1992, weapons tests in tunnels and shafts utilized a "line-of-sight" pipe (LOS). The LOS contained chambers within which experiments were placed to measure the effects of the test shot. Prior to the shot, pipefitters frequently modified beryllium-containing flanges using grinders on-site in the underground environment. The flanges were installed into the sides of the line-of-sight pipe, and held cables which secured the diagnostic canisters holding the experiments. The network of flanges and cables helped minimize the destruction of the experiments. The diagnostic canisters contained x-ray permeable windows that were lined with beryllium foils, often referred to as "beryllium windows", as well as beryllium-copper alloy pins, springs, and switches. Canisters were placed at various points along the line-of-sight pipe. Canisters closer to "ground-zero" were more likely to be "destroyed" than those further away.

Re-entry crews, who returned to the test-chambers within the LOS following the test shot, were likely to be exposed to beryllium dust and/or vapors from the "beryllium windows", from the reflector of the destroyed device itself, and from the LOS attached flanges. During re-entry, pipefitters and miners used gas torches to cut and disassemble the LOS pipe, the walls of which were contaminated with beryllium dust. Re-entry crews involved many trades, including miners, laborers, pipefitters, Rad-Safe personnel, laboratory scientists, and security personnel.

Modification of Beryllium Products by EG+G in North Las Vegas

Beryllium was machined by EG+G Energy Measurement in North Las Vegas, a contractor which provided diagnostic and technical support to operations at the NTS. A 1988 memo stated that EG+G worked with beryllium beginning in 1958. The earliest data found evidencing beryllium use by EG+G is an industrial hygiene record from a 1966 lathe machining operation of unspecified location. In 1974, the "Atlas" facility in North Las Vegas was erected. Industrial hygiene records spanning from 1974 until the moratorium on nuclear testing in 1992 indicate that two forms of beryllium were modified: 1) pure beryllium foils for X-ray permeable windows, and 2) copper-beryllium alloys used in switches, pins, and springs. All of these products were placed into diagnostic canisters for

underground experiments. The greater portion of beryllium work involved cutting foils with metal shears. No aerosols or dust were produced in this procedure. However, work with beryllium alloys was more hazardous. A 1988 EG+G memo detailed such work: "beryllium alloy is used to produce pins which facilitate installation of parts in detector units. Metal rods, which are comprised of 2% beryllium, are lathed, milled, heat treated, and cooled to produce the pins. Pins are heated to 600 degrees Fahrenheit. Approximately 50-60 man-hours per month are spent manufacturing pins (4)." Work with the beryllium alloys took place in the "B" building of the Atlas complex. Intermittent sampling of personnel and breathing areas in the vicinity of these operations occurred throughout Atlas's existence.

B. Documented Instances of Beryllium Exceeding OSHA Limits

The current occupational standard for beryllium metal, 2.0mcg/m3 for an 8-hour time-weighted average, was originally introduced by the Atomic Energy Commission (AEC) in 1949. OSHA adopted the standard in 1971 (5,6). In 1977, the National Institute for Occupational Safety and Health (NIOSH) recommended that OSHA adopt an exposure limit of 0.5mcg/m3 (6). A yet more protective standard of 0.2 mcg/m3 was proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) IN 1998 (6).

The OSHA standard was intended to prevent the development of beryllium sensitization and chronic beryllium disease (CBD). Unfortunately, even in cases in which the PEL was adhered to, cases of beryllium-sensitized workers and CBD continued to be reported. This is demonstrated in a later section of this report, "Analogous Risks in non-NTS Industrial Settings".

Although we have been provided with limited industrial hygiene data, the following samples (out of approximately 1500) suggest that beryllium exposure at the NTS is a significant hazard for the at-risk workforce. It must be pointed out that approximately half of the samples which we were provided did not include a specific location, and most samples did not specify as to whether or not

a time-weighted average (TWA) was used. The following air samples exceeded the OSHA permissible exposure limit for beryllium on the following dates and locations.

