ORAU TEAM
Dose Reconstruction
Project for NIOSH

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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
12/22/2004	00-A	New Technical Basis Document: Basis for the Development of an Exposure Matrix for Chapman Valve Manufacturing, Orchard, Massachusetts. Initiated by Patricia L. Lee.
12/28/2004	00-B	Incorporates internal review comments. Initiated by Patricia L. Lee.
02/06/2005	00-C	Incorporates OCAS comments. Also addresses new information. Extends assumes operational period from 12/31/1948 to 4/30/1949, which impacts the assigned intakes, and the 1949 external doses. Modified external dose table slightly. Notes the possibility of radiological work for Oak Ridge prior to 1948. Initiated by Patricia L. Lee.
02/11/2005	00-D	Added reference for 1952 newspaper article. Modified wording regarding assumed intake dates and penetrating radiation energy assumption. Initiated by Cindy W. Bloom.
02/22/2005	00	First approved issue. Initiated by Patricia L. Lee
10/16/2006	01	Approved Revision 01. Replaced boilerplate language in Section 1.0. Added information from February 2005 Worker Outreach meeting. Added additional claim-supplied information. Added discussion supporting assumption of unenriched uranium. Added information regarding the use of a furnace/incinerator and provided a comparison of internal exposures to NUMEC incinerator operators with derived Chapman Valve exposures. Added information on the radiological safety program from a 1952 newspaper account. Added information regarding the month of the previously reported 1948 fire. Provided information developed for SEC petition evaluation report. Reanalyzed intake regimes as directed by OCAS using the largest of the 40 results not associated with the fire, 0.03 mg/L, for each sampling period to calculate a non-fire intake rate, and using the largest result associated with the fire, 0.08 mg/L, for the June 11, 1948 result, and keeping the other results the same as for the non-fire scenario to calculate the fire-associated intake scenario. Both intake scenarios are directed to be constant distributions in IREP. Added a comparison of Chapman derived air concentrations with air concentrations measured at other facilities. Added figures showing location of chip burner and dust, debris and soil sampling. Corrected two residual radioactivity external exposure values (increased rates by a factor of 2). Incorporated formal internal review comments, NIOSH and DOL comments. This revision results in an increase in assigned dose and a PER is required. Training required: As determined by the Task Manager. Initiated by Cindy W. Bloom.

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
AWE	atomic weapons employer
cm	centimeter
d	day
dpm	disintegrations per minute
DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ft	foot
FUSRAP	Formerly Utilized Sites Remedial Action Program
GM	Geiger-Mueller
GSD	geometric standard deviation
HASL	Health and Safety Laboratory
hr	hour
ICRP	International Commission on Radiological Protection
in.	inch
IREP	Interactive RadioEpidemiological Program
keV	kiloelectron-volt, 1,000 electron-volts
L	liter
m	meter
MDA	minimum detectable activity
mg	milligram
mR	milliroentgen
mrad	millirad
mrem	millirem
NYDO	New York Department of Operations
NYOO	New York Operations Office
pCi	picocurie
R	roentgen
SF	source and fissionable
U.S.C.	United States Code
μg	microgram
μR	microroentgen
§	section or sections

1.0 PURPOSE AND SCOPE

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions for particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" (AWE facility) or a "Department of Energy facility" (DOE facility) as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA, as amended, provides for employees who worked at an AWE facility during the contract period and/or during the residual contamination period.

Employment at an AWE facility is categorized as either (1) during the contract period (i.e., when the AWE was processing or producing material that emitted radiation and was used in the production of an atomic weapon), or (2) during the residual contamination period (i.e., periods during which NIOSH has determined there is the potential for significant residual contamination outside of the period in which weapons-related production occurred). For contract period employment, all occupationally derived radiation exposures at the facility must be included in dose reconstructions. NIOSH does not consider the following exposures to be occupationally derived:

- radiation from naturally occurring radon present in conventional structures
- radiation from diagnostic X-rays received in the treatment of work-related injuries

For residual contamination period employment, only the radiation exposures defined in 42 U.S.C. § 7384n(c)(4) (i.e., radiation doses received from DOE/AEC-related work) must be included in dose reconstructions. Radiation dose received from DOE/AEC-related work includes: (1) radiation from radon consistent with NIOSH's policies for including such radiation in the contract period; and (2) medical screening X-rays, but not diagnostic X-rays for the treatment of work-related injuries. It should be noted that: (1) under subparagraph A of 42 U.S.C. § 7384n(c)(4), radiation associated with the Naval Nuclear Propulsion Program is specifically excluded from the employee's radiation dose; and, (2) under subparagraph B of this section, radiation from a source not covered by subparagraph A that cannot be reliably distinguished from radiation that is covered by subparagraph A is considered part of the employee's radiation dose. This site profile covers only exposures resulting from nuclear weapons-related work. Exposures resulting from non-weapons-related work, if applicable, will be covered elsewhere.

This site profile provides an exposure matrix for workers at the facility listed as Chapman Valve Manufacturing Company in Indian Orchard, Massachusetts. Chapman Valve was a manufacturer of nonradioactive valves and manifolds, some of which were purchased by the Federal government. In 1948, Chapman Valve machined uranium rods for Brookhaven National Laboratory. In 1959, Chapman Valve was purchased by the Crane Company.

