

INDUSTRIAL HYGIENE SURVEY

OF

THE BRUSH-WELLMAN PLANT

June 12-16, 1972

August 21-25, 1972

NIOSH PERSONNEL

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<p>Worker exposures to beryllium (7440417) (Be) were surveyed at the Brush Wellman Company (SIG-3339) in Elmore, Ohio, from June 12 to 16 and August 21 to 25, 1972. A total of 215 personal and area samples were collected. The highest Be values were found at the powdering, compact loading, scrap reclamations, chipping lathe, and attrition mill areas, however, no workers were exposed to Be concentrations in excess of the threshold limit value of 2 micrograms per cubic meter.</p>					
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PLACE VISITED : Brush Wellman Company  
Elmore, Ohio  
Phone #: 419/862-2745

DATES OF SURVEYS : June 12-16, 1972  
August 21-25, 1972

PERSONS CONTACTED : Mr. Philip Wilson, Manager, Health and Safety  
Mr. E. M. Smith, Vice President Manufacturing

UNION : Non Union



## INTRODUCTION & GENERAL COMMENTS

The Elmore plant, formerly of the Brush Beryllium Company, is located on the Portage River in a farming area in northwest Ohio, approximately five miles east of the town of Elmore, Ohio (population 1200) and five miles west of Oak Harbor, Ohio (population 3500). Toledo is about 25 miles northwest, Fremont, a town of about 22,000 is about 20 miles to the southeast. This is a rural community with farm land and small towns with Lake Erie located about 12 miles directly to the north.

The plant occupies about 300 acres which stretches for one mile along the Portage River. The site was chosen because of its rural nature and its low population density, which has not changed appreciably since the site was purchased in the early 1950's. It should be remembered that the reason for choosing a sparsely populated area was because the Lorain plant, which burned in 1948, was located in densely populated downtown area in Lorain, Ohio and from this plant 22 out-plant cases of beryllium related disease resulted.

The present plant with its 300 ft. stack was built in 1956-57 with a few buildings added since this time. The alloy division, with its 175 ft. stack was built in 1953, making a total of about 8 major buildings at the present time. The plant has filled in sludge lagoons on the river side of the road and a large sludge lagoon to the east and rear of the plant. Disposal of sodium sulfate-ammonium sulfate liquors to the river have recently become a problem due to the tighter state restrictions, but with the mining of a non-beryl ore and production of  $\text{Be}(\text{OH})_2$  in Utah, the sulfate process at Elmore, which produces most of the waste liquor, will eventually phase out.

One of the major interests in surveying the Elmore plant is because of the occupational disease berylliosis which was initially recognized in the early 1940's in and around the Brush Lorain plant, first as an out-plant problem and later as an in-plant problem. The epidemiology of this disease for several years puzzled the medical community. One of the reasons for this being its varied incubation period of less than one year after exposure to more than 20 years after exposure before symptoms of the disease began to appear either in x-ray changes or disability, or both, and also the lack of documentation to significant exposure to beryllium or its compounds.

In 1948, Eisenbud and Machle, working for the Health and Safety Laboratory of the AEC (a major customer for beryllium) decided that the disease was caused by breathing beryllium dust and fumes and suggested a TLV of  $2 \mu\text{g Be}/\text{M}^3$  for airborne beryllium. This number finally became adopted as an official TLV for beryllium, and though it has never been fully met, in plants where it has been closely approached, there appears to be no production of beryllium related disease.

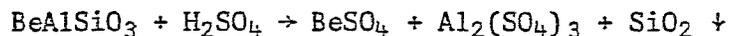
The Brush-Wellman plant at Elmore at present is equipped with local exhaust ventilation and other controls necessary to meet in most cases and approach in all operations the  $2 \mu\text{g Be}/\text{M}^3$  TLV when sampling according to the AEC method (see appendix D attached).

## PROCESS

The Brush plant at Elmore, Ohio was designed to produce beryllium metal, Be-Cu, alloys and BeO ceramics, starting from the ore beryl.

Beryl, ( $3 \text{ BeO} \cdot \text{Al}_2\text{O}_3 \cdot 6 \text{ SiO}_2$ ), a beryllium aluminum silicate containing 4-5% beryllium occurs in nature in pegmatite deposits as an admixture along with mica and feldspar. The ore beryl is widely scattered over the world, however, because of economic reasons (labor costs), all beryl used in the United States is imported from undeveloped countries where it is hand cobbled from pegmatite deposits.

Beryl is processed by crushing to pieces about an inch in diameter, then fed into an electric arc furnace known as a beryl furnace where the beryl is fused and then poured into a pool of water to form frit. The frit is raised in a basket, drained, fed to a rotary kiln to heat treat at 800-900°C, fed to a ball mill, ground to 325 mesh, fed to mixer where it is slurried with 66° Baume  $\text{H}_2\text{SO}_4$  and fed by air pressure into a rotating gas fired, sulfating mill where the beryllium is chemically separated from the ore matrix thus:

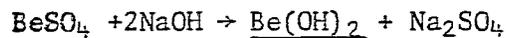
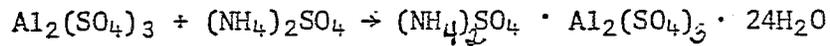


At this point the beryllium and the aluminum are in solution and on going thru the separators, the insoluble silica sludge is separated from the soluble sulfates of beryllium and aluminum and trace elements such as iron.

The major portions of the aluminum is then separated by the addition of aqueous ammonia to form aluminum alum, which is separated in a totally enclosed and ventilated Byrd type centrifuge and flushed to

the industrial waste disposal system. The beryllium is precipitated as  $\text{Be}(\text{OH})_2$  by heating to boiling with strong sodium hydroxide. It is separated from aqueous solution by use of a totally enclosed Byrd centrifuge and dropped directly into fiber drums or into a reaction kettle depending on how it is to be used.  $\text{Be}(\text{OH})_2$  is the starting material from which either of three major product lines may be produced.

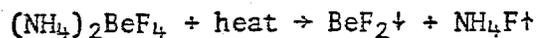
The alum and  $\text{Be}(\text{OH})_2$  are precipitated according to the following reactions:



Be-Cu alloy: This product is produced by first gas firing the crude  $\text{Be}(\text{OH})_2$  produced above, in a screw feed furnace to form  $\text{BeO}$ , which is fed along with carbon and copper to an electric arc furnace where a 4% Be-Cu master alloy is formed, cast, and subsequently remelted and diluted with copper to form alloys of lower concentration which are cast, hot rolled and otherwise fabricated.

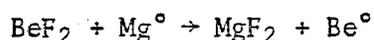
BeO Ceramics: The oxide for this material is made by dissolving the crude  $\text{Be}(\text{OH})_2$  in sulfuric acid, crystallizing out a pure  $\text{BeSO}_4$  which is roasted for about 24 hours at  $1200^\circ\text{C}$  to form  $\text{BeO}$ . The pure ceramic grade  $\text{BeO}$  is further fabricated and fired up to  $1600^\circ$  to form  $\text{BeO}$  ceramics.

Beryllium Metal Production: This process involves the reaction of crude  $\text{Be}(\text{OH})_2$  with  $(\text{NH}_4)\text{HF}_2$  to form a solution of  $(\text{NH}_4)_2\text{BeF}_4$ . After several purification steps, the ammonium beryllium fluoride solution is concentrated, and a pure  $(\text{NH}_4)_2\text{BeF}_4$  salt is precipitated, dried and fed into the fluoride furnace. These contain hot carbon "torpedoes" which decomposes the salt as follows:



The BeF<sub>2</sub> flows like a taffy into rotating carbon molds like an ice tray with approximately 1" squares. The NH<sub>4</sub>F goes off as a gas which is collected in scrubbing devices and recycled in the process.

The BeF<sub>2</sub> cubes are mixed with cubes of Mg metal about 1" square and heated in a furnace where the following reaction takes place.



The beryllium occurs in the form of pebbles which after being separated from the MgF<sub>2</sub> matrix are further purified by vacuum melting. The billet is then chipped up and undergoes powder metallurgy, whereby, the finely powdered metal is hot pressed (sintered) to form a billet of small and uniform grain structure. The metal in this form is capable of undergoing fabrication, such as milling, sawing, machining, etc.