7-25-62	Area 16 tunnel U16A	2.86 mcg/m3
1-11-68	Area 12, E tunnel	6.31 mcg/m3
1-17-68	Area 12, E tunnel	2.82 mcg/m3
3-14-68	Area 25, cell #1	3.2X10(squared)/m3
4-24-68	Area 25, cell #11	3.5 mcg/m3
4-24-68	Area 25, cell #11	2.91mcg/m3
8-18-69	Area 25, untold location	4 mcg/m3
4-5-72	location unknown	3.4 mcg/m3, 3.0 mcg/m3

Swipe data rarely reported the actual surface area sampled, indicating only mcg/"per sample", or nothing at all. However, the most conspicuous swipes are listed:

1962	Area 401, disassembly bldg	5.4mcg/100cm2
1967	Area 12, E tunnel	43.2 mcg per ft 2
1967	Area 12, E tunnel	55.0 mcg per ft 2
1967	Area 25, EMAD building	19.5 mcg per ft 2
1967	Area 16, N tunnel LOS pipe	1.86 mcg per sample
1967	Area 25, RMAD building	362.7 mcg/Be
1967	Thermocouples, location unknown	6.8 mcg/ft2
1968	Area 12, E tunnel	1800 mcg/sample
1968	Area 25, EMAD building	5.6 mcg/sq in, 4.0 mg/sq in
1968	Area 25, cell #11	8,12, and 15 mcg/ Be per swipe
1968	Area 25, EMAD building	89, 143 mcg Be/swipe
1968	Area 25, masks from hot cell #10	2mcg/swipe outside

		mask, 1mg inside mask
1968	location unknown, likely Area 25	2625mcg/per sample
1968	Area 25, EMAD building	4.0 and 5.6 mcg/per sq
1969	Area 25, EMAD cell #1	44, 38.5, and 11.5 mcg/sample
1971	Area 25, cell #10	8 mcg, 10mcg/sample
1972	Area 25, location unspecified	40mcg/per gram of "turnings"
1972	location unknown	2000, 6000 mcg/ft2
1977	Area 25, EMAD fuel chute vibrator	2-4 mcg per sample
1977	Area 25, EMAD, random fuel rack	5 mcg per sample
1977	Area 25, EMAD, transfer mask	5 mcg per sample
1977	Area 25, EMAD	3-6 mcg on floor, 10mcg on lamps numerous swipes between 1-8mcg

C. Sample Means of Beryllium Exposures at NTS

Again, we must mention that most of the available data did not indicate whether or not an 8-hour time-weighted average was used in air sampling. Swipe samples were generally vague in describing exact locations sampled, or how much of the surface area was actually swiped. However, we have enough samples to provide a blueprint for defining areas where beryllium was typically used, and how it was used.

Sample arithmetic means were derived from data only under the following circumstances: when it was clear that more than one sample was obtained, that they were taken on the same date, and that they were taken from the same location. An exception is the sole piece of industrial hygiene data obtained from the North Las Vegas Atlas Facility, which contains only one air sample (.00012mcg/m3). No other records could be found for this location. Please refer to the Appendix

A for a complete list of both air and swipe sample means.

Data for underground exposure to beryllium is taken from two tunnels at different times: U16A in 1962, and E tunnel in 1968. The mean air samples from these two locations and eras are in close proximity: .71 mcg/m3 for U16A and .53 mcg/m3 for E tunnel, creating a mean underground exposure of .62mcg/m3. Unfortunately, it is not known whether samples were taken prior or subsequent to a shot. Swipe samples of U16A, E tunnel, and N tunnel are much more varied, with means of 3.63 mcg, .34mcg, and 95.02mcg respectively.

Exact locations within buildings at NRDS were rarely specified in air sampling. However, several locations where machining, assembly, and disassembly occurred were sampled between 1961-3, with a range of measurements from .00048mcg/m3 to 1.04mcg/m3 and a mean of .3mcg/m3. Swipe samples were more specific in describing their origin (see appendix), and were also more varied. Notable samples include: a mean of 116mcg based on two samples from the Engine Maintenance Assembly and Disassembly building (EMAD) in 1968, a mean of 5.02mcg taken from 167 samples within the EMAD building in 1977, and a mean .61mcg taken from two samples of a drilling area at NRDS.

D. Presence of Beryllium Subsequent to Rocket Motor Firing Tests at Eniwetok Atoll, Marshall Islands

In order to help demonstrate the extent of the beryllium hazard that might have existed at NTS during and subsequent to nuclear rocket motor firing, we have obtained data measuring beryllium levels in soil, air, and on surfaces from tests in the Eniwetok Atoll of the Marshall Islands during the late 1960's.