Section 2.0 of this document describes the Chapman Valve site and its history including some information about the radiological processes and source terms as well as the radiological controls and monitoring practices. Sections 3.0 and 4.0 discuss internal and external dose, respectively. Section 5.0 provides information for use in reconstructing dose during the residual period.

2.0 SITE DESCRIPTION AND OPERATIONAL HISTORY

The information that follows supports an assumed period of AEC operations at Chapman Valve from January 1, 1948, through April 30, 1949, involving AEC-contracted uranium work. This analysis assumed that the residual contamination period extended from May 1, 1949, through December 31, 1993. Exposures during the decontamination period in 1994 and 1995 are not addressed.

A 1952 newspaper article (*Springfield Union News* ca. 1952) stated that a small group of Chapman Valve employees might have been involved in work with radioactive materials for Oak Ridge prior to1948. At this time, no data have been found to substantiate or refute this statement. Additional information is being sought, and the site profile will be updated if necessary to address an earlier exposure period. Many reports indicate that Chapman Valve was involved in the manufacture of nonradioactive equipment and parts for the Manhattan Engineer District.

The Chapman Valve radiological source term consisted primarily of natural uranium metal, uranium oxides, and natural uranium's short-lived progeny. Long-lived progeny in the uranium series prevent significant ingrowth past ^{234}U in the ^{238}U decay series and beyond ^{231}Th in the ^{235}U decay series.

2.1 SITE DESCRIPTION

The Chapman Valve main office and works were located on Hampshire Street in Indian Orchard, Massachusetts. Uranium shipments were made to Oak Street and claims refer to uranium operations in the building on Pine Vale Street, which this document assumes to be Building 23. Figure 2-1 shows the location of Building 23 on the site.

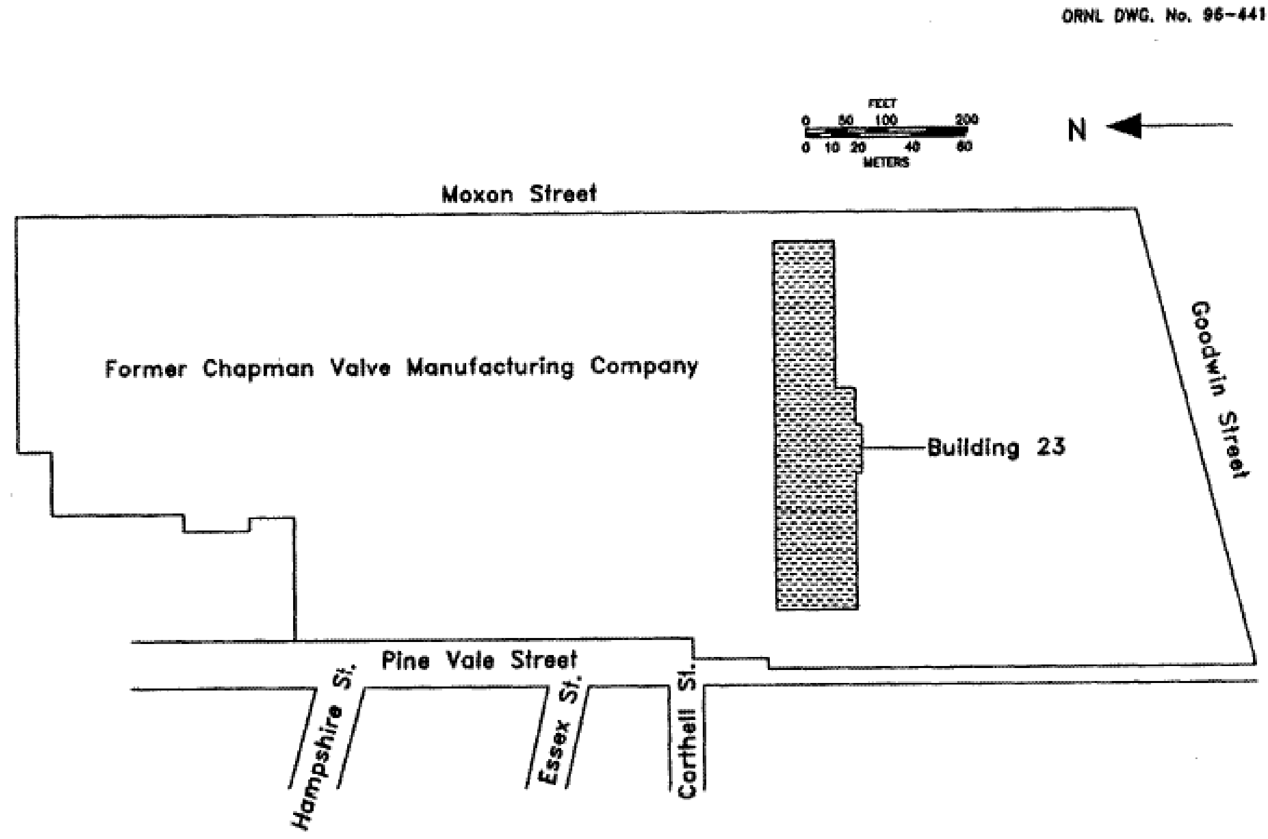

Fig. 1. Location of Building 23 at the site of the former Chapman Valve Manufacturing Company, Indian Orchard, Massachusetts.