#### INDUSTRIAL HYGIENE CONTROLS

Since beryllium has a TLV of 2 µg Be/M<sup>3</sup> a beryllium plant must be operated with the philosophy of total containment of process material. In other words, the material being processed is enclosed in the stream and in the pipes or vessels. Where they have to be opened, they are supplied with local exhaust ventilation which collects any material which may escape from the system. This means that all tanks are ventilated and that all centrifuges are totally enclosed and ventilated. Powder transfer connections are supplied with special valves and vacuum cleaning devices which operate to contain powders during transfer. Since all operations cannot be completely enclosed, as for example where compacts are loaded with Be metal powder it is necessary in such a case to build a room which is supplied with an air lock. For example, when a man must enter the compact load chamber he wears a fresh air supplied positive pressure respirator while he is in this chamber. The breathing air used is purchased in cylinders which insures that it is free of beryllium dust.

Since all processes are ventilated by local exhaust ventilation or process ventilation the exhaust air from these systems are fed thru some type of collector before the air is discharged, which usually is to the 300 ft. stack.

Collectors of all types are used, for example, cyclones, packed towers, venturi type scrubbers, and bag collectors, some as large as 40,000 cfm capacity. One of these large bag collectors services the powdering and machining areas. In machining operations the cutting tool is fitted with a hood which picks up the chips generated, with air velocities ranging from 12-15,000 ft/min.

Multiple collection devices are in some cases used in series, for example, exhaust gases from the sulfate mills pass through wet cyclones, then packed tower, where they are scrubbed with caustic soda, then venturi type scrubbers, before being exhausted to the 300 ft. stack.

In the beryllium plant, about 350,000 cfm is exhausted and somewhat less than this is added as make up air which is heated in the winter.

In the alloy plant fume and dust from the Be-Cu arc furnace pass thru a cyclone which collects about 40% of the CuO-BeO dust which is recycled back into the process. Then the air goes thru a series of dust collectors, one of these being a conventional bag collector (Dracco) that is shaken mechanically when pressure drop reaches a certain level. The final polishing collector is of the Day reverse jet type from which the air is exhausted to a 175 ft. stack.

## CONTROL AREAS

In general, areas in the plant where beryllium metal or oxide are produced or beryllium copper is reduced will be designated as control areas. In such areas, company clothes or shop coat plus appropriate safety gear must be worn and other precautions are followed as outlined below.

Employee Practices: Except as noted below, employees who work in areas where beryllium is being processed are attired from skin out in company clothes, including safety shoes and safety glasses, and they take a shower at the end of each work day. Employees who do not handle beryllium or regularly work in beryllium process areas, and who are in these areas for supervisory or informational purposes only, may wear a shop coat in lieu of a complete change of clothing and need not take a shower. No company clothing is removed from the plant site, and personnel are not permitted to leave the premises, drive, or ride in private cars while wearing company clothes.

Eating in plant areas is discouraged, however, dispensing machines for coffee and snacks are located within "control" areas, and lunch rooms are located in various convenient areas of the plant where a man may sit down to eat his lunch. A central lunch room where hot meals are served and where both plant and office worker eat together is located in an area where people must walk across a road to reach it. This practice tends to clean the shoes of the plant employees and as a result the lunch room air levels usually range well below  $2.0 \mu\text{Be}/\text{M}^3$ . The general philosophy on eating in or around beryllium areas is that beryllium is toxic by inspiration only and that eating in a beryllium area is not a hazard, but on the other hand as a general plant practice, eating in any processing

area, whether it be in a beryllium plant or any other plant is to be frowned upon.

#### GENERAL CLEAN UP PRACTICES

In order to keep employee exposure in a beryllium plant in the vicinity of  $2 \mu\text{gBe}/\text{M}^3$ , besides having excellent containment of materials in process and extensive local exhaust ventilation, a continuing clean up process is also an integral part of the plant procedure.

Clean up services includes a complete commercial type laundry that operates three shifts, so that clean clothes are available to each shift as they report for work.

There is a clean and dirty locker room procedure. When a man reports to work, he draws a complete set of clothing except shoes from a pass out window or directly from the laundry itself. It should be noted that clothing is interchangeable and is issued on a size basis only. In other words, each man gets clothes, but the clothes he gets one day was probably worn by some one else on a previous shift. After donning company clothes the man puts on his shower togs and passes thru the shoe locker room where he picks up his plant shoes, leaving his shower clogs in his foot locker. At the end of the shift the man sheds his clothes into hamper in the shoe locker room, (these hampers have water sprays fitted above them) puts on his shower clogs, goes thru the shower and comes out in an infrared heated area where towels are available, and then proceeds to his locker where he dons his street clothes. It should be understood that providing clothes for the workmen not only protects the worker, but keeps the beryllium in the plant and prevents it from going home with the worker. This is extremely important since it prevents incidences of beryllium disease occurring in the worker's family.

In addition to laundry and shower facilities, the plant has a decontamination crew which not only runs a mechanical floor washer over the floors of the plant each shift, but also there is a group which washes down the overhead to keep dust off the beams and piping. Usually, hourly rate workers start to work in the plant at this level and bid in on production jobs as they come up.

Clothes changing, showering and cleaning down the plant is an integral part of the operation of a beryllium plant as is the ventilation of reaction vessels and furnaces, as well as the presence of make up air units.

#### SURVEY PROCEDURES

During the first week of survey, June 11-15, both personal and AEC types of sampling methods were used. Each worker involved wore two personal sampling pumps at the same time throughout most of his work shift. One pump drew air through a Millipore AA filter in a cassette attached to the worker's lapel to collect the total airborne fraction of airborne beryllium in his breathing zone. The other pump (dampened) provided the necessary vacuum to force air through a cyclone in front of another AA filter clipped to the lapel of the worker on the opposite side. The cyclone allows only particulates smaller than about 10 microns through, and thereby the filter collects only the respirable airborne beryllium, as defined by the Los Alamos curve for the upper respiratory retention of particulates. Both units were operated at a flow rate of 1.7 l/min. The purpose of this procedure was to provide a direct comparison between the personal gross and personal respirable sampling methods. After distributing the personal pumps at the beginning of the shift, the survey team then collected AEC type samples on hi-volume units. The larger units were placed on tripods and run at about 20 cfm to collect the general air samples at strategic locations. A smaller unit which pulls around 11 cfm

was used to take breathing zone samples. Whatman 41 filters were used for the collection of all AEC samples.

The filters were analyzed for beryllium content by atomic absorption. From the results of the AEC samples, the average exposure for each phase of each operation is found, time weighted, and then a final daily weighted average is computed. The personal gross and personal respirable samples taken represent an integrated value for that worker's exposure for that shift.

### RESULTS & DISCUSSION

Two hundred and fifteen simultaneous pairs of personal gross and personal respirable samples were taken and are shown in Table 1. Every type of production employee was sampled at least once. In order to get a more complete picture, sampling was done on all three shifts. By inspection, as would be expected, the total fraction of airborne beryllium is generally higher than the respirable fraction. It is nearly the same at low levels indicating essentially all respirable Be dust present. These samples were run for about six hours in order to collect enough material for analytical purposes and also to obtain an integrated value of the beryllium concentration present in the worker's breathing zone essentially during his whole shift. Relatively high values for these personal samples were obtained usually in the powdering area. The compact loading personnel were particularly high, followed by the scrap reclamation, chipping lathe, and attrition mill operators. The highest single value came for the sintering welder, but it should be noted that one of his duties is die cleaning, a particularly dusty job. He does wear a fresh air mask doing this in a hood to protect himself. This shows that one disadvantage with the personal sampling method is that it does not take into account any personal protection that the worker might be wearing and can indicate a higher level of exposure to the airborne contaminant, than that to which the worker was actually exposed.

Table II contains the AEC type Daily Weighted Average calculation sheets for 33 different jobs using data collected by the standard AEC method. Samples were gathered in the general work area and breathing zone samples were taken for specific operations indicated on the time study sheets. Most jobs indicated exposure values near the present standard of  $2 \mu\text{g}/\bar{\text{M}}^3$ , though the melt crusher through pebble inspection showed  $10.2 \mu\text{g}/\bar{\text{M}}^3$ . The vacuum cast area was high,  $7.26 \mu\text{gBe}/\bar{\text{M}}^3$ , but some samples were discounted when it was found they were collected while a collector was not operating. It is recommended that ventilation on Vacuum Cast Furnaces be engineered so that the furnaces cannot be operated unless blower is on. The powder handling operations were surprisingly low.