In April 1968 and January 1970, two rocket motor firing tests were conducted in the Eniwetok Atoll. Like the rocket motor tests conducted at NRDS, the rockets used beryllium as one of the propellant constituents. The first test, called the Beryllium Demonstration Motor Static Firing, was designed specifically to quantify risk of beryllium exposure to personnel involved in nearby

test operations. The 1968 test yielded the following results (7):

Sample Obtained:	**Type**	**Reading**
Motor installation breathing zone (before firing)	Air	48-967 mcg-min Be/m3
During firing (location unnamed)	Air	0.276 to 16.9 mcg-min Be/m3
Total integrated dose during test fire, inside blockhouse	Air	<83.4 mcg-min Be/m3
Post-operation (location unnamed)	Air	0.000145 to 0.00195 mcg Be/m3
Post-operation (location unnamed)	Soil	<0.25 to 22,500 mcg Be/g of soil
Post-operation (location unnamed)	Water	<0.005 ppm
Post-operation, inside blockhouse	Wipe	<0.25 mcg Be/ft2
Post-operation, outside of blockhouse	Wipe	12 to 1125 mcg Be/ft2

The unusually high amount found in the motor installation breathing zone was believed to be due either to dust suspended by a nearby caterpillar, or due to the motor case being contaminated with beryllium propellant particles left over from the manufacturing process (7). These figures are useful, however, in framing the range of beryllium's release into the surrounding environment during and subsequent to a rocket motor firing test.

E. Analogous Risks in Non-NTS Industrial Settings

1. Beryllium Machinists

Beryllium machining occurred in above-ground machine shops at NRDS, and at the Atlas facility in North Las Vegas. Underground, in the line-of-sight pipe, beryllium was cut, ground, and modified by 75% of all pipefitters, although few marked off exposure to beryllium in our screening questionnaire. Interviews with several former workers at all three locations revealed a common theme: that workers were "unsure of what they were working with" much of the time.

At DOE's Rocky Flats facility in Golden, CO, an analysis of CBD incidence among various job functions shows that machinists had by far the highest rate at 9.4% (21/223). The averages for personnel categorized as "administrative", "professional", and "among all employees tested", were 1.2% (23/1903), 1.1% (15/1396), and 1.0% (64/6254), respectively (6). An analysis of the air monitoring data associated with machining at this facility showed that average exposures were "less than but near the 2 mcg/m3 limit, and that excursions above the limit were common" (6).

In contrast, DOE's Oak Ridge, TN Y-12 plant reported that cases of CBD surfaced among those employed in a beryllium ceramic machine shop despite the fact that no recorded measurements exceeded 2 mcg/m3, except in one instance where an exhaust duct malfunctioned (6).

2. Maintenance Personnel

Custodians, laborers, and janitors at NTS, NRDS, and the North Las Vegas Atlas buildings were likely to have been exposed to beryllium dust/fumes, as cleaning, sweeping, and similar activity could have resuspended beryllium dust. Interviews with Pan Am and REECO custodians who were employed at the RMAD and EMAD buildings in the mid-1960's revealed that these workers were not aware of what they were sweeping in the machine shops of these facilities, nor did they wear respiratory protection. Our evidence confirms that beryllium was machined at these times in these areas. A 1997 study showed that maintenance personnel in an unnamed beryllium metal, oxide, and alloy production plant had a 2.9% prevalence of beryllium disease (n=104) (7). Although production operations differ from machining operations, the concern raised by agitation of beryllium dust, for which there is no proven safe exposure limit, remains.

3. Working with and around Be-Fuel

The data from the rocket motor firing tests in the Enewetok Atoll showed a wide range of exposure levels, illustrating the magnitude of beryllium exposure from fuel combustion. There are no known studies on the burden of beryllium disease resulting form this form of exposure. However, the air monitoring data, in excess of the OSHA standard, certainly indicates fuel

exhaust as a substantial exposure warranting concern.

F. Summary of At-Risk Personnel at NTS

The NTS populations facing highest risk for beryllium sensitization and disease are:

- Machinists, custodians, and industrial hygienists employed in the Atlas facility "B" building from the 1974-1992, particularly those involved in the production/modification of beryllium windows, beryllium-copper alloy switches, and/or beryllium-copper springs;

- Workers employed at the Nuclear Rocket Development Station (NRDS) from its inception in 1955 to its decommissioning in 1973 as machinists, mechanics, industrial hygienists, custodians, maintenance personnel, RAD-SAFE technicians, welders, pipefitters, security guards, carpenters, sheet metal workers, photographers, and laborers;

- Tunnel re-entry personnel, who were exposed upon re-entry to post-shot beryllium dust from beryllium inside the LOS pipe and from the device itself;

- Pipefitters and miners who disassembled the LOS pipe post-shot;

- Pipefitters who performed grinding, modification and/or installation of flanges in the line-of-sight pipe;

- Health chemistry and other personnel involved in the 1954 Area 5 beryllium distribution experiments near Kay bunker, known as Teabag, Sugar and Uncle (not to be confused with the Uncle and Sugar *shots* in 1951).