Figure 2-1. Chapman Valve Manufacturing Company (ORNL 1997).

A former employee recalls that in 1947 Chapman Valve set aside approximately one-third of Department No. 40 at the Chapman Valve site for the machining of uranium rods for Brookhaven National Laboratory (Fiore 1987, Attachment). It is not clear that the Department No. 40 designation would be an indicator of whether or not someone worked in the restricted area of Building 23. The “set aside” portion of the building measured approximately 200 ft long by 60 ft wide and greater than 50 ft high. The area was separated from the remainder of the building by a floor-to-ceiling wooden partition, which has since been removed. Although there is no definitive statement regarding where the restricted area was in the building, based on later radiological surveys, it is likely that it was located in the western portion of the building. The building that contained the uranium operations has been vacant since Crane discontinued all manufacturing at Indian Orchard early in 1987.

2.2 SOURCE TERM AND PROCESS DESCRIPTION

Under contract with Brookhaven National Laboratory, Chapman Valve machined uranium metal during the period January to November 1948 (Young 1987). Preparation for this effort may have begun in November 1947 with the initiation of health and safety programs (Wolf 1947). An inventory report indicated that Chapman Valve had less than 50 pounds of uranium as of January 1948 (Morgan 1948). Actual production may not have started until May 1948, but a set of contamination measurements from March 19, 1948, indicates start-up activities may have occurred prior to May 1948 (LeVine 1948). Records indicate that machining operations ceased in November 1948, and it was assumed that all identified uranium materials and scrap were sent off site before January 1, 1949 (Fiore 1987).

The AEC Medical Director from the New York office (Wolf 1947) stated: "On November 24 [1947], a conference was held with Chapman Valve and Ferguson personnel as a result of which a complete set of health and safety recommendations were made a few days later in writing. Chapman is planning to undertake work involving the machining of uranium."

Twenty-six tons of uranium rods were sent on January 9, 1948, to the Chapman Valve Oak Street facility (Fiore 1987). There is a single report (LeVine 1948) of three radioactive dust samples dated March 19, 1948, but production-scale (versus trial run) machining may not have started until May 1948, as indicated in an attachment to the Fiore (1987) letter. In January 1948, Wolf (1948a) begins the notation regarding Chapman Valve with the words "A survey of proposed uranium machining operation" indicating that the facility was not machining large quantities of uranium. In May 1948, Wolf (1948b) stated "Health and safety preparations at the Chapman Valve plant in Indian Orchard, Mass. for the proposed machining operation were investigated by the Radiation Survey and Safety Sections," indicating the facility had not begun machining as of May 6, 1948.

An inventory form (Morgan 1948, 1949) indicated that the beginning inventory in January 1948 was about 48 [pounds] of "SF Material" (source and fissionable material, assumed to be uranium). From January to July 1948, documentation indicated that about 141,200 pounds of SF material were received and about 42,600 pounds in the form of slugs and turnings were shipped off site. Because that same inventory form was attached to Morgan's (1949) letter, it was unclear if another shipment of SF was made. Uranium rods were brought to the facility by railroad on a track immediately adjacent to the building. Rods were cut by mechanical saw and then machined to the desired shape.

Records regarding the Chapman Valve AEC machining work indicate the uranium was of normal enrichment (normal enrichment is about 0.72% U-235 weight). Chapman Valve uranium processing was related to reactor needs, and the use of enriched uranium in reactors was rare until 1950. The Chapman Valve contract with Brookhaven National Laboratory was to machine uranium for reactor pile, which was likely the Brookhaven Graphite Research Reactor. This breeder reactor first went critical in 1950 and was initially loaded with natural uranium (BNL 2006).

Chapman Valve participants in the February 2005 Worker Outreach Program meeting noted a contamination result of 2.16% enriched uranium was reported in later years (ORAUT 2005a). A review of the ORNL (1992) document that reported this result shows that two dust and debris samples, M10 and M31, were analyzed isotopically (see Attachment A, Figure A-2, for locations). Reported U-238 results were respectively 25 ±7 and 120 ±10 pCi/g of dust and debris (2-sigma counting errors). Sample M31, which was collected to the north of a west door of Building 23 (see Figures in Attachment A) was reported as enriched to 2.16% U-235 by weight. The report did not include U-235 results or mention the uncertainty associated with the enrichment determination. A second report (ORNL 1997) included seven radioisotopic measurements of soil at Chapman Valve (see Figure A-3 for locations) and attributed the measured results to background levels. Soil sample VS1 from the 1997 survey was collected just north of the location where a chip burner was shown on a 1996 map and perhaps slightly south of the area where M31 had previously been collected. The results were 14 ±1 pCi/g U-238 and 1 ±0.07 pCi/g U-235, which are consistent with unenriched uranium.

