DATE: June 16, 1960

SUBJECT: Safety, Health Physics, and Operating Procedures for Chemical Technology Division Beryllium Facility

TO: F. L. Culler

FROM: K. S. Warren and L. M. Ferris

ABSTRACT

A summary of the safety precautions, operating techniques, and monitoring methods required for efficient use of the Chemical Technology Division beryllium facility is presented.

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1.0 INTRODUCTION

The Chemical Technology Division has installed a special laboratory in the basement of Bldg. 4501 which will be used to develop processing methods for reactor fuels containing beryllium and some of its compounds. This memo contains a description of the laboratory facilities, a discussion of beryllium toxicity, operating procedures for experimentation and waste disposal, monitoring of air and surfaces, general safety precautions and emergency procedures. This memo replaces a preliminary issue, ORNL-CF-59-9-89.

2.0 TOXICITY OF BERYLLIUM COMPOUNDS

Exposure to beryllium and its compounds gives rise to three maladies — dermatitis, pneumonitis, and chronic pneumonitis. Dermatitis of the skin develops from handling compounds such as beryllium sulfate and beryllium chloride. The introduction of these compounds into a cut or wound produces ulcerations which require excision for proper healing. A more serious, and frequently fatal class of beryllium poisoning derives from exposure of a worker to beryllium-containing dusts. The eyes and respiratory tract become seriously inflamed. Chest pains render breathing difficult, and cyanosis may result. The third class, and the most insidious, is known as chronic pneumonitis, a slowly progressive lung condition which may result in death. Apparently this disease resembles the miners' disease "silicosis" in some ways, being basically a granulomatous reaction, characteristic of a chronic allergic reaction. The gradual loss of oxygen exchange space in the lungs reduces the individual's ability to ward off infection. There are no good methods of treatment; the fatality rate approaches 35 percent.

Limits of exposure under three different conditions have been established based upon experience. The following data are taken from a memorandum written by Dr. G. F. Zanolli of the ORNL Health Division, as quoted from a notice sent to Mr. C. E. Center from Mr. S. R. Sepirie of the Atomic Energy Commission.

1949 Toxicity Limits for Beryllium Compounds

Be Conc.,

\[
\begin{align*}
\text{Be Conc.,} & \\
\mu g/m^3 \text{ of air} & \\
\text{Eight hour maximum working exposure, air-borne} & 2.0 \\
\text{Maximum momentary exposure, air-borne} & 25.0 \\
\text{Average monthly concentration in air near plant} & 0.01
\end{align*}
\]

These values have also been quoted by British authors who ascribed the Advisory Committee of the U. S. Atomic Energy Commission as the source.

Floors should not exceed 20 \( \mu g/ft^2 \) as measured by filter paper smears; and equipment which might be touched should not exceed 5 \( \mu g/ft^2 \).

*For a good summary of the toxic effects of beryllium, the reader is referred to the recent book by Darwin and Buddery.*
3.0 GENERAL DESCRIPTION OF THE BERYLLIUM LABORATORY

The beryllium facility is Room BG-73 in the basement of Building 4501; its main entrance connects directly with the large bay. The adjacent room on the north side of BG-73 is used by the Reactor Chemistry Division for high pressure work. The masonry walls between the two rooms are lined with 1/2 in. steel plate and 3/4 in. plywood for additional safety. The adjacent room to the south of BG-73 is used by the Chemical Technology Division and currently contains thorium- and plutonium-handling equipment. A door connects this area with the beryllium laboratory and will be employed only as an emergency exit from the beryllium laboratory in the event that the main entrance is accidently blocked. Both doors contain transparent windows to permit observation of personnel from without. Both doors are equipped with crash bars and will be locked at all times. Keys will be assigned only to personnel working in the room. One key will be retained in the Section office, Room B-8. Permission must be obtained for entry of unauthorized people to the room.

Fig. 1 shows the relative location of the laboratory furniture and the three hoods in which beryllium operations will be conducted. The air flow pattern for the room is as follows: Separate fans propel the fresh supply of air and the hood exhaust air, respectively. Fresh air enters directly from outside the building through special ductwork through opening "B". The air flows across the room and into the hoods through coarse filters located at the top of the hoods. The air flow through the filter ports is regulated so that a negative pressure of 0.5 in. of water will exist in the hoods at all times.