To provide a direct comparison between the three methods of sampling the average concentration of personal gross and respirable samples was computed for each job so they could be compared to the AEC, DWA value. These averages for each job is tabulated along with the AEC results in Table III. The number of samples collected along with the range is given and with the number of samples collected for each job was in general five or less. There is little chance of calculating meaningful statistical data like a "t" test from so few numbers. A quick inspection of Table III indicates that for the same job, the personal gross result would in general be highest, followed by the AEC, and then the personal respirable. A possible explanation for this trend is that the personal gross sample would be higher than a daily weighted average computed from AEC data since the personal sampler is always right in the breathing zone of the worker whereas some AEC samples are general airs, and those that are breathing zones are not attached to the worker, and not taken as close to the work as is the personal sampler. If the worker is moving around a lot, it is

difficult for the person doing the sampling to follow him very closely. It is very reasonable for the personal gross results to be higher than the respirable samples since no size separation is done on the gross sample. Apparently, even though the personal respirable sampler is in the breathing zone of the worker more than the AEC samples, the AEC result should be higher since it collects the total airborne fraction of beryllium

From a knowledge of the operation and the manner in which AEC, DWA calculations are made (as indicated in Appendix D attached). It is obvious that since in operations where a fresh air mask (FAM) is part of the operating procedure, that in such operations the AEC method can show a lower value than either of the personal samples. This is true in compact load operations and others.

#### CONCLUSIONS & RECOMMENDATIONS

The beryllium surveys referred to herein, which measured the concentrations of airborne beryllium to which the workers at the Elmore facilities of the Brush Wellman Company are exposed, indicates that with minor exception, the plant is operating approximately within the TLV of  $2 \mu\text{gBe}/\text{M}^3$  as recommended by the ACGIH TLV committee and also recommended by the criteria doctrine for a recommended standard, Occupational Exposure to Beryllium, published by NIOSH in 1972.

The only recommendation is that the same effort continue to be put forth in the area of occupational health problems, as the company is now pursuing.

Pursuant of such a policy does not mean that occupational disease due to beryllium will be entirely stamped out, since there are, as shown in this report, unmonitored or accidental exposures, for example, failure to turn on ventilation or vacuum casting furnace. However, the mode of operation as it now exists is such that a continuation of this manner of operation should result in a minimal incidence of beryllium related disease.

## A P P E N D I X

### TABLE OF CONTENTS

Table I	List of Gross and Respirable Paired Personal Samples Collected at the Brush Wellman Company, Elmore, Ohio
Table II (a)	Summary of AEC Type Daily Weighted Averages Brush Wellman Company, Elmore, Ohio
Table II (b)	Individual Daily Weighted Average Sheets (39 in all)
Table III	Comparison Between Results of Personal and AEC Samples Brush Wellman Company, Elmore, Ohio
Appendix D	Health and Safety Contract Between AEC and Its Beryllium Contractors (1956)

TABLE I  
 LIST OF GROSS AND RESPIRABLE PAIRED PERSONAL SAMPLES  
 COLLECTED AT THE  
 BRUSH WELLMAN COMPANY  
 Elmore, Ohio  
 June 11-16, 1972

JOB	SAMPLE #	GROSS $\mu\text{g}/\text{M}^3$	RESP. $\mu\text{g}/\text{M}^3$	SHIFT
Material Handlers (Dump Powder, etc.-Respirator worn 1 1/2 - 2 hrs.)	1&2	2.85	0.15	1
Maintenance	3&4	1.84	0.16	1
Maintenance	5&6	0.93	0.31	1
Maintenance	7&8	1.91	0.44	1
Maintenance	9&10	1.77	0.30	1
Maintenance	11&12	2.36	0.15	1
Maintenance	13&14	0.91	0.15	1
Maintenance	15&16	1.25	0.16	1
Maintenance	17&18	2.81	0.16	1
Maintenance	19&20	0.93	0.15	1
Maintenance	21&22	1.17	0.15	1
Maintenance	23&24	2.19	0.16	1
Maintenance	25&26	2.0	0.31	1
Maintenance	27&28	6.8	0.31	1
Maintenance	29&30	1.56	0.16	1
Maintenance	31&32	0.63	0.16	1
Maintenance	33&34	0.48	0.32	1
Instrument & Repair (Maintenance)	35&36	0.62	0.16	1
Instrument & Repair (Maintenance)	37&38	0.16	0.16	1
Maintenance - Electrical	39&40	0.62	0.16	1
Maintenance - Electrical	41&42	0.31	0.15	1
Maintenance - Electrical	43&44	2.70	0.16	1
Maintenance - Electrical	45&46	0.97	0.16	1
Maintenance Instrument Shop	47&48	0.33	0.16	1
Maintenance Instrument Shop	49&50	0.99	0.10	1

TABLE I

<i>JOB</i>	<i>SAMPLE #</i>	<i>GROSS</i> $\mu\text{g}/\bar{M}^3$	<i>RESP.</i> $\mu\text{g}/\bar{M}^3$	<i>SHIFT</i>
Instrument Shop	51&52	0.33	0.16	1
Instrument Shop	53&54	1.17	0.67	1
Maintenance	55-56	----	----	1
Control Lab	57&58	0.82	0.95	1
Control Lab	59&60	18.69	0.81	1
Control Lab	61&62	0.49	0.16	1
Control Lab	63&64	0.49	0.16	1
Control Lab	65&66	3.62	0.16	1
Control Lab	67&68	0.32	0.32<	1
Control Lab	69&70	18.11	2.03	1
Scrap Dispatcher	71&72	31.46	5.98	1
Lead Operator Scrap	73&74	1.70	0.17<	1
Scrap Rec. Operator	75&76	9.95	0.51	1
Scrap Rec. Operator	77&78	4.82	0.34	1
Control Lab	79&80	0.52	0.17<	1
Maintenance	81&82	0.51	0.17	1
Maintenance	83&84	1.65	0.18<	1
Maintenance	85&86	0.91	0.18<	1
Maintenance	87&88	5.55	0.18	1
Maintenance	89&90	0.18	0.18	1
Electrician	91&92	0.74	0.37	1
Maintenance	93&94	3.37	0.15	3
Maintenance	95&96	5.41	1.20	3
Maintenance	97&98	0.74	0.15	3
Electric	99&100	1.05	Lost	3
Electric	101&102	0.30	0.15<	3
Electric	103&104	0.58	0.14	3
Electric	105&106	1.33	0.15	3
Furnace Rebuild	107&108	2.53	0.15	3
Furnace Rebuild	109&110	5.01	0.44	3
Machinist	111&112	2.64	0.16	3
Inspector	113&114	0.92	0.15	3
Machinist	115&116	2.20	0.16	3
Machinist	117&118	1.73	0.32	3
Sintering Lead Operator	119&120	0.73	----	3
Furnace Operator-Hot Press	121&122	1.61	0.15	3
Die Cleaner - FAM	123&124	217.39	0.96	3
Mix Powder Batch for Hot Press	125&126	----	1.09	3

TABLE I

<i>JOB</i>	<i>SAMPLE #</i>	<i>GROSS</i> $\mu\text{g}/\text{M}^3$	<i>RESP.</i> $\mu\text{g}/\text{M}^3$	<i>SHIFT</i>
Mix Powder Batch for Hot Press	127&128	23.50	1.59	3
Chipping Lathe	129&130	15.14	0.33	3
Chipping Lathe	131&132	1.31	0.16	3
Chipping Lathe	133&134	2.97	0.50	3
Attrition Mill Lead Operator	135&136	1.13	0.16	3
Attrition Mill	137&138	----	0.82	3
Attrition Mill	139&140	----	0.32	3
Attrition Mill	141&142	6.21	0.98	3
Scrap Rec. - FAM	143&144	4.43	0.33	3
Scrap Rec. - FAM	145&146	2.97	0.33	3
Lead Operator-Wet Plant	147&148	1.69	0.51	3
Ore Furnace Melt	149&150	0.68	0.34	3
G.C. Salt	151&152	1.91	0.19	3
Vacuum Cast	153&154	4.02	0.18	3
Vacuum Cast	155&156	3.15	0.93	3
Red. Furnace	157&158	2.65	0.78	3
Pebble Finisher	159&160	0.78	0.16	3
F Furnace Operator	161&162	1.23	0.18	3
Pebble Area	163&164	2.75	----	3
Wet Plant Operator	165&166	2.31	0.71	3
Lead Man Wet Plant	167&168	5.51	1.24	3
Ceramics - Oxide Furnace - FAM	169&170	11.69	1.42	3
Ceramics - Punch Press	171&172	0.68	0.17	3
Ceramics Press Operator	173&174	8.26	0.69	3
Ceramics Lead Man	175&176	1.56	0.35	3
Arc Furnace-BeCu	177&178	16.30	0.84	3
Arc Furnace Operator	179&180	2.72	0.17<	3
Arc Furnace Operator	181&182	19.89	----	3
Arc Furnace Operator	183&184	10.55	1.04	3
Maintenance	185&186	1.69	0.31	2
Maintenance	187&188	0.87	0.14	2
Maintenance	189&190	1.01	0.14	2
Maintenance	191&192	0.61	----	2
Furnace Rebuild	193&194	1.05	0.21<	2
Control Lab	195&196	0.58	0.29	2
Control Lab	197&198	0.44	0.15<	2
Bery Furnace Operator	199&200	0.29	0.58	2
G.C. Salt	201&202	1.44	0.29	2
Beryl Furnace - Lead Operator	203&204	4.17	1.08	2
F Furnace Operator	205&206	2.18	0.73	2

