



# Beryllium Sensitization Associated with Low Exposure in the Manufacture of Nuclear Weapons



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## Abstract

The nuclear weapons industry has long been known as a source of beryllium exposure. We screened 1,004 former AEC nuclear weapons workers from the Iowa Army Ammunition Plant (IAAAP) in Burlington, IA for sensitization to beryllium (BeS). The screenings were part of the Department of Energy (DoE) Former Worker Program established in 1996 to identify hazardous exposures in atomic weapons production, and provide medical screenings to detect health effects from those exposures.

Twenty three (2.3%) workers were found sensitized to beryllium by two abnormal or one abnormal and one borderline Beryllium Lymphocyte Proliferation Test (BeLPT). We found no statistically significant association with duration of employment or smoking status but found a suggested dose response trend with exposure intensity to beryllium (3.9% for directly exposed vs. 2.4% for indirect and 1.8% for exposure not likely  $p=0.49$ ). The prevalence of sensitization was comparable or higher than in other DoE sites with the exception of production, research and development machinists. These results confirm the need to screen the low exposed populations for effects of exposure to Beryllium

## Project Background

The University of Iowa College of Public Health Project started in 2001

Funded by DOE under Public Law 102-484 Section 3162 of the 1993 Defense Authorization Act

Goal: *Identifying, locating, and providing former IAAAP AEC workers employed in manufacture of nuclear weapons between 1949-1975 with medical evaluation of long term health effects that might have resulted from employment*

## Iowa Army Ammunition Plant (IAAAP)

Located in Middletown, IA (Des Moines County) ~ 70 miles south from Iowa City - over 19,000 acres of Government Owned Contractor Operated (GOCO) establishment with >1000 buildings, 142 miles of roads and 103 miles of railroad tracks

Built between 1941-1943 as conventional munitions Loading, Assembly and Packing (LAP) facility

Atomic weapons assembled, disassembled and repaired between 1949-1975 on **Line 1** under Atomic Energy Commission (AEC, pre-DoE) contractual agreements with Silas Mason Company

Between 1949-1951 the only large scale manufacturer of nuclear weapons in the country. Production terminated/moved in 1975 to Pantex, IAAAP's sister Plant in Amarillo, TX

## Nuclear Weapons Workers

Estimated 5,000 workers (M>F ~80%) worked on AEC Line 1, workers subgroup Division B, between 1949 and 1975

Substantial cross-over of workforce with adjacent conventional munitions manufacturing lines (95-100% worked on both lines)

Still in operation - current workforce approx. 600 employees

Main exposures:

- Ionizing radiation      High Explosives
- Beryllium                    Isocyanates
- Asbestos                    Epoxy adhesives
- Solvents                     Curing agents

## Methods

Cohort selection was based on subcontractor employment records, plant radiation dosimetry records, union seniority records and employment validation by other former workers

Participants were recruited by mail, telephone, press releases, town hall meetings and word of mouth

All participating former workers received BeLPT

Abnormal, borderline and uninterpretable results were repeated with a split test sent to two laboratories within 6 -12 months of the initial testing.

Confirmed 'abnormal' result was defined as two abnormal or one abnormal + one borderline test results from any laboratory

All workers with normal results were offered repeat testing within three to five years.

Exposure category for each worker was assigned based on job codes/job titles in subcontractor's employment records or union seniority lists (n= 982; 97.8%)

Workers with no documented job code (n=22; 2.2%) were assigned exposure category based on self reported jobs and co-worker evaluation thereof

## Beryllium Exposure

Beryllium surface wipe sample reports for 1970-1974 – the only available historical beryllium exposure data served as indicators of the presence and relative levels of beryllium on surfaces in various locations within the plant, - these could not be used to directly estimate workers' inhalational exposures at the plant.

Interviews of former DoE workers - production, trade and health and safety workers - were also used to assess areas, activities and eras for risk of beryllium exposure.

A survey of surface contamination at this facility in 2007 revealed only two samples out of one hundred collected throughout the facility which exceeded the DoE surface contamination housekeeping level of 3 µg/100 cm<sup>2</sup> and both of these were from surfaces in the area in which millwrights used belt sanders to occasionally resurface alloy tools. (Sanderson et al., JOEH 5(7) p.475, 2008)

Job codes, job titles, and work tasks were reviewed by industrial hygienists and a group of former workers to develop a qualitative exposure matrix (JEM) for beryllium. The estimates for each job code/category were based on task frequency and proximity to potential sources of airborne beryllium and reflected the group's consensus.