The air drawn from all three hoods in the beryllium laboratory mixes in a common duct, passes through fine and coarse fibre glass filters and exits out a special stack above the roof of the building. This duct does not join exhaust ductwork from other laboratories.

Engineering drawings for the entire facility are listed as follows:

D - 35658 Hood modifications
    35659 Service piping
    35660 Drains for Room BG-73
    35661 Hood alterations
    35662 Hood alterations
    35663 Ventilation supply
    35664 Exhaust system
    35665 Exhaust system
    35666 Fire damper
    35729 Site preparation
    36111 Power and lighting
    36297 Ladder and platform for ventilation system

Information on connecting drains in adjacent rooms are listed as follows:
Drains for high pressure laboratory before Room BG-73 was created
25825 Drains for dark room and x-ray room
25825 Drains in Unit Operations Laboratory, BG-74
25358 Sump Details for Unit Operations Laboratory, BG-74

The direction of flow and final disposition of the contents of these drains is outlined in a later section of this report ("Waste Disposal").

The location of 115 volt, single phase, A.C. power circuits in Room BG-73, and their corresponding circuit breaker locations are tabulated as follows: All circuit breakers listed are located in Panel "c", in the main hallway leading into the bay, basement, 4501 Building.

<table>
<thead>
<tr>
<th>Location of Circuit Controlled by Circuit Breaker</th>
<th>Breaker Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling fluorescent light fixture</td>
<td>3</td>
</tr>
<tr>
<td>Laboratory workbench - all three duplex outlets; all wall outlets on west wall</td>
<td>17</td>
</tr>
<tr>
<td>Hood # 1</td>
<td></td>
</tr>
<tr>
<td>Duplex outlets at left end only</td>
<td>32</td>
</tr>
<tr>
<td>Duplex outlets at right end; also hood lights</td>
<td>32+</td>
</tr>
<tr>
<td>Hood # 2</td>
<td></td>
</tr>
<tr>
<td>Duplex outlets at left end; also center</td>
<td>7</td>
</tr>
<tr>
<td>Duplex outlets at right end; also hood lights</td>
<td>11</td>
</tr>
<tr>
<td>Hood # 3</td>
<td></td>
</tr>
<tr>
<td>Duplex outlets at left end; also center</td>
<td>19</td>
</tr>
<tr>
<td>Duplex outlets at right end; also hood lights</td>
<td>21</td>
</tr>
</tbody>
</table>

Note: "32+" indicates the lower of a pair of circuit breakers, both of which are labelled "32".

3.1 Description of Hoods

The three chemical hoods which were originally of conventional design have been converted into modified glove boxes. Provision has been made for air to enter only through coarse filters at the top of each hood. Arm-length rubber gloves sealed at the ends to ports in the Lucite front panels will be used for all manipulations and assembly of apparatus. These facilities meet the Chemical Technology requirements for radiation and safety control.

Each hood is equipped with the following services, two outlets each:

- Compressed air
- Water, process
- Water, distilled
- Electricity, 115 v
- Electricity, 0-130 v variable
House vacuum (relatively high vacuum, low volume)
Off-gas (relatively low vacuum, high volume)
Drains (one cup sink leads to a hot process drain, and the other to a "contamination" bottle)

The natural gas outlets have been disconnected because of the explosion hazard.

4.0 RESPONSIBILITY

General responsibility for local cleanliness, good housekeeping procedures, and compliance with safety regulations shall be placed with K. S. Warren. Personnel working in the facility must comply with established safety regulations and maintain their areas in an acceptable condition. Suggested changes in established techniques and procedures will be referred to L. M. Ferris and R. E. Blanco for approval.