TABLE I

<i>JOB</i>	<i>SAMPLE #</i>	<i>GROSS</i> $\mu\text{g}/\text{M}^3$	<i>RESP.</i> $\mu\text{g}/\text{M}^3$	<i>SHIFT</i>
Lead Operator - Wet Plant	207&208	----	0.89	2
Salt Evap.	209&210	1.18	0.59	2
Red. Furnace	211&212	2.08	0.86	2
Pebbles	213&214	2.30	2.87	2
Vacuum Cast Furnace	215&216	0.30	0.90	2
Sintering	217&218	1.50	0.60	2
Vacuum Cast Furnace	219&220	7.24	2.11	2
Chip Lathe	221&222	4.88	0.30	2
Chip Lathe	223&224	2.75	1.62	2
Attrition Mill Lead Man	225&226	1.97	0.15	2
Attrition Mill	227&228	1.22	0.30	2
Attrition Mill	229&230	1.38	0.21	2
Attrition Mill	231&232	4.98	0.60	2
Attrition Mill	233&234	2.14	0.46	2
Compact Lead - FAM	235&236	16.58	7.65	2
Compact Lead - FAM	237&238	145.51	19.92	2
Sintering	239&240	1.13	0.16	2
Machinist	241&242	1.03	0.17	2
Machinist	243&244	2.11	0.35	2
Machinist	245&246	0.88	0.53	2
Machinist Be-Cu	247&248	0.35	0.17	2
Machinist Be-Cu	249&250	0.34	0.17	2
Machinist Be-Cu	251&252	0.18	0.18<	2
Machinist Be-Cu	253&254	0.36	0.18<	2
Furnace Rebuild	255&256	0.73	0.73	2
Furnace Repair	257&258	1.65	0.37	2
Oxide Furnace	259&260	7.05	8.03	2
Kiln Operator - Ceramics	261&262	5.26	0.33	2
Punch Press - Ceramics	263&264	1.33	0.17<	2
Lead Man Ceramics	265&266	1.17	0.17	2
Ceramic Saw	267&268	1.34	0.17	2
Isopress Ceramics	269&270	7.10	0.51<	2
Machine Ceramics	271&272	3.06	0.34	2
Machine Ceramics	273&274	1.53	0.34	2
Ceramics - Lead Man Machine	275&276	4.10	0.34	2
G.C. Salt	277&278	----	0.39	1
Beryl Furnace Operator	279&280	1.31	1.31	1
Ore Crusher	281&282	2.26	0.57	1
Beryl Area-Lead Operator	283&284	1.31	0.53	1
Evap. Operator	285&286	----	0.39	1
Chem Operator-Wet Plant	287&288	2.07	0.26	1

TABLE I

JOB	SAMPLE #	GROSS $\mu\text{g}/\text{M}^3$	RESP. $\mu\text{g}/\text{M}^3$	SHIFT
Extraction Oxide	289&290	----	0.13	1
F Furnace	291&292	1.60	0.53	1
Red. Furnace	293&294	1.74	1.32	1
Pebble Finisher	295&296	0.52	0.13<	1
Vacuum Cast Furnace	297&298	2.91	0.28	1
Sintering	299&300	0.14	0.28	1
Sintering	301&302	5.65	0.28	1
Compact Loading- Resp.	303&304	76.40	7.83	1
Compact Loading- Resp.	305&306	14.36	3.45	1
Sintering	307&308	----	0.14	1
Die Construction	309&310	----	0.28	1
Machinist	311&312	----	0.30	1
Machinist	313&314	----	0.30	1
Machinist	315&316	1.19	0.30	1
Machinist	317&318	1.60	0.30	1
Press Powder	319&320	0.88	0.74	1
Press Powder	321&322	1.14	0.14<	1
Die Cleaner-Resp. P.T.	323&324	----	5.58	1
Vacuum Cast Furnace	325&326	4.31	0.36	1
Chip Lathe Operator	327&328	4.47	0.33	1
Attrition Mill Operator - Lead	329&330	4.21	0.60	1
Decontamination	331&332	1.74	0.35	1
Attrition Mill	333&334	3.90	0.78	1
Attrition Mill-Resp.	335&336	11.83	0.48	1
Chip Lathe	337&338	4.58	0.44	1
Attrition Mill	339&340	19.03	1.11	1
Attrition Mill	341&342	2.21	0.63	1
Arc Furnace-Charge Man-Resp.	343&344	1.95	0.32	1
Arc Furnace Mix Man	345&346	4.64	0.17	1
Arc Furnace-Lead Operator	347&348	4.86	0.49	1
Arc Furnace Pour	349&350	----	0.33	1
Molder-Cast & Tool Shop	351&352	1.72	0.16<	1
Lead Operator Cast Shop	353&354	0.48	0.16<	1
Deck Man - Cast Shop	355&356	0.66	0.53	1
Melt Furnace Cast Operator	357&358	0.50	0.33	1
Pour Man - Cast Shop	359&360	0.85	0.17<	1
Furnace Rebuild	361&362	0.67	0.17	1

TABLE I

JOB	SAMPLE #	GROSS µg/M <sup>3</sup>	RESP. µg/M <sup>3</sup>	SHIFT
Furnace Rebuild	363&364	1.02	0.20<	1
Arc Furnace Charge Man	365&366	3.48	0.32	1
Arc Furnace Operator	367&368	3.03	1.12	2
Arc Furnace Operator	369&370	1.28	0.32	2
Mix Makeup Man Ajax	371&372	1.34	0.17<	2
Ajax	373&374	18.43	1.34	2
Ajax Furnace Operator	375&376	0.68	0.17<	2
Lead Man Ajax	377&378	1.34	0.17<	2
Mold Man	379&380	1.18	0.17	2
Ajax Furnace Operator	381&382	0.35	0.87	2
Ajax Furnace-Mix Prep.	383&384	0.17	0.17	2
Ajax Furnace Operator	385&386	1.19	1.02	2
Arc Furnace - Lead Operator	387&388	2.60	0.35	2
Laundry	389&390	0.87	0.29	1
Oxide Furnace Ceramics	391&392	4.02	1.12	1
Ceramics	393&394	----	0.16<	1
Kiln Operator Ceramics	395&396	0.81	0.32	1
Ceramics Punch Press Operator	397&398	0.48	0.16<	1
Cleanupman Ceramics	399&400	1.70	0.19	1
Lead Man Ceramics	401&402	2.12	0.25	1
Material Prep. Kiln Operator - Ceramics	403&404	----	0.82	1
Material Prep. - Ceramics	405&406	2.81	0.16<	1
Ceramics - Centerless Grinder	407&408	1.48	0.16<	1
Ceramics - Machining	409&410	1.65	0.16<	1
Ceramics - Machining	411&412	4.99	0.33	1
Ceramics - Machining	413&414	0.67	0.16<	1
Ceramics - Inventory Control	415&416	0.67	0.16<	1
Machining Ceramics - Lead Man	417&418	10.80	0.69<	1
Inspect Ceramics	419&420	0.86	0.35	1
Inspect Ceramics	421&422	0.68	0.16<	1
Inspect Ceramics	423&424	1.20	0.17	1
G.C. Salt	425&426	1.02	0.85	1
Machine Be	427&428	1.44	0.41	1
Machine Be	429&430	2.25	0.16<	1