A number of factors, in addition to counting techniques, add to the uncertainty of isotopic measurements, and it appears that the uncertainties reported in ORNL (1992, 1997) only include consideration of counting errors. In addition, if gamma spectrometry were used to analyze the dust and debris sample, and if the 186-keV photons [the most abundant photons for both U-235 and Ra-226 (ORNL 2003)] were used to quantify both U-235 and Ra-226, there is a possibility that some Ra-226 was inadvertently reported as U-235.

Given that there are no other data to indicate that the uranium processed at Chapman Valve was enriched, and that enriched uranium was not typically sent to non-government-controlled sites without extra precautions, it is concluded that this single 1992 sample result is not evidence of enriched uranium work at Chapman Valve in 1948.

Crane Company (Young 1987, Enclosure 1) noted, "One AEC memorandum, William to Kelly, date illegible, indicates that Chapman Valve may also have conducted rolling operations on uranium metal." A review of available references (the William memorandum was not available) and claimant-provided information does not indicate that Chapman Valve ever rolled uranium rods. An October 1948 New York Directed Operations report (AEC 1948a) does not include Chapman Valve in the mentioned uranium rolling sites.

In July 1992, ORNL (1992) states:

> *After contract work was completed, Chapman Valve had in their possession over 27,000 pounds of metal scrap, oxides, and sweepings. Termination of these operations is indicated in a Chapman Valve letter dated November 8, 1948, which requested termination of AEC film badge services. All radioactive residues and contaminated materials were surveyed by Brookhaven Medical Group and shipped off-site. The actual shipment date is unknown, but the shipment probably took place in December 1948.*

This offsite shipment date appears to be based on a Crane Company letter, which noted that there was correspondence that indicated that all radioactive residues and contaminated material were shipped off site in December 1948. Another note indicates that the 27,000 pounds of metal scrap, oxides, sweepings, etc. were shipped off site several months after the contract was complete. Morgan (1949) is unclear regarding whether another shipment of SF material would be made after January 25, 1949. ORNL (1992) and an enclosure to Fiore (1987) state that Chapman Valve had in its possession over 27,000 pounds of metal scrap, oxides, sweeping, etc., for several months beyond completion of the contract. Both documents refer to a Chapman Valve letter dated November 8, 1948, that requested termination of AEC film badge services and indicated that all radioactive residues were surveyed by the Brookhaven Medical Group and shipped off site in December 1948. An Electro Metallurgical (1949) weekly production report for April 1 to 30, 1949, mentioned about 28,000 pounds of metal received from Chapman Valve, which indicated that the final shipment would have been no later than April 30, 1949.

It was noted that 100 film badges were needed for the film badge program (Musgrave 1948). The film badge records show that workers were employed by Chapman Valve, H. K. Ferguson, or Brookhaven National Laboratories. The records indicate that at least for one week in May, two shifts may have been involved in the AEC work (AEC 1948b). The available bioassay records include 37 names. Job categories noted in the records included supervisory personnel (electrician, heat treater, steamfitting and plumbing, machine shop and maintenance, inspector, guard, personnel), engineer, guards, inspectors, trades (electrician, machine repair, master mechanic, milling machine operator, steamfitter and turret lathe operator), helpers (janitor, weigher, not specified), and several assistants to the director of research. The external dose data sheets also list jobs such as brushing and packer. A quick review of claim information indicates that job titles listed in the claims might not always be consistent with the job titles held in 1948.

Area access controls were in place at Chapman Valve, but these controls are not clearly associated with job categories. Rather, they were an issue of both security and contamination control. A May 26, 1948, handwritten, two-page, "Plant Protection" list might indicate the number of hours in a week that workers were in the AEC work area (AEC 1948b, pp. 155–157). The reported number of hours ranged from zero to 58; the majority of entries were less than 40 hours. Eleven entries were greater than 40 hours. Similar lists including dates from May 3, 1948, through the week of May 19, indicate that these lists show the number of times and the number of hours a [film] badge was worn.

This document assumes that workers might have been exposed to uranium for up to 8 hours per day, 250 days per year, although it appears likely that uranium work was not in full swing until May 1948 and was essentially over in November 1948.

2.2.1 Incinerator Information

A furnace was used during the 1948 AEC operations, probably for oxidizing uranium turnings and scraps to reduce the risk for uranium fires during storage and shipping. The Chapman Valve Final Remedial Action Report (Robbins 1996) and the February 14, 2005, Chapman Valve Worker Outreach Program meeting discussion included the terms *chip incinerator*, *chip burner*, and *cracking furnace* (ORAUT 2005a). On the map (Author unknown ca. 1996) provided at the meeting and shown in Figure A-1, a location for a chip burner is marked in the west side of Building 23 in an area consistent with the AEC restricted area. At what appears to be a similar location (see Figure A-2), ORNL (1992) reported elevated contamination near a window. Robbins (1996) reported contamination was found in the area "where a chip burner was located in the southwest corner of Grid A-1 [of Building 23] that exhausted to the atmosphere out a nearby window. The exhaust location and the shape of the roof of the building would lead to the deposition of more contamination on the south roof than the north roof as indicated by characterization measurements." On May 4, 1948, the AEC (1948c) made air concentration measurements at the furnace outlet on the roof and on the roof 4 feet from the outlet.