5.0 RECOMMENDED OPERATING TECHNIQUES

5.1 Contemplated Laboratory Operations

The present facilities are deemed adequate for most of the anticipated chemical operations, such as handling boiling aqueous systems, vapor phase chlorination, and molten fluoride work. No more than 50 g of contained beryllium (except in massive form) will be allowed in any hood. Operations involving potentially hazardous chemicals, e.g. low boiling organics and ClF₃, must be reviewed by the Safety Committee. Certain modifications will be introduced if more stringent conditions must be met. Grinding of beryllium samples if particle size reduction proves necessary, after review by the Safety Committee, will be performed with secondary containment, i.e. enclosure in a polyethylene bag. High-temperature gas-solid reactions will be designed so as to scrub out evolved mists, smokes and other suspensions. Protection of the metal ductwork from HF and other corrosive agents will be achieved through the use of alkali traps, etc.

5.2 Storage of Beryllium

Samples of beryllium oxide, beryllium salts, and prototype fuel elements containing beryllium and its alloys will be stored in polyethylene containers in a special locked cabinet in the beryllium laboratory. An inventory of such beryllium-containing materials will be maintained and posted. Removal of a sample from the storage cabinet to the hoods will be conducted in such a manner that the material will not be exposed. The transfer locks (Fig. 1) will normally be used to introduce samples into the hoods.

5.3 Waste Disposal

Liquid waste containing no beryllium will be disposed of by way of the process drains in Room BG-73, the details of which follow. One collared cup sink located in each of the three hoods, a sink in the center of the room,
Fig. 1. Schematic Diagram of Chemical Technology Division Beryllium Laboratory, Room BG-73, Building 4501.
and two floor drains all empty into the common 3 in. Duriron process drain (Dwg. D-36660). Upstream from Room BG-73, Reactor Chemistry personnel in BG-72 use this drain also, but the nature of their work in the high pressure cells produces very little liquid waste. Downstream, the same 3-in. drain serves Unit Operations personnel in Room BG-74, and the combined waste from Rooms BG-72, -73 and -74 finally empties into a concrete sump* (Dwg. W-25358) in one corner beneath the floor of Room BG-74 (Dw. 25828). The contents of the sump will automatically be pumped to the hot drain.

Waste beryllium and attendant uranium or thorium will be disposed of through a second collared cup sink located in the working area of the hoods. This waste will flow by gravity into a 6-1/2 gal polyethylene bottle for subsequent transfer to the tank farm. The collar on this sink is high enough so that in the case of a large spill in the hood the liquid will automatically go to the hot drain.

Contaminated glassware and other items such as torn gloves and analytical samples will be removed from the beryllium hoods through the entry port and immediately placed in polyethylene bags and deposited into labelled 2-gal or 5-gal fiber drums. Periodically, these containers will be sealed and deposited in the yellow Dempster Dumpsters located at the rear of the building. The waste will ultimately be buried along with other solid radioactive waste.

5.4 Transfer of Analytical Samples

Samples intended for analysis will be wrapped in polyethylene bags and shipped in a small wooden box to W. F. Vaughan, Building 9201-2, Y-12, where the analyses will be performed. Transportation will be handled by the Analytical Chemical Division. Questions of an administrative nature should be referred to J. C. White, Building 9733-4, phone 7242.

5.5 Cleaning and Maintenance of the Beryllium Laboratory and Accessory Equipment

(a) Floor: The floor covering is 3/16 in. asphalt tile (waxed). Sweeping with a dry broom will not be permissible; instead, dust will be removed from the floor with a wet mop in order to decrease the chance of air-borne contamination. Wet cloths will similarly be used to clean overhead pipes and other horizontal surfaces in the beryllium laboratory.

(b) Rubber Gloves: Routine replacement of the gloves used in the hood ports will be conducted in the manner approved for plutonium laboratories:

(1) Slip old glove to front part of glove ring but do not remove from ring.

(2) Turn new glove inside out and slip over old glove on the glove ring.

*As this report goes to press modifications in the drainage system are being made. Waste from the beryllium laboratory will be routed to a hot drain instead of going to the sump.
After new glove is firmly in place pull old glove off into the hood, making certain that the new glove does not slip off the glove ring.

Treat old glove as contaminated solid waste.

Monitor around edge of glove ring by surface smear testing and clean if necessary with cheese cloth soaked in Versene solution.