FAM = FRESH AIR MASK

TABLE II

CALCULATION SHEETS FOR DAILY WEIGHTED AVERAGE EXPOSURES

COMPUTED FROM AEC TYPE SAMPLES

BRUSH WELLMAN COMPANY  
Elmore, Ohio

June 11-15, 1972 & August 21-25, 1972

SUMMARY OF AEC TYPE DAILY WEIGHTED AVERAGES

<u>Beryllium Metal Operation</u>	<u>μgBe/M<sup>3</sup></u>	<u>Beryllium Metal Operation</u>	<u>μgBe/M<sup>3</sup></u>
Beryl Furnace	0.72	Attrition Mill Operator	1.45
Ore Processing Operation	0.74	Attrition Mill Operator (Lead Man)	1.42
Sulfate Mill - not in operation during survey		Compact Loading (Die Prep. & Strip)	2.25
G.C. Salt Operation	1.28	Compact Loading (Powder Prep. & Die Loading)	1.69
Thickener Hydroxide Area	1.60	Sintering Furnace Operation	1.39
Oxide Furnace Operation	0.88	Sintering Welder Operation	0.51
Be Metal Wet Plant Theater Op.	0.94	Sintering Machining Operation	0.51
Be Metal Wet Plant Sludge Op.	1.04	Press Operation (M&M, Dross #1, Dross #2, Haller, MYM Jr.)	0.58
Evaporator Operator	2.42	Iso Press Operation-BeO	0.41
Fluoride Furnace Operator	0.92	Machine Operation (ceramics)	2.90
Reduction Furnace Operation	1.37	Kiln Operation	0.74
Melts Crusher Thru Pubble Insp.	10.10	Control Laboratory Personnel	0.42
Misc. Powder Material Handler	1.02	Machine Shop Operation (maint.)	0.20
Vacuum Cast Furnace (7.26)*	2.86	Boiler Operator	2.58
Billet Packing & Chipping Lathe	2.96	Laundry Operation	1.04
Chip Compact Press (Scrap Reclamation)	0.73		
Chip Centrifuge	0.66		
Sink & Float Operation	0.97		
Chip Inspection, Magnetic Separator, Chip Crusher, Vibrating Dryer	2.07		

<u>Alloy Operation</u>	<u>μgBe/M<sup>3</sup></u>
Arc Furnace Crew Chief	2.01
Arc Furnace Helper	2.03
Mixer	2.05
Arc Furnace Charge Man	2.85
Ajax Furnace Operator	0.57

\* taken with #8 Furnace collector turned off

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Beryl Furnace

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION μgBe/M <sup>3</sup>			CONC. T. TOTAL T. (T x C)
					LOW	HIGH	AVE.	
GA Work Area	370	1	370	5	.56	.82	.63	233.1
GA Shoe Change Room	6	1	6	5	2.00	3.19	2.66	16.0
GA Locker Room	12	1	12	3	.15	.18	.17	2.0
GA Cafeteria	30	1	30	2	.10	.19	.15	4.5
GA General Plant	30	1	30	8	.37	2.64	1.20	36.0
BZ Pour Beryl Furnace	10	5	50	1			1.39	6.95

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.72} \text{ } \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 361.1$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Ore Processing Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Beryl Furnace Work Area	145	1	145	5	.56	.82	.63	233.1
GA Heat Treat & Grind Area	115	1	115	1			.30	34.5
GA Thickener Area	120	1	120	2	.12	.17	.15	18.0
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	60	1	60				1.26	36.0
BZ Raise or lower	2	5	10	2	2.42	3.06	2.76	27.6

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.74} \mu\text{g Be}/\text{M}^3$$

DWA 498  $\Sigma T$

$$\Sigma (T \times C) = 371.7$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Sulfate Mill Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\bar{\text{M}}^3$			CONC. TI TOTAL TI (T x C)
					LOW	HIGH	AVE. (C)	
GA Mill Work Area	402.4	1	402.4					
GA Shoe Change Room	6	1	6					
GA Locker Room	12	1	12					
GA Cafeteria	30	1	30					
GA General Plant	30	1	30					
BZ Remove door	4.4	4	17.6					
PROCESS NOT IN OPERATION AT TIME OF SURVEY								

$\frac{\Sigma(T \times C)}{\Sigma T} =$  \_\_\_\_\_  $\mu\text{g Be}/\bar{\text{M}}^3$       DWA      498       $\Sigma T$        $\Sigma (T \times C) =$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: G C Salt Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Work area	381	1	381	2	.72	.72	.72	274.3
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
BZ Load Carbonate into tank	30	1	30	Brush's Data August			9.6	288.0
BZ Change discharge drum	9	1	9				2.10	18.9
GA General Plant	30	1	30				1.20	36.0

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.28 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 639.7$$

NOTE: Some of Brush's Data Included in Calculation

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Thickener Hydroxide Area

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE. (C)	
GA Thickener-Hydrox Area	405	1	405	8	.12	3.10	1.75	696.6
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Change discharge	1.5	10	15	3	.23	4.42	2.82	42.3

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.60 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 797.4$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Oxide Furnace Operation by ceramics

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE. (C)	
GA Oxide Furnace Area	120	1	120	8	.35	10.56	3.18	381.6
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ**Change Sweco Drum	2	6	12	1			5.84	-----
BZ**Handle Salt	80	1	80	2	1.21	2.41	1.81	-----
BZ**Unload Furnace	168	1	168	1			2.58	-----
BZ**Screen BeO	40	1	40					-----

\*\* FRESH AIR MASK

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{\quad .88 \quad} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 440.1$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Be Metal Wet Plant Treater Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Metal Wet Plant Work Area	413	1	413	7	.51	1.98	.97	400.6
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Dump drum of carbonate into treater tank	7	1	7	1			1.42	9.9

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{\underline{.94}} \mu\text{g Be}/\text{M}^3$$

DWA 498 ET

$$\Sigma (T \times C) = 469.0$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Be Metal Wet Plant Sludge Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
			PER SHIFT (MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Metal Wet Plant Work Area	210	1	210		6	.51	1.21	.77	161.7
BZ By-Product Mill	120	1	120		1			1.98	237.6
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ Hand Picking Dress	60	1	60		2			.52	31.2
BZ* Load Product Mill	30	1	30		1			1.03	30.9

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.04 \mu\text{g Be}/\text{M}^3$$

DWA 498  $\Sigma T$

$$\Sigma (T \times C) = 519.9$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Evaporator Operator

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
			PER SHIFT (MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Evaporator Area	180	1	180		6	.41	17.90	5.36	964.8
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	30	1	30					1.20	36.0
GA Wet Plant Area	240	1	240		6	.51	1.21	.77	184.8

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{2.42} \mu\text{g Be}/\text{M}^3$$

DWA 498  $\Sigma T$

$$\Sigma (T \times C) = 1208.10$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Fluoride Furnace Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIMES TOTAL TIME (T X C)
			(MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Top Deck	233	1	233		4	.20	.54	.38	88.5
GA Floor Level	150	1	150		4	.86	2.74	1.52	228.0
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ* Probe Fume Duct	2	2	4		1			10.16	40.6
BZ Canning Station	5	6	30		2	1.09	2.03	1.56	46.8
BZ Clean Feed Tube	1	3	very seldom	done					

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 0.92 \mu\text{g Be}/\text{M}^3$$

DWA 498  $\Sigma T$

$$\Sigma (T \times C) = 462.4$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Reduction Furnace Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
			PER SHIFT (MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Reduction Furnace Area	282	1	282		7	.25		.41	115.6
GA Shoe Change Room	6	1	6					2.66	16.0
GA Cafeteria	30	1	30					.17	2.0
GA Locker Room	12	1	12					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ Charge Furnace	4	16	54		3	2.58	9.26	5.01	270.5
BZ Probe Melt	0.5	8	4		3	3.37	19.80	11.42	45.7
BZ Change Drums in Charge Cart	10	4	40		1			1.60	64.0
BZ Pour Furnace & Clean Out Crucible	10	4	40		3	1.48	5.53	3.24	129.6

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{1.37} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 683.9$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Melts Crusher Thru Pebble Inspection

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Work Area	367.3	1	367.3	5	.25	29.18	13.45	4940.2
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	16.0
BZ Transfer & Crush Melt. Clean & Paint Pot	4	1	4	1			3.56	14.2
BZ Remove Leaching Mill Cover	Infrequently done							
BZ Inspect Pebbles	180	0.2	36	1			.80	28.8
BZ Remove Discharge Drum	0.6	0.2	0.1	1			2.57	.3

$$\frac{\Sigma(T \times C)}{\Sigma T} = 10.10 \mu\text{g Be}/\text{M}^3$$

DWA 497.4  $\Sigma T$

$$\Sigma (T \times C) = 5022.0$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Miscellaneous Powder Material Handler

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
			(MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Powder Hood Area	212	1	212		1			.51	108.1
GA Scrap Reclamation	60	1	60		4	.27	.59	.44	26.4
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	60	1	60					1.20	36.0
BZ* Connect or Disconnect Drums	2	2	4		1			2.90	11.6
BZ* Dump Powder Samples or Package Powder	1	114	114		1			2.70	307.8

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.02 \mu\text{g Be}/\text{M}^3$$