## Exposure Categories/Job titles

Exposure Category 0 – no exposure, same as background: security guard, medical, administrative, storage operator, cafeteria, construction worker

Exposure Category 1 – rare/low indirect or bystander exposure: production operator, scientist, engineer, pipefitter, plumber, electrician, laundry worker, custodian

Exposure Category 2 – occasional direct or indirect exposure: millwright, tool and die worker, machinist, welder,

Exposure Category 3 – frequent, direct exposure: not assigned

## Results

Table 1 Screened AEC workforce N=1,004

Parameter	Number screened (%)
<b>Gender</b> Male Female	831 (82.8) 173 (17.2)
<b>Race</b> White Other Missing	953 (94.8) 49 (5.0) 2 (0.2)
<b>Age (years)</b> ≤ 59 60-69 70-79 80-89 ≥ 90	114 (11.4) 304 (30.3) 396 (39.5) 177 (17.6) 13 (1.3)
<b>Smoking</b> Ever smoker Never smoker Missing	707 (70.4) 295 (29.4) 2 (0.2)
<b>First Hire</b> <1/1/1960 ≥1/1/1960 Missing	500 (49.8) 497 (49.5) 7 (0.7)
<b>Beryllium exposure</b> Cat 0 Cat 1 Cat 2	391 (38.9) 507 (50.5) 106 (10.6)
<b>BeLPT</b> Confirmed Abnormal Normal/Not confirmed	23 (2.3) 981 (97.7)

Table 2. Unadjusted analysis of confirmed abnormal BeLPT by age, gender, race, smoking status, date of hire and beryllium exposure

Parameter	Confirmed Abnormal BeLPT (%)	OR (95% CI)	p value
<b>Age (years)</b> ≤ 59 60-69 70-79 80-89 ≥ 90	3 (2.6) 4 (1.3) 9 (2.3) 5 (2.8) 2 (15.4)	1.0 0.49 (0.08-3.43) 0.86 (0.21-5.03) 1.08 (0.21-7.06) 6.54 (0.50-63.88)	0.18
<b>Gender</b> Male Female	18 (2.2) 5 (2.9)	1.0 1.34 (0.39-3.82)	0.57
<b>Race</b> White Other	23 (2.4) 0 (0.0)	N/A N/A	N/A
<b>Smoking</b> Never Ever	6 (2.0) 17 (2.4)	1.0 1.19 (0.44-3.71)	0.72
<b>First Hire</b> ≥1/1/1960 <1/1/1960	8 (1.6) 15 (3.0)	1.0 1.89 (0.74-5.20)	0.15
<b>Be exposure</b> Cat 0 Cat 1 Cat 2	7 (1.8) 12 (2.4) 4 (3.9)	1.0 1.33 (0.48-4.03) 2.15 (0.45-8.64)	0.49

No logistic regression model generated as none of the candidate variables statistically significantly associated with confirmed abnormal BeLPT

## Discussion

The 2.3% rate of sensitization is higher than sensitization rates in some other populations with relatively low exposure

-0.3% ( $p=0.0003$ ) in aluminum smelters (Taiwo et al., JOEM, 50(2), p.157, 2008)

-0.8% ( $p=0.002$ ) in former/current nuclear weapons cleanup/decontamination workers (Sackett et al., JOEM 46(9) p.953, 2004)

-1.0% ( $p=0.72$ ) in Be-Cu alloy distribution facility (Stanton et al., JOEM 48(2) p.204, 2006)

-1.3% ( $p=0.062$ ) in former Nevada Test Site workers (Rodrigues et al., AJIM, 51(7) p. 512, 2008)

-1.4% ( $p=0.031$ ) in former/current nuclear weapons facilities construction workers (Welch et al., AJIM, 46(3), p.207, 2004)

The two-fold increase in risk of sensitization in directly exposed workers compared to non-exposed (category 0) subjects in this study suggests a trend for sensitization to beryllium increasing with exposure although this finding is not statistically significant

## Findings/Recommendations

Elevated rate of beryllium sensitization was confirmed despite low exposures

Implications for more widespread screenings of DoE populations and other workforces (DoD, NASA etc.),utilizing Be alloys

## Copper-Beryllium (1-2%) alloy tools



## Tool and Die Shop