Light rubber gloves will be worn inside the regular box gloves.

Filter Replacement: Three types of filters are in use by the beryllium laboratory; their uses are outlined below.

Hood filter - Each hood interior is isolated from the atmosphere of the room except for two coarse filters ('Amerglas Airflow Model D-2, 10" x 20" x 2", Stores Catalogue No. 07-644-7422) through which air is drawn from the room into the hood. Any abnormally large release of gas within the hoods should expel very little dust into the room because of the presence of these filters.

Duct-filter - Both the intake air duct and the exhaust air duct are equipped with coarse filters; the exhaust air also passes through fine "absolute" filtering medium. The coarse filter unit is 20" x 25" x 2" ('Fiberglas Dustop, Stores Catalogue No. 263-9025), as is also the fine filter unit (Cambridge Filter Corporation, CWS Absolute, Protexol treated, Stores Catalogue No. 263-9128). The filtered air is sent up the exhaust duct into the outside air. A liquid U-tube manometer indicates the pressure drop in inches of water across the filter bank of three coarse and three fine units in the exhaust duct. This pressure drop was 0.4-0.5 in. in January 1960, when the filter system was newly installed. Visual check of this manometer (located on the first floor, bay area, behind the stairway to the third floor) shall be conducted bivewekly and plotted on coordinate graph paper. This graph shall be a guide in ordering replacement of the filter units.

Filter replacement is regularly undertaken by a crew of men under the direction and supervision of Sam Prince (6255). The following is an outline of the steps to be taken in routine replacement of contaminated filters in the exhaust duct (first floor level).

Face masks, gloves, coveralls, and plastic shoe covers which extend above the ankle are worn. Blotting paper is placed on the floor (a steel grating in this case). With the supply and exhaust fans still running, the face plates on the filter bank are removed. A Health Physics Division representative checks for possible activity in and around the filter units before the crew continues their operation. The old filters are placed in cardboard cartons. The new filter units are inserted in place. The cartons containing the old filters are bagged in polyethylene, sealed with tape, and transported to a yellow Dempster Dumpster for burial.

Gloves, shoe covers, and coveralls are removed at the site of the completed operation; the men then proceed to the change room and take a shower. Smear samples are taken for analytical detection of beryllium at the site after removal of the blotting paper.
6.0 INDUSTRIAL HYGIENE AND SAFETY PRACTICES

6.1 Special Clothing

Building 4501 is a Health Physics "Regulated Area," i.e., "Contamination clothing" may be worn anywhere in the building. Room BG-73 in Building 4501 will not be designated as a "Contamination Zone," however, since air and surface contamination inside the room is expected to remain well below the α- and β, γ-limits established by the Health Physics Division.

Workers in this room will normally wear the standard khaki clothing issued by Company Stores. For short periods of exposure, a laboratory coat worn over street clothes will be considered acceptable. Clothing worn in the beryllium laboratory will be dampened with water and pre-sorted into nylon net bags which will be sent to the laundry in plastic bags properly labelled as to beryllium hazard.

Clothing known to be contaminated with beryllium or its compounds will be discarded because it is not possible, without destructive testing, to determine if such clothing is completely decontaminated. Yellow shoes or plastic shoe covers will be worn in BG-73 and must be removed upon leaving the room.

6.2 Routine Monitoring of Beryllium Contamination In and Around Room BG-73

Air Sampler Heads (Y-12 Stores Catalogue No. 06-670-1700) are positioned close to the faces of the beryllium hoods. These heads contain 3.3 cm dia Whatman # 42 filter paper, through which ambient air is drawn at a rate of at least 1 cubic meter/day as measured on a Fischer and Porter (model 10A3135) manometer, Y-12 stores Catalogue No. 06-030-0400).

The paper discs are replaced daily. The old disc is folded, numbered in code, placed in a glassine envelope and sent to Y-12 in an outer envelope by plant mail for analysis. Surface smear samples are also taken weekly on filter paper at selected locations in the laboratory, near the ducts and on the roof near the exhaust outlet. These samples are folded, numbered, and placed in envelopes for similar transmittal to Y-12.