DWA 498  $\Sigma T$

$$\Sigma (T \times C) = 512.4$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Vacuum Cast Furnace Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TI. TOTAL TI. (T x C)
			(MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Vacuum Cast Area	371	1	371		6	.38	1.51	.74	274.5
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA General Plant	30	1	30					1.20	36.0
GA Cafeteria	30	1	30					.15	4.5
BZ Pour Furnace	12	2	24		4	1.43	4.16	2.60	62.4
Change Molds, Chip & Rake Dross									
BZ Charge Furnace & Replace Probe Rod Assembly	5	2	10		4	1.86	13.20	7.53	75.3
BZ Dumping Dross OR Billets	5	3	15		4	3.60	142.1	63.63	954.4

NOTE: #205 & #206 (about  $650 \mu\text{g}/\text{m}^3$ ) discarded since collected while #8 furnace collector turned off. If these were included in the calculation DWA would be 7.26

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{2.86 \mu\text{g Be}/\text{M}^3} \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 1425.1$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Billet Picking & Chipping Lathe

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Lathe Area (center)	225	1	225	6	.23	3.37	1.02	229.5
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Install & Remove Billets In Lathe	6	5	30	2	4.71	14.82	9.77	293.1
BZ Pick Billets	60	2.5	150	3	1.50	3.71	2.26	539.0
BZ* Change Chip Pickup Drum	5	3	15	3	1.74	12.82	8.42	126.3

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{2.96 \mu\text{g Be}/\text{M}^3} \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma(T \times C) = 1478.1$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Chip Compact Press (Scrap Reclamation)

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION μgBe/M <sup>3</sup>			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE.	
GA Work Area	374	1	374	4	.27	.59	.44	164.6
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ* Change Feed Drum	6	2	12	2	1.49	2.17	1.83	22.0
BZ Operate Press	2	8	16	GA at Press	.27	.59	.44	7.0
BZ* Change Product Drum	6	3	18	3	2.11	18.89	6.30	113.4

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = .73 \text{ } \mu\text{g Be}/\text{M}^3$$

DWA

498 ΣT

$$\Sigma (T \times C) = 365.5$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Chip Centrifuge

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE. (C)	
GA Work Area	380	1	380	2	.40	.48	.44	167.2
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ* Load Basket & Install Lid	20	1	20	2	1.74	3.29	2.52	50.4
BZ* Remove Lid & Unload Basket	20	1	20	2	1.72	3.83	2.77	55.4

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.66} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 331.5$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Sink & Float Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
			PER SHIFT (MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Work Area	377	1	377		12			.64	241.3
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ* Change Feed Can	4	1	4		1			3.79	15.2
BZ* Skim and Add Be Chips to BCM	3	12	36		1			4.19	150.8
BZ* Change Product Drum	3	1	3		1			6.82	20.5

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{0.97} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 486.3$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Chip Inspection, Magnetic Separator, Chip Crusher, Vibrating Dryer

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Work Area	302	1	302	4	.46	.98	.67	202.3
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
<u>CHIP INSPECTION UNIT</u>								
BZ* Change Feed Can	1	2	2	2	1.22	5.60	3.41	6.8
BZ Inspect Chips	90	1	90	2	2.27	6.16	4.22	379.8
BZ* Change Prod. Drum	1	2	2	1			3.49	7.0
<u>MAGNETIC SEPARATOR</u>								
BZ* Change Feed Can	3	2	6	1			.90	2.7
BZ* Remove Sample	1	2	2	1			11.67	93.4
BZ* Remove Sample Drum	3	2	6	1				
<u>CHIP CRUSHER</u>								
BZ* Change Feed Can	1.5	2	3	2	3.16	4.61	3.89	11.7
BZ* Change Prod. Drum	2.5	2	5	2	46.46	60.36	53.41	267.0
<u>VIBRATING DRYER</u>								
BZ Change Feed Can	0.5	2	1					
BZ Change Prod. Drum	0.5	2	1					

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 2.07 \mu\text{g Be}/\text{M}^3$$

DWA

496  $\Sigma T$

$$\Sigma (T \times C) = 1029.2$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Attrition Mill Operator

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIM TOTAL TIM (T X C)
					LOW	HIGH	AVE. (C)	
GA Attrition Mill Platform	326	1	326	4	.51	3.07	1.47	479.2
GA Screen Deck	10	4	40	4	.51	1.27	.73	29.2
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ* Remove or Install Feed Can	5	6	30	2	2.88	7.64	5.26	157.8

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.45 \mu\text{g Be}/\text{M}^3$$

DWA

498  $\Sigma T$

$$\Sigma (T \times C) = 724.7$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Attrition Mill Operator (Leadman)

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIMES TOTAL TIME (T x C)
					LOW	HIGH	AVE.	
GA Floor Area	190	1	190	3	.31	2.64	1.16	266.8
GA Attrition Mill Area	10	4	40					
GA Mesh Check Deck	5	16	80	4	1.86	2.93	2.26	180.8
GA Rotex Deck	10	4	40	4	.51	1.27	.73	29.2
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA General Plant	30	1	30				1.20	36.0
GA Cafeteria	30	1	30				.15	4.5
BZ* Change Oversize Drum	5	12	60	4	1.51	3.71	2.45	147.0
BZ* Change Mesh Check Sample & Check Mesh	2.5	4	10	2	2.45	3.02	2.74	27.4

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.42 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma(T \times C) = 709.7$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Compact Loading (Die Prep & Strip)

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE. (C)	
GA Die cleaning area	280	1	280	1			1.10	308.0
GA Die Storage Area	30	1	30	1			.74	22.0
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ* Die Cleaning	60	1	60	1			3.16	189.6
BZ* Die Stripping (respirator)	20	1	20	Brush's Data August			21.6	432.0
BZ* Water Blasting Billet	30	1	30	Brush's Data August			3.6	108.0

\* Respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 2.25 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 1118.1$$

NOTE: Some of Brush's Data included in Calculation

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Compact Loading (Powder Prep & Die Loading)

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)	
					LOW	HIGH	AVE. (C)		
GA Compact Load Hood	100	1	100	Brush's	Data	0.6	1.2	1.0	100.0
GA Blending Area	206	1	206	3		.51	2.48	1.28	264.0
GA Screening Area	45	1	45	Brush's		1.0	1.7	1.0	45.0
GA Screening Platform	30	1	30	Data		1.0	1.7	1.0	30.0
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.4
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ* Tapout Station (con or discon drum)	2	2	4	Brush's	Data			7.8	31.2
BZ* Screening Station (con or discon feed or prod. drum)	2	2	4	1				8.14	32.5
BZ* Blending Station (con or discon feed drum to blender)	2	2	4	2		13.97	28.09	21.02	85.0
BZ* Sample Roll Blender	5	1	5	Brush's	Data			24.4	122.0
BZ* Compact Load (con or discon feed drum)	2	1	2	1				4.54	9.2
BZ* Load Compact (top platform)	15	1	15	1				3.00	45.0
BZ* Change rotex screen at Screening Station	5	1	5						

\* Respirator  
\*\* Fresh Air Mask

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.69 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 842.4$$

NOTE: Brush's Data included in the calculation

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Sintering Furnace Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Leadman Desk Area	60	1	60	2	.33	1.47	.90	54.0
GA In Pit, Furnace, Deck Area	136	1	136	3	.31	1.19	.66	89.8
GA #8 & 9 Furnace Deck	60	1	60	1			.26	15.6
GA Horizontal Furnace Deck Area	60	1	60	3	.40	1.68	.87	52.2
GA Stripping Press	30	1	30	1			.78	23.4
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Remove Die From Furnace	7	2	14	1			.94	13.2
BZ Remove Furnace Lid	4	2	8	1			2.81	22.5
BZ* Die Stripping	30	1	30	2	3.70	17.25	10.48	314.4
BZ Load Die in Fur- nace	7	2	14	3	.79	4.64	2.42	33.9
BZ Install Lid on Furnace	4	2	8	3	.68	4.14	2.05	16.4

\* respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 1.39 \mu\text{g Be}/\text{M}^3$$

DWA 498  $\Sigma T$

$$\Sigma (T \times C) = 693.9$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Sintering Welder Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Sintering Welder	319.5	1	319.5	2	.49	.50	.50	159.8
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Weld Die	45	0.9	40.5	3	.80	1.34	1.00	40.5
BZ**Stripping Dies In Hood	60	1	60	2	70.44	72.22	71.33	----

\*\* Fresh Air Mask

$$\frac{\Sigma(T \times C)}{\Sigma T} = 0.51 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 258.8$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Sintering Machining Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIMES TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Machine Area South Center	209	1	209	4	.25	1.58	.73	152.6
GA Machine Area North Center	208	1	208	1			.19	39.5
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ* Change Be Collector Drum	6	0.5	3	2	2.25	2.78	2.52	7.6

\* respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{0.51} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 258.2$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Press Operation, (M&M, Dorst #1 Dorst #2, Haller & MYM Jr.)