High rates of berylliosis among machinists and maintenance workers at other sites direct our focus toward those who performed similar work at NTS and its North Las Vegas "Atlas" facility as the groups with the highest potential sensitization and disease burden. While little is known about the

potential disease burden among those who worked with beryllium rocket fuel and/or from post-shot underground beryllium dust exposure, the high levels of exposure which have been described earlier in this report render them to be at risk.

4. Estimated Beryllium-Related Disease Burden of Former NTS Workers

Acute pneumonitis is probably less likely than the chronic form of beryllium disease to have been prevalent at NTS, as our data suggests that low-level exposure to beryllium was more typical in each setting. Please refer to the graph, "Estimated Beryllium Disease Burden Among NTS Workers", in the appendix.

We are using a range of 1-7% to estimate the number of personnel within specified groups that have been sensitized to beryllium. We can assume that approximately 10% of those sensitized progress on to chronic beryllium disease per year.

Underground Workers

The underground workers most likely to have been exposed to beryllium are those who performed re-entry, those who worked pre-or post-shot in or on the line-of-sight pipe, and those who hauled debris out of the tunnel post-shot. 40% of our screening participants through June 2000 have reported that they performed re-entry work. If this percentage is consistent among the 6000 living REECO underground workers, 2400 workers would have been exposed to beryllium due to re-entry work, and we could expect 24 to 168 of them to become sensitized. Pipefitters face a dual risk, as 75% of them performed modification, cutting, and grinding on beryllium flanges pre-shot, as well as performing disassembly work on the beryllium-contaminated line-of-sight pipe post-shot. This is estimated to be 900 pipefitters, of whom between 9 and 63 would have been sensitized.

NRDS Workers

An estimated 2600 would have worked at NRDS in any capacity. Former workers in this area estimated that 90% of all personnel who worked NRDS area would have had at least indirect contact with one or more of the following: beryllium fuel exhaust, dust from machining or clean up of machining areas, and dust/fumes from reactor/engine disassembly. This is estimated to be 2340 workers, with between 23 and 163 sensitized. 90% of Pan American World Services' workforce, which was the largest contractor at NRDS, worked with or near beryllium. This is estimated to be 639 persons exposed, with a sensitization range of 7 to 45 persons.

EG+G Workers at the North Las Vegas Atlas Facility

Approximately 400 were employed at the EG+G North Las Vegas Atlas facility over a 20-year period. If all personnel were exposed to beryllium, this would reflect a range of between 4 or 28 sensitized. However, it is highly unlikely that all of those employed there were exposed, as not all personnel were involved in machining, industrial hygiene sampling, or clean-up/maintenance of a beryllium-contaminated area. We have been told that the personnel exposure database for this facility has been lost, so it is difficult to make a precise estimation of workers' job tasks, or the number potentially exposed to beryllium in the Atlas workforce. We are in the process of obtaining hard copies of personnel exposure records from Bechtel Nevada.

5. Non-Beryllium Hazards Faced By This Cohort

Those whose exposures to beryllium occurred during underground work at the NTS are already included in our program's current cohort due to their high exposure to diesel exhaust, noise, asbestos, radiation, and silica dust (9). Participants who were employed at the North Las Vegas Atlas facility were exposed to high noise levels from machining operations of beryllium and other metals. Personnel employed at NRDS, of whom 90% held non-administrative positions and were in direct contact with experiments, were exposed to radiation from the rocket motor firing tests, asbestos from brake linings used at NRDS, noise from machining processes and firing tests.