2.3 SAFETY

An affidavit from a former Chapman Valve employee describes some of the radiological safety controls (Redacted 1987, Attachment 1). Workers would remove their clothes and don white coveralls prior to entering the uranium manufacturing area. Workers wore dosimeters on their uniforms. Inspectors would pass through the site carrying Geiger counters. At the completion of a day's work, the employees would return to the dressing room and remove their white coveralls. Each employee was then required to take a shower as a safety measure. The floors were swept every night. Cuttings from the machining process were stored in drums and disposed of periodically by Brookhaven. A later description of activities by this former tinshop employee (Claim File redacted, DOL Initial Case_redacted.pdf, p. 31-32), noted that he "entered the work area to perform jobs… which consisted of taking measurements of splash guards, chip deflectors, suction systems, holding pans or [taking measurements of] anything else required. We then returned to our shop, performed our layouts and fabricate[d] these articles (some took a week) returned ASAP to install in place. Periodically we had to clean the main suction system, which we had installed, as it was highly susceptible to catching fire, it did on occasion (it's a matter of record). [My assistant] and I were never required (to my knowlede [sic]) to put on a uniform, probably because of the short time spent on site. The long jobs wer [sic} done on weekends when the operation was down."

A 1952 newspaper article (*Springfield Union News* ca. 1952) included the following description of the radiation protection program:

> *Workers in this location were fully protected by means of special clothing and entered the workshop only through a labyrinth entrance into a specially constructed room where they changed their street clothes for the special uniforms. Each worker was equipped with a badge which he wore on his chest at all times while at work. These badges contained a sensitive film, which was frequently developed to reveal if the worker had received any dangerous radiation and also the degree of absorption. Geiger-Muller and other sensitive instruments kept a close check on the safety of workers in areas where radiation was most likely to occur. Many of the key personnel, who were in and out, carried a fountain-pen-like instrument known as a minometer [type of personal direct reading dosimeter], which was checked daily as an infallible safety precaution.*

Eisenbud (1948) indicated that employees could use the lunchroom for snacks or smoking provided the hands and face were thoroughly washed and clean laboratory coats and shoe covers were worn over protective clothing. His requirement that the lunchroom be surveyed and decontaminated, if contamination was detected, implies the expectation that these procedures might not eliminate the spread of contamination to the lunchroom and the locker room. Records of surface contamination surveys in these areas have not been located. Uranium air concentration measurements indicate elevated activity in the lunch and wash rooms.

2.3.1 Air Concentrations

During World War II, permissible levels for uranium dust in air were set at 500 μg/m^3 for insoluble uranium compounds and 150 μg/m^3 for soluble uranium compounds. After the war, the University of Rochester lowered its recommendation for soluble uranium compounds to 50 μg/m^3 based on the chemical toxicity, which for natural uranium is equivalent to 70 dpm/m^3. This level was based primarily on animal studies. The Medical Division of the AEC New York Operations Office (NYOO) felt that a maximum permissible level was unknown and should be based on human data. Therefore, the 50 μg/m^3 level was referred to as the *preferred level* (AEC 1949).

Very few records of uranium air concentration measurements taken during AEC operations were found for Chapman Valve. Results included data sets from May 4, 1948, and May 24, 1948 (AEC 1948c, d).

2.3.2 Contamination/Radiation

Available documentation of radioactive contamination during the operational period was limited to three wipe samples from March 19, 1948, one of which could not be evaluated. The results were 8 counts per minute for the cracking furnace and 300 counts per minute for the "centerless grinder." No measurements of radiation levels for the AEC uranium operational period were located.

2.4 INCIDENTS

Chapman Valve (Fox (1949) notes, "A fire occurred in the restricted area of the AEC project and on June 11th [1948] urine for analyses… was sent to the School of Medicine and Dentistry of Rochester New York." Collection of urine samples from the workers who put out the fire and from cleanup personnel suggests that the uranium was involved in the fire. The exact date of the 1948 fire has not been found, although AEC's transmittal note (Wolf 1949) regarding urinalysis results for samples "collected from the seven employees involved in the fire fighting episode last June [1948]" is evidence that the firefighting occurred in June. This appears to be the fire referred to in claim redacted. No documentation was found on the exact date of the fire.

A claimant provided a description of an explosion:

> *There was a significant event at Chapman Valve sometime during those two years [1948-1949]. It appears that a cupola blew up on the first shift destroying a large portion of the plant with the result being that one worker was killed and several were seriously injured. The plant was closed for some time after this incident. The resultant fire consumed three floors of one section of the building.*

No evidence could be found to support a major fire during AEC uranium operations at Chapman Valve, except as noted for June 1948. However, a newspaper search revealed that an explosion took place when power to an oil transformer was engaged in the early 1940s. Seven workers were injured, and a small brick building that housed the electrical equipment collapsed. The newspaper (*Springfield Union News* ca. 1942) reported 17 hours of lost production time and that:

> *pouring operations in the iron and steel foundries which turn out giant valves for the navy* [sic] *continued without interruption throughout the night, Duggan said, so that a backlog of work would be on hand for the resumption of finishing operation in the machine shop.*