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIMES TOTAL TIME (T x C)
			PER SHIFT (MIN)	PER SHIFT (T)		LOW	HIGH	AVE. (C)	
GA Press Area	60	1	60		1			.29	17.40
GA Shoe Change Room	6	1	6					2.66	16.00
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	30	1	30					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ Operate Press	360	1	360		2	.58	.60	.59	212.4

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.58} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 288.3$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Isopress Operation - BeO

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH (C)	AVE.	
GA Work Area	282	1	282	1			.25	70.5
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	16.0
BZ Load Die with BeO	20	3	60	Brush's Data July			.30	18.0
BZ Load Dies into Isopress	3	3	9	Brush's Data July			1.7	15.3
BZ Unload Die in Hood	3	3	9					
BZ Take Die from Press	20	3	60	1			.84	58.0

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.41} \mu\text{g Be}/\text{M}^3$$

DWA

498  $\Sigma T$

$$\Sigma (T \times C) = 202.3$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Machine Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE. (C)	
GA Machining Area	155	1	155	5	.27	.79	.47	72.9
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Operate Machines when sample turn away 180°	265	1	265	4	.62	12.63	4.97	1317.0

$$\frac{\Sigma(T \times C)}{\Sigma T} = 2.90 \mu\text{g Be}/\text{M}^3$$

DWA

498  $\Sigma T$

$$\Sigma (T \times C) = 1448.48$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Kiln Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME		NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIM TOTAL TIM (T X C)
			(MIN)	(T)		LOW	HIGH	AVE. (C)	
GA Tunnel Kiln Area	105	1	105		3	.39	2.36	1.49	156.9
GA Periodic Kiln Area	55	1	55		2	.38	.66	.52	28.6
GA Press Area	105	1	105		1			.29	30.4
GA Shoe Change Room	6	1	6					2.66	16.0
GA Locker Room	12	1	12					.17	2.0
GA Cafeteria	35	1	35					.15	4.5
GA General Plant	30	1	30					1.20	36.0
BZ Load Tunnel Kiln	15	1	15		Brush's Data August			.50	7.5
BZ Load or Unload Periodic Kiln	120	1	120		Brush's Data August			.50	60.0
BZ Dump Shapes From Tunnel Kiln Saggars	15	1	15		2	.83	2.46	1.65	24.8

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.74} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 366.3$$

NOTE: Some of Brush's Data included in the calculation

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Control Lab Personnel

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Lab Work Area	410	1	410	4	.06	.53	.36	147.6
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Weigh Be Powder Sample	10	1	10	2	.27	.75	.51	5.1

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.42} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma(T \times C) = 211.2$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Machine Shop Operation (Maintenance)

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T x C)
					LOW	HIGH	AVE. (C)	
GA Work Area	420	1	420	3	.06	.14	.10	42.0
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{.20} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \text{ n}\Sigma\text{T} \quad \Sigma (T \times C) = 100.5$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Boiler Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Boiler Area	390	1	390	3	.59	3.88	3.12	1216.8
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA General Plant	30	1	30				1.20	36.0
GA Cafeteria	30	1	30				.15	4.5
GA Water Treatment Plant	30	1	30	2	.22	.49	.34	10.2

$$\frac{\Sigma(T \times C)}{\Sigma T} = 2.58 \mu\text{g Be}/\text{M}^3$$

DWA

498  $\Sigma T$

$$\Sigma (T \times C) = 1285.5$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Beryllium - Oxide, Metal, Ceramics

OPERATION: Laundry Operation

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE. (C)	
GA Laundry Area	432	1	432	2	.21	1.55	.88	380.2
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
BZ Load Dirty Outer Clothing into Washer	2	4	8					
BZ Load Dirty Under Clothing into Washer	5	2	10	1			4.50	81.0

$\frac{\Sigma(T \times C)}{\Sigma T} = 1.04 \mu\text{g Be}/\text{M}^3$       DWA      498  $\Sigma T$        $\Sigma (T \times C) = 519.7$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Alloy Plant

OPERATION: Arc Furnace Crew Chief

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Ground Floor	292.5	1	292.5	10	.88	5.80	2.08	608.4
GA Platform	90	1	90	4	1.11	3.61	2.45	220.5
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ Clean out transfer & rubble dross	5	1.5	7.5	1			5.62	42.2
BZ Pour castings	20	1.5	30	2	2.34	2.42	2.38	71.4

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{2.01} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 1001.0$$

T.E BRUSH WELLMAN COMPANY

Eimore, Ohio - Alloy Plant

OPERATION: Arc Furnace Helper

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIME TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Ground Floor	232.2	1	232.2	10			2.08	483.0
GA Platform Area	30	1	30	4			2.45	73.5
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	30	1	30				1.20	36.0
BZ*Tap Arc Furnace	8	1.5	12	1			9.63	115.6
BZ Clean out transfer pot & rubble dross	8	1.5	12	1			5.62	67.4
BZ Pour castings	20	1.5	30	2	2.34	2.42	2.36	70.8
BZ Change or charge feed drum (oxide unit)	2.5	5.5	13.8	2	1.21	2.41	1.81	25.0
GA Oxide Unit	90	1	90	2	1.14	1.53	1.34	120.6

\* respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = 2.03 \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \Sigma T \quad \Sigma (T \times C) = 1014.4$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Alloy Plant

OPERATION: Mixer

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIMES TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Ground Floor	274.6	1	274.6	10			2.08	571.2
GA Arc Furnace Plat- form	133.4	1	133.4	4			2.45	326.8
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.0
GA General Plant	30	1	30				1.20	36.0
BZ Clean out transfer pot & rubble dross	8	1.5	12	1			5.62	67.4

$$\frac{\Sigma(T \times C)}{\Sigma T} =$$

2.05  $\mu\text{g Be}/\text{M}^3$

DWA

498

$\Sigma T$

$$\Sigma (T \times C) = 1023.9$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Alloy Plant

OPERATION: Arc Furnace Charge Man

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION $\mu\text{gBe}/\text{M}^3$			CONC. TIMES TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Platform Area	420.4	1	420.4	4	1.11	3.61	2.45	1030.0
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.5
GA General Plant	10	1	10				1.20	36.0
BZ*Electrode Change	3.3	1.4	4.6	1			56.50	259.9
BZ Charge Furnace	1	15	15	2	4.86	5.05	4.95	74.2

\* respirator

$$\frac{\Sigma(T \times C)}{\Sigma T} = \underline{2.85} \mu\text{g Be}/\text{M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 1422.6$$

THE BRUSH WELLMAN COMPANY

Elmore, Ohio - Alloy Plant

OPERATION: Ajax Furnace Operator

OPERATION OR OPERATING AREAS	TIME PER OPER. (MIN)	OPER. PER SHIFT	TIME PER SHIFT (MIN) (T)	NUMBER OF SAMPLES	CONCENTRATION µgBe/M <sup>3</sup>			CONC. TIMES TOTAL TIME (T X C)
					LOW	HIGH	AVE.	
GA Ajax Furnace Work Area	258	1	258	6	.13	.99	.46	118.7
GA Shoe Change Room	6	1	6				2.66	16.0
GA Locker Room	12	1	12				.17	2.0
GA Cafeteria	30	1	30				.15	4.0
GA General Plant	30	1	30				1.20	36.0
BZ Charge Furnace	32	2.25	72	1			.61	43.9
BZ Skim dross & rub	4	2.25	9	1			1.28	11.5
BZ Pour Furnace	36	2.25	81	2	.64	.69	.66	53.5

$$\frac{\Sigma(T \times C)}{\Sigma T} = 0.57 \text{ } \mu\text{g Be/M}^3 \quad \text{DWA} \quad 498 \quad \Sigma T \quad \Sigma (T \times C) = 286.1$$

TABLE III

## BRUSH WELLMAN COMPANY

Elmore, Ohio

June 11-16, 1972 &amp; August 21-25, 1972

Comparison between results of Personal and AEC Samples  
(All results in  $\mu\text{g Be}/\text{M}^3$ )