6. Proposed Action

We will begin screening participants using the BeLPT in March of 2001. Participants will be selected for this test in phases. The first group will consist of those who responded positively to any of ten questions identifying beryllium risk on the Initial Contact form. We approximate that 80 people per screening will be identified using the initial contact form. The second group will consist of those who attended previous screenings that are considered to be at risk for beryllium exposure. We will invite these individuals to be tested with the BeLPT in the following order of priority:

1) Those who were found to have a chest x-ray of 1/0 or greater (abnormal reading) and who answered positively to beryllium-identifying questions on the Medical and Work History Questionnaire.

2) Those who answered positively to the question "have you ever worked with beryllium?" on the Medical and Work History Questionnaire (who do not fall into the previous subgroup);

3) Those with abnormal chest x-ray only (who do not fall into the previous two subgroups);

4) Persons who answered positively to questions on the Medical and Work History Questionnaire regarding having performed work on or entry of a line-of-sight pipe pre-and/or post-shot (who do not fall into the previous three subgroups).

5) Persons who answered positively to questions regarding having performed re-entry (who do not fall into the previous four subgroups)

We will test 20 people from Group 2 per quarterly screening. These individuals will be notified and scheduled for the March 2001 and subsequent screenings.

The BeLPT will be sent to the National Jewish Hospital for analysis, and the results will be returned to UCSF. Those participants with a negative test will be notified of the results by letter. Those participants with a positive test will be notified by phone and instructed to return for a second blood test. The second test will be divided and sent to two labs (National Jewish and Specialty) to "double check" the positive result. If it remains

positive, the participant will be instructed on how to contact the closest beryllium disease diagnostic center.

The third group, which will be invited in early 2002, consists of those who worked with beryllium and who would not be found within our current cohort of former NTS workers, specifically, those who were employed exclusively at the North Las Vegas Atlas facility or at the Nuclear Rocket Development Station. We will conduct a search for these individuals, of whom there are approximately 3000, and notify those who can be located. All BeLPT-eligible individuals will also be eligible to take part in the entire screening, as there are several shared exposures.

7. Conclusion

Industrial hygiene data, personal interviews with current and former employees, and citations obtained from DOE's Open Net and Bechtel Nevada support the conclusion that beryllium exposure occurred at the Nevada Test Site in several forms, eras, and areas. Despite evidence of beryllium's widespread use at NTS, few former NTS workers are familiar with beryllium, its function, or its toxicity. There is no clear evidence that the OSHA standard for beryllium exposure of 2.0mcg/m3 has served to prevent cases of beryllium disease. Rather, several studies to date have shown that beryllium disease has occurred in other settings where frequent sampling reflected airborne beryllium levels well below the OSHA standard. The large number of personnel exposed to this toxic metal at NTS, the long average latency period of developing chronic beryllium disease, and lack of workers' knowledge about having worked with beryllium support the argument for notification of these workers and invitation to undergo the BeLPT in our screening. Knowledge of beryllium sensitization will afford former NTS workers the option of seeking preventive medical care, monitoring symptoms, and initiating lifestyle changes that may stall—or prevent—the onset of a potentially fatal disease.

8. Bibliography

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Appendix A: Beryllium Exposure Means at NTS Locations

Appendix B: Estimated Beryllium Disease Burden in NTS Workers

NTS BERYLLIUM EXPOSURE: RESPIRABLE MEAN SAMPLES (AIR) (microgram/m3)									
LOCATION	DATE	N	MEAN	MIN/MAX	% OVER .2	% OVER	%OVER 2.(	ALL VALUES	
TUNNELS									
E Tunnel 04 (illegible)	Jan-68	2	0.62	.24, 1.0	100	50	0	.24, 1.0	
E Tunnel, 04/GC7	Jan-68	5	1.55	.019, 6.31	40	40	20	.019, .06, .06, 1.33, 6.31	
E Tunnel, 04/GC7	Jan-68	9	0.76	.024, 2.82	44	33	11	.024, .033, .034, .044, .045,	
E Tunnel, unspecified	Mar-68	3	0.15	.12-.20	33	0	0	.12, .13, .2	
E Tunnel, unspecified	Mar-68	5	0.12	.07, .26	20	0	0	.07, .1, .1, .1, .26	
U16A 16+50	Jul-62	2	1.6	.353-2.86	100	50	50	.353, 2.86	
U16A Crosscut face in LOS	Nov-62	1	1.4	n/a	100	100	0	1.4	
U16A drift	Oct-62	2	0.34	.037, .66	50	0	0	.037, .66	
U16A LOS pipe work area	Nov-62	1	0.4	n/a	100	0	0	0.4	
U16A LOS pipe, unspec.	Jul-62	2	0.0214	both equal	0	0	0	.0214, .0214	
U16A, unspecified	Jul-62	2	0.04	.0028-.084	0	0	0	.0028, .084	
NUCLEAR ROCKET DEVELOPMENT STATION AREA									
Area 401 N. Check Station	Oct-61	3	0.075	.046-.11	0	0	0	.046, .07, .11	
Area 401 Tent area	Jun-62	2	0.32	.3-.35	100	0	0	.3, .35	
Asesmbly Bldg, area 401	Jul-62	2	0.006	.00048-.0124	0	0	0	.00048, .0124	
MAD building	May-62	2	0.76	.48-1.04	100	50	0	.48, 1.04	
Reflector stand	May-63	1	0.35	n/a	100	0	0	0.35	
NORTH LAS VEGAS ATLAS BUILDINGS									
B-1 Machine shop	Dec-86	4	0.015	.01-.03	0	0	0	0, .01, .02, .03	
B-1 Machine shop	Feb-87	4	0.0125	0-.03	0	0	0	0, .01, .01, .03	
			OSHA 2.0						
			NIOSH 0.5						
			ACGIH 0.2						