The Chapman Valve Special Exposure Cohort petition stated that documentation at other facilities shows that uranium fires are prevalent in uranium milling/lathing operations due to the fact that uranium is a pyrophoric material (ORAUT 2006). Although fires were not rare at uranium metal processing sites in the early days of Manhattan Engineer District and AEC operations, more rigorous controls were being employed to prevent fires, as seems to be the case at Chapman Valve after the June fire. One claimant noted his job was to clean the suction system to reduce the possibility for fires (Claim File redacted, DOL Initial Case_redacted.pdf, p. 31-32). No other claims were found that mentioned fire. A comment from the February 14, 2005 Worker Outreach Program meeting (ORAUT 2005a) noted, “If they were machining uranium on the lathe, there would have been heat and fire.” Based on general knowledge of uranium metal operations during this early period, it is conceivable that one or more additional small fires occurred. Such fires if they occurred were probably controlled by the local workforce.

2.5 PHYSICAL EXAMINATIONS – X-RAYS

No information regarding AEC-required physical examinations for Chapman Valve employees has been located.

2.6 SUMMARY OPERATIONAL PERIOD ASSUMPTIONS, WORKDAYS, WORK HOURS, AND WORK CATEGORIES

Because bioassay data and film badge data were used to estimate internal and external exposures during the AEC uranium operations, an estimate of workdays or work-hours per year is not important.

For later years, it was assumed that workers worked 8 hours per day for 50 weeks per year, for a total of 2000 hours per year.

While different tasks resulted in differences in exposures, it is evident from the records that workers did not always perform the same tasks. Exposure assignments are based on data that are suggestive of workers’ exposures and further modified by uncertainty parameters, when appropriate, to ensure that the reconstructed dose distributions capture the larger exposures. No attempt has been made to sort workers into exposure categories. Depending on the organ of interest and the ancillary data associated with a specific claim, additional considerations might be appropriate.

2.7 CLEANUP/RESIDUAL CONTAMINATION PERIOD

A former tinshop employee (Claim File redacted, DOL Initial Case_redacted.pdf, p. 31-32) recalled disassembling all sheet metal fabrications at the end of operations and removing them to another area for disposal. He also stated that he helped with “washing down the wall and the entire Dept., including removal of the floor bricks, (contrary to some who said they were never removed) removing 6” of concrete flooring with re-enforced wiring and hauling away for proper disposal.” He further noted that the Carpenter shop installed new concrete and flooring in the area, and that he worked in Welding and Fabrication, which was in that same area from 1966 to January 1, 1983.

Crane discontinued plant operations in June 1986 and was in the process of closing down the plant for sale as of August 1987 (Young 1987). ORNL (1992, 1997) stated, “The building that contained the uranium operations has been vacant since Crane discontinued all manufacturing at Indian Orchard in 1987.” However, information in the claim files (redacted) indicates that the building was not closed until February 22, 1991, or later. This document assumes that residual exposures occurred from May 1, 1949 through December 31, 1993. Site decontamination took place in 1994 and 1995. This period of exposure is not addressed in this document.

No documentation has been found to indicate the radiological condition of the site when operations ceased and little information is available to describing cleanup activities for this period. Redacted (1987) indicates that records that might have contained information related to radiological conditions were destroyed during the 1970s. However, elevated levels of contamination were found in surveys performed in the early 1990s (ORNL 1992) under the Formerly Utilized Sites Remedial Action Program (FUSRAP). This period is discussed further in Section 5.0.

3.0 ESTIMATION OF INTERNAL EXPOSURE

The primary source of internal radiation exposure at Chapman Valve was uranium dust produced from the manipulation and oxidation of the metals during machining and related processes. It is assumed that the uranium was of natural enrichment. Recycled uranium did not enter process streams until 1952, so no recycled uranium would have been processed at Chapman Valve.

3.1 URANIUM

Human and animal studies have indicated that oxides of uranium can be very insoluble (ICRP 1995), indicating absorption type S (0.1% and 99.9% with clearance half-times on the order of 10 minutes and 7000 days, respectively). Other *in vitro* dissolution studies of compounds found at uranium facilities have shown that oxides of uranium exhibit moderate solubility (Eidson 1994; Heffernan et al. 2001) suggesting absorption type M (10% and 90% with clearance half-times on the order of 10 minutes and 140 days, respectively). *In vitro* dissolution tests on oxides produced from uranium metal during depleted uranium armor penetrator tests have indicated multicomponent dissolution rates, with 25% of uranium dissolving with a half-time of less than or equal to 0.14 days and 75% dissolving with a half-time of 180 days. Because there was no specific information on the solubility of aerosols produced during operations, this analysis assumed that both types M and S were available. The selection of absorption type should depend on the organ of interest.

3.1.1 Uranium Bioassay

Individual uranium urinalysis data are available for some workers at Chapman Valve. Results less than 0.01 mg/L were reported as zero. A note on a sheet of uranium results (Author unknown 1948) states, "The uranium content of those samples listed as containing less than 0.01 mg U/l is below the limit for reliable determination by the photofluorometric method." The urinalyses range from <0.01 to 0.08 mg/L. For unmonitored workers or unmonitored periods, this document analyzes the bioassay results to provide estimates of coworkers' uranium intakes.