JOB	NO. OF SAMPLES	PERSONAL GROSS AVERAGE OF SAMPLES	RANGE	AEC METHOD AEC	NO. OF SAMPLES	PERSONAL RESPIRABLE AVERAGE OF SAMPLES	RANGE
Beryl Furnace	4	1.61	0.29-4.17	0.72	4	0.83	0.34-1.51
Ore Processing Operator	2	1.78	1.31-2.26	0.74	2	0.55	0.53-0.57
Thickner, Operator Hydroxide	0	----	---	1.60	1	0.13	---
GC Salt Operator	3	1.46	1.02-1.91	1.28	4	0.43	0.19-0.85
Oxide Furnace	3	7.58	4.02-11.7	0.88	3	3.52	1.12-8.03
Be Metal Wet Plant Sludge Operator	4	2.90	1.69-5.51	0.99	5	0.72	0.26-1.24
Evaporator Operator	1	1.18	---	2.42	2	0.49	0.39-0.59
Fluoride Operator	3	1.67	1.23-2.18	0.92	3	0.48	0.18-0.73
Reduction Furnace	3	2.16	1.74-2.65	1.37	3	0.99	0.78-1.32
Melt Crusher thru Pebble Inspection	4	1.59	0.52-2.75	10.2	3	1.05	0.13-2.87
Misc. Powder Handler	1	2.85	---	1.02	1	0.15	---
Vacuum Cast Operator	6	3.66	0.30-7.24	2.86	6	0.79	0.18-2.11
Chipping Lathe Operator	7	5.16	1.31-15.14	2.96	7	0.53	0.16-1.62
Scrap Reclamation*	6	9.50	1.70-33.2	1.11A	6	1.28	0.33-5.98
<i>Δ Average of individual DWA's in Scrap Reclamation</i>							
Attrition Mill Operator	9	5.88	1.22-19.03	1.45	11	0.81	0.21-1.11
Attrition Mill Lead Man	3	2.44	1.13-4.21	1.42	3	0.30	0.15-0.60
Compact Load* (Prep & Strip)	2	45.4	14.4 -76.4	2.25	2	5.64	3.45-7.83
Compact Load* (Powder Prep & Die Loading)	3	13.8	1.45-23.5	1.69	4	7.56	1.09-19.9
Sintering Furnace	8	1.60	0.73-5.65	1.39	9	0.62	0.15-5.58
Sintering Welding*	1	217.4	---	0.51	1	0.96	---
Sintering Machine Operator	15	1.67	0.18-2.64	0.51	17	0.25	0.15-0.53
Press Operator	4	2.69	0.48-8.26	0.58	4	0.30	0.16-0.69
Isopress Operator	2	4.45	2.81-7.10	0.41	2	0.33	0.16-0.51
Machining Operator (ceramics)	8	2.35	0.67-4.99	2.90	9	0.24	0.16-0.34
Kiln Operator	2	3.09	0.81-5.36	0.74	3	0.49	0.32-0.82
Control Laboratory	10	4.41	0.52-18.69	0.42	10	0.52	0.17-2.03
Machine Shop (maintenance)	43	1.51	0.16-6.8	0.20	41	0.23	0.10-0.57
Laundry Operator	1	0.87	---	1.04	1	0.29	---
Arc Furnace Charge Man	4	4.68	1.95-10.55	2.85	4	0.47	0.18-1.04
Arc Furnace Crew Chief	1	4.86	---	2.01	1	0.49	---
Arc Furnace Helper	3	8.07	1.28-19.9	2.03	3	0.59	0.32-0.93
Mixer	2	10.47	4.64-16.3	2.05	2	0.47	0.17-0.84
Ajax Furnace Operator	14	2.25	0.17-18.43	0.57	14	0.41	0.17-0.80
TOTAL		380.99		54.09		32.91	
AVERAGE		11.55 $\mu\text{g Be}/\text{M}^3$		1.64 $\mu\text{g Be}/\text{M}^3$		1.00 $\mu\text{g Be}/\text{M}^3$	

DWA = Daily Weighted Average

\* = Indicates Fresh Air Mask Worn

APPENDIX D

HEALTH & SAFETY

A. In-Plant Recommendations

- a. The average in-plant atmospheric beryllium concentration should not exceed 2 micrograms per cubic meter.

If the result of the daily weighted average concentration, computed on a quarterly basis, for any occupation exceeds  $2 \mu\text{M}^3$ , but is less than  $5 \mu\text{M}^3$ , the Contractor will submit plans for necessary corrections for Commission approval and provide all personnel exposed in this area with approved personal respiratory protective equipment. If the daily average concentration exceeds  $5 \mu\text{M}^3$ , the operation in question will be halted until the necessary improvements can be accomplished. A daily average concentration exceeding  $2 \mu\text{M}^3$  will not be permitted to exist for a period exceeding 60 days except with the specific approval of the Commission. This approval will be granted only in the event that satisfactory procedures for reducing the concentration to below  $2 \mu\text{M}^3$  have been accepted by the Commission.

- b. In the event that a single air sample shows a concentration in excess of  $25 \mu\text{M}^3$  within the operating area, but is less than  $100 \mu\text{M}^3$  (and this is to be confirmed within 10 days of the time at which such a sample was obtained) all exposed individuals will be provided with personal respiratory protection approved by the Commission and the Commission will be notified of steps which are being taken to eliminate the high concentration. If the concentration exceeds  $100 \mu\text{M}^3$  in a single sample (and this is to be confirmed within the above time limit) operations will be halted and the necessary corrections made to reduce the air-borne concentrations at this single point to below  $25 \mu\text{M}^3$ . In no case will concentrations above  $25 \mu\text{M}^3$  be permitted to exist for a period exceeding 60 days without the specific approval of the Commission. This approval will be granted only if steps have been undertaken which can be expected to provide a satisfactory reduction in air concentration.

B. Out-Plant Recommendations

In the neighborhood of the plant handling beryllium compounds, the average concentration at the breathing zone level should not exceed 0.01 microgram per cubic meter.

In the event that the maximum average neighborhood concentration at the ground during any calendar month, as determined on a monthly basis, exceeds 0.01 microgram per cubic meter, but does not exceed  $0.05 \mu\text{M}^3$ , the plant will be expected to inform the

B. Out-Plant Recommendations (con't.)

AEG of specific procedures which will be undertaken to reduce the air-borne concentration. In the event that the concentration exceeds  $0.05 \text{ } \mu\text{/M}^3$ , operations will be immediately halted and the necessary corrections made to reduce the average concentration to below  $0.01 \text{ } \mu\text{/M}^3$ . In any event, concentrations above  $0.01 \text{ } \mu\text{/M}^3$  will be permitted to exist for not more than a 60-day period unless specifically authorized by the Commission. Such authorization will be forthcoming only if steps are being taken which are expected to result in a satisfactory reduction in effluent material.

C. Medical Supervision

- a. There should be a medical program, supervised by a physician, to cover all workers exposed to beryllium and its compounds.
- b. If there is any evidence that an individual has chronic beryllium poisoning, such an individual should be excluded from any further exposure to beryllium compounds.

D. Sampling Requirements

In order to insure adequate sampling of breathing air concentrations, the following or equivalent procedures approved by the Commission should be followed:

- a. Each separate plant operation will be broken down into its primary components and the average time per day required for the accomplishment of each component and the number of times it is repeated will be determined. A minimum of 3 breathing zone samples will be taken to evaluate the exposure arising from each such job component in addition to an adequate sampling of the general air so that a complete overall exposure may be arrived at for each plant operator.

On the basis of these samples, a daily average exposure will be computed for each operation. The average will be weighted with time by multiplying the average concentration for each job component times the amount of time spent by the operator each day in accomplishing the component. The sum of all of these products divided by the total time per day will yield the time weighted average concentration.

A minimum of 4 such evaluations will be performed each year for each operator.

- b. Representatives of the Commission will be permitted to perform similar surveys at their discretion in order that procedures being followed by the Contractor may be evaluated.

D. Sampling Requirements (con't.)

- c. Determination of the average neighborhood concentration will be made by not less than 3 permanent monitoring stations utilizing air sampling equipment capable of handling an average air volume in excess of 1 M<sup>3</sup>/min. These monitoring stations will sample continuously. Other equivalent procedures may be approved by the Commission. Meteorological data will be obtained to insure that the samples obtained by the monitoring stations can be interpreted in terms of the direction of maximum ground level concentration.

All equipment and procedures employed in the determination of these concentrations must be approved by the Commission prior to operation

E. Approval of Construction Plans

Prior to construction, a flow diagram plus plans and specifications of hazard control procedures to be followed at each operation will be reviewed by the Commission for adequacy in meeting the very rigid standards necessary for the control of health hazards in beryllium processing. Approval, however, will be based on performance.

F. Reports

Submit such reports as the Contracting Officer may request.