.41, 1.39, 2, 2.82	

ESTIMATED BERYLLIUM DISEASE BURDEN IN NTS WORKERS

all values are in micrograms per cubic meter

GROUP AT RISK	EXPOSURE CAUSE	AVG EXPOSURE	GROUP SIZE	AVG LOS	IF 2% SENSITIZED	CBD RISK
Underground Workers						
All underground REECO workers	Post shot dust/fume	.58 mcg/m3	6000	10 years	120	60
All post-shot re-entry/support	Post shot dust/fume	.58 mcg/m3		10 years		
Pipefitters, pre-shot	dust from grinding	unknown	900	10 years	7%=63	9
Pipefitters in general	cutting pipe, reentry	.58 mcg/m3	1200	10 years	240	12
Miners/laborers union	pipe cut, reentry,clean	.58 mcg/m3	3150	10 years	63	32
Pipefitters/Min/Lab combined	cutting pipe, reentry	.58 mcg/m3	4350	10 years	87	44
NRDS Workers						
NRDS All contractors	mach dust/fume, fuel	.3 mcg/m3	2600	5 years	52	26
Pan Am Employees, all	mach dust/fume, fuel	.3 mcg/m3	710	5 years	14	7
Pan Am Personnel, non admin	mach dust/fume, fuel	.3 mcg/m3	639	5 years	13	7
Pan Am machinists	mach dust/fume, fuel	.3 mcg/m3	25	5 years	7%=2	1
Pan Am maintenance/support	mach dust/fume, fuel	.3 mcg/m3	75	5 years	2	1
WANL/ACF Employees (all)	mach dust/fume, fuel	.3 mcg/m3	366	5 years	7	4
WANL/ACF machinists	mach dust/fume, fuel	.3 mcg/m3		5 years		
Reeco employees @NRDS (all)	mach dust/fume, fuel	.3 mcg/m3		5 years		
Reeco custodians/laborers	mach dust/fume, fuel	.3 mcg/m3		5 years		
Aerojet employees (all)	mach dust/fume, fuel	.3 mcg/m3	646	5 years	13	7
Lockheed employees (all)	mach dust/fume, fuel	.3 mcg/m3		5 years		
Bendix employees (all)	mach dust/fume, fuel	.3 mcg/m3		5 years		
EG+G employees (all)	mach dust/fume, fuel	.3 mcg/m3		5 years		
Wackenhut employees (all)	mach dust/fume, fuel	.3 mcg/m3	300	5 years	6	3
Atlas Workers						
All EG+G employees (Atlas only)	mach dust/fumes	.013mcg/m3	2021	10 years	40	20
All Atlas machinists	mach dust/fumes	.013mcg/m3		10 years		
All Atlas maintenance personnel	mach dust/fumes	.013mcg/m3		10 years		
All Atlas mach/maint personnel	mach dust/fumes	.013mcg/m3		10 years		
All Atlas beryllium machinists	mach dust/fumes	.013mcg/m3		10 years		

RANGE(1-7%)
60 to 420
9 to 63
12 to 84
32 to 220
44 to 304
26 to 182
7 to 50
7 to 45
1 to 2
2 to 5
4 to 26
7 to 45
3 to 21
20 to 141