A total of 40 uranium urinalysis results are available for Chapman Valve employees. The first available bioassay samples, dated June 11, 1948, were analyzed by the School of Medicine and Dentistry of Rochester, New York (Fox 1949) and were collected because of a fire involving uranium. Two workers who put out the fire had results of <0.01 mg/L. The five workers, who were involved in cleanup, had results ranging from 0.01 mg/L to 0.08 mg/L. The actual date of the fire is unknown, although AEC (Wolf 1949) noted in the transmittal of the urinalysis results that the samples had been "collected from the seven employees involved in the fire fighting episode last June [1948]." Only two of the workers involved in putting out the fire or in the associated cleanup had later results. Bioassay results were also available for urine samples collected on July 26-27, September 8-9 and October 7 of 1948 from 22, 6 and 5 workers, respectively.

To calculate the intake not associated with the fire, the largest of the 40 results not associated with the fire, 0.03 mg/L, was assigned to each sampling period (the period when results were collected due to the fire was also assigned a bioassay result of 0.03 mg/L). To calculate intakes that include the fire scenario, the largest result associated with the fire, 0.08 mg/L, was used for the June 11, 1948, result, and results for the other sample dates were again assumed to be 0.03 mg/L. The daily uranium excretion in urine was calculated by multiplying the results in mg/L by the specific activity of natural uranium (682.96 pCi/mg) and by reference man's daily urine output (1.4 L/day) (ICRP 1975). Table 3-1 shows the bioassay values used to estimate upper bound inhalation intakes based on an acute exposure in June 1948 and a chronic exposure from January 1, 1948, to April 30, 1949.

Table 3-1. Maximum coworker bioassay data used to estimate intakes.

Bioassay date	Fire scenario (pCi/day)	No fire scenario (pCi/day)
6/11/1948	76.5	28.7
7/27/1948	28.7	28.7
9/8/1948	28.7	28.7
10/7/1948	28.7	28.7

When intakes are estimated from bioassay data, the mode of intake is usually assumed to be inhalation, unless there is information that indicates that other modes of intake are more likely. When using bioassay data, the inhalation intake model assumes that some of the intake behaves as ingested material. In general, intakes from bioassay will be larger when an inhalation rather than an ingestion intake is assumed.

Although the exact date of the June 1948 fire is unknown, it seems reasonable to assume that it could have occurred as early as June 1, 1948, and this should be considered when fitting individual bioassay data. For the coworker data, assuming the intake from the fire occurred on June 10, 1948 resulted in the largest total intake for the period January 1, 1948 to April 30, 1949, and provided a satisfactory fit to the data; the other assumed June fire dates produced total intakes that were within 3.6% of this largest intake. The intake from the fire might have occurred over several days, but it was assumed to be an acute intake when fitting the data to simplify assumptions. The intakes were calculated with IMBA Expert™ ORAUT-Edition, Version 4.0.9, assuming an absolute uniform error of 1 and a normal error distribution. To calculate the level of chronic intake for workers, who might not have been on site during the June fire, the June 11, 1948, bioassay was set to the maximum result not associated with the fire.

As can be seen from the total intake results in Table 3-2, the accounting for the acute intake (as might occur from fires) with a chronic intake assumption results in intake determinations that are sufficiently large to account for possible acute intake situations that occurred over shorter periods. This is evidenced by the similar results for total intakes from fire and non-fire scenarios obtained in this analysis.

Table 3-2. Inhalation intakes based on coworker data.

Scenario	Absorption type	Chronic 1/1/1948 to 4/30/1949 (pCi/d)	Acute 6/10/1948 (pCi)	Total (pCi)
U machining and fire	M	4.81E+02	2.17E+03	2.35E+05
U machining and fire	S	1.43E+04	7.39E+04	7.00E+06
U machining	M	4.96E+02	Not applicable	2.40E+05
U machining	S	1.49E+04	Not applicable	7.23E+06

The Chapman Valve chronic inhalation rates for 1948 through April 30, 1949 in Table 3-2 are, respectively, two and more than four times the types M and S median Y-12 coworker inhalation intake rates for the period 1947 through 1952 (ORAUT 2005b). The intake scenarios to be used for Chapman Valve dose reconstruction are summarized in Table 3-3.

3.1.2 Uranium Air Sampling

The AEC provided analyses for air samples collected on May 4 and 24, 1948 at Chapman Valve (AEC 1948c, d). The results from May 4 (AEC 1948c) are measurements of the effluent from the furnace outlet on the roof and are not appropriate for determining worker doses (it is unlikely that any worker spent significant time 4 ft from a rooftop furnace outlet). The results from May 24, 1948 (AEC 1948d) are 10-minute grab samples listed as “Inspection Bench, Packing Bench, Work Bench, Wash Room and Lunch Room.” Because it is not clear how these samples relate to the workers’ activities, they are not directly used in determining worker intakes. However, an inhalation intake can be calculated by assuming that the maximum result reported, 29.1 dpm alpha/m^3 measured at the workbench, was the concentration for the entire work year as follows.