"Air" samples and "smear" samples are kept separate, and each group is accompanied by a "request for analysis" Form C-1042, in triplicate. Samples and requests are addressed to Virginia Hill, Building 9995, Y-12, and the copies of all analytical reports shall be kept on file in Room BG-73.

6.3 Hood Exhaust Monitors

For quick, visible checking of the relative pressure within the hoods, each hood is equipped with a Magnehelic Gauge (F. W. Dwyer Mfg. Co., range 0 - 2" of water). For optimum glove manipulation, the maintenance of a vacuum of about 0.5 in. of water is recommended.
The electrical circuit for continuously monitoring hood exhaust conditions is sketched in Fig. 2. Two pneumatic switches (Bryant Industrial Prod. Corp. # PS-R) have been placed in parallel in the exhaust duct between the hoods and the filters and are adjusted to remain open at a pressure of about 1 in. of water below the average atmospheric pressure. Any of the following conditions will result in an increase of the air pressure in the vicinity of the pneumatic switches, closing the "normally-open" contacts:

1. Power failure at the terminals of the fan motor,
2. Fan belt breakage, or other mechanical difficulties which would cause the fan to stop,
3. Accumulation of dirt in the filters themselves, blocking movement of air through them, or
4. Damage to the duct between the filter and the fan, or between the filter creating a leak of ambient air into the duct.

If any of the above conditions prevail, three warning lights will immediately burn and two buzzers will sound.

The location of the alarms are as follows:

Inside the beryllium laboratory (BG-73) one red light, one buzzer.
On wall outside the beryllium laboratory, and located on a sign (see later) - one red light.
In the Unit Operations Laboratory (BG-76) - one red light, one buzzer.

These warnings are designed to persist until reset even if normal pressure conditions are automatically restored in the beryllium laboratory and its air flow system.

The alarm system will be tested periodically.

Two push buttons are located in the beryllium laboratory:

(a) "Test" Button "A" for simulating closure of vacuum switches, without disturbing exhaust fan operation and air flow patterns.
(b) "Reset Button "A" for manually resetting relay and turning off the visible and audible alarms.

This system can also be used for local alarm in the event of an accident or emergency situation not involving the exhaust fan operation.

On the wall outside the beryllium laboratory, located just to the right of the main entrance, is the following sign:
Fig. 2. Alarm Circuit for Monitoring Pressure Changes in Hood Exhaust System, Beryllium Laboratory, Building 4501.

(Based on Dwg. Q-2101-1 RO)
and a red light bulb mounted in a socket in the center above the door.

On the inner wall of the Unit Operations Laboratory, Room BG-74, is a sign, with another red light mounted on it, reading

| TROUBLE IN THE |
| BERYLLIUM LAB |

The monitor system will be tested weekly for proper functioning, by means of Push Button "Test".

6.4 Failure of Exhaust Fan

In the event that the exhaust fan motor drops out of service, the motor which drives the air supply fan is wired so as to stop automatically. The reverse type of operation is not true, however. The purpose of this arrangement is to avoid air movement from Room BG-73 toward adjoining rooms in the basement.

If a hood exhaust abnormality develops, as evidenced by alarms described in Sect. 6.3, workers shall immediately leave the room. Before re-entering personnel shall put on the following equipment:

(a) a protective mask - Model M9AI Field Mask - fitted with an M-11 canister. Three such units are located in a closed cupboard just outside the room.
(b) coveralls marked "Contamination." These are available in the men's change room in Building 4501.
(c) shoe covers
(d) cap
The first acts after reactivating the exhaust fan shall be to reset the alarm, and then to take air filter and smear samples. Reports from the Spectrographic Laboratory in Y-12 (Building 9995) can be obtained on such samples in one day. During the interim of waiting for such reports, operations will be suspended.

"Contamination" clothing used during such an incident will be placed in a plastic bag and transported to the X-10 laundry, making certain that adequate instructions for special handling are communicated to the Laundry Foreman. These garments will be washed in the same manner as plutonium-contaminated or other γ-contaminated garments are cleaned.

7.0 REFERENCES


DISTRIBUTION

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8. W. H. Dykes
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