An intake in pCi was calculated by dividing the maximum reported workplace air concentration by 2.22 dpm/pCi and multiplying this result by the annual breathing rate, 2,000 hours per year, and 1.33 years. The breathing rate of 1.2 m^3/hr was used based on the default for light work (ICRP 1994, Table 6, p. 23). The result is an inhalation intake of 4.18×10^4 pCi, as compared to the total values in Table 3-2. Intakes from resuspended material and ingested material might increase this number by about 10% based on similar calculations in other site profile documents. Based on reported beta film badge results, it is likely that the uranium workload increased during June through September 1948, which would likely have increased air concentrations, so it would be reasonable to assume a factor of 2 to 4 increase in time-weighted air concentrations during the months of June through September, because of the change in workload throughout the year. Because there are more bioassay than air sample results and the bioassay results are spread throughout the work year and are likely to be a better indicator of worker exposures, especially during the production period, the air sample data are not used to calculate intakes at Chapman Valve.

During the February 14, 2005, Worker Outreach Program meeting attendees provided air concentrations and bioassay data collected from workers involved in 1966 and 1967 NUMEC incinerator operations. The incinerator operation was referred to as "primitive" by NUMEC (Schnell and Caldwell 1967), and was thought to be perhaps a comparable operation. Although NUMEC appears to have handled greater quantities and higher enrichments of uranium, and 1960s NUMEC operations might have been quite different from the 1948 Chapman Valve work, comparisons can be made. The average breathing zone concentration at different NUMEC locations ranged from 848 to 6,666 pCi/m^3 (these could be a factor of 2 to 100 lower when normalized for the difference in specific activity between the NUMEC and Chapman Valve uranium enrichments); these compare with calculated exposures (not considering the fire scenario) of 75 to 2,270 pCi/m^3 derived from Chapman Valve coworker bioassay results. The bioassay data for workers in the incinerator area at NUMEC were also available in the provided report and these, too, were considered. The 1966 and 1967 NUMEC incinerator operators' uranium urinalysis results (Schnell and Caldwell 1967) were based on activity measurement and because NUMEC handled a variety of uranium enrichments this is considered in the comparisons. The NUMEC incinerator operators' urinalyses in terms of mass concentrations would have ranged from 37 to 68 µg/L for normal uranium, 16 to 29 µg/L for 2% enriched uranium, and 0.24 to 0.45 µg/L for 93.5% enriched uranium. Bioassay results at Chapman Valve ranged from <10 µg/L to 80 µg/L, and the maximum result of 30 µg/L (not considering results collected because of the June fire) was used to estimate intakes.

Air concentrations were measured on May 4, 1948 at the furnace outlet on the roof. The four measurements ranged from 1,010 to 29,100 dpm/m^3. Two more measurements made the same day 4 ft from the roof exhaust were 136 and 2,280 dpm/m^3. If workers breathed 1% of the maximum furnace exhaust air concentration, which was 29,100 dpm/m^3 for 2,000 hours per year, the intake rate would be 862 pCi/d in comparison to the range of chronic intake calculated from bioassay, which is 481 to 14,900 pCi/d. Based on the description of Chapman Valve's uranium processing, which indicates that the work was done in less than a year and that the furnace use was unlikely to have been continuous for uranium processing, it seems very unlikely that any worker was exposed to the maximum air concentration from the furnace exhaust for 2,000 hours per year, and direct exposure to the undiluted effluent would have been highly unlikely because it was an incinerator exhaust.

A comparison of the air concentrations derived from the Chapman Valve intakes in Table 3-3 and air concentration data collected by AEC for typical uranium operations related to machining is shown in Attachment B.

3.2 OCCUPATIONAL INTERNAL DOSE RECONSTRUCTION ASSUMPTIONS AND SUMMARY

The uranium photofluorometry urinalysis reporting limit at Chapman Valve was 0.01 mg/L. Uranium oxides could be either absorption type M or S.

The assumed operational exposure period ran from January 1, 1948, to April 30, 1949, which this analysis assumes to be the uranium intake period. A uranium fire is assumed to have occurred sometime between June 1 and 11, 1948. The intake from the fire can be assumed to be acute and to have occurred on June 1, 1948, if no other information is available.

For **unmonitored workers or unmonitored periods**, Table 3-3 lists inhalation intakes for dose reconstruction. Chronic intakes are given in units of pCi per calendar day and acute intakes are given in pCi. Four different intake scenarios are listed. The first or second scenario accounts for exposure to the uranium fire in June 1948. The third or fourth scenario can be used when an individual had no exposure to the fire, or these last scenarios can be used to supplement intakes for workers whose bioassays are only associated with the fire. The dose distribution is assumed to be constant.

Table 3-3. Inhalation intake summary for operational period.

Scenarios[a]	Start	End	Intake type	Absorption type	Intake (pCi/day or pCi)
Fire plus workplace exposure	1/1/1948	4/30/1949	Chronic	M	4.81E+02
	6/10/1948	-[b]	Acute	M	2.17E+03
Fire plus workplace exposure	1/1/1948	4/30/1949	Chronic	S	1.43E+04
	6/10/1948	-[b]	Acute	S	7.39E+04
Workplace exposure	1/1/1948	4/30/1949	Chronic	M	4.96E+02
Workplace exposure	1/1/1948	4/30/1949	Chronic	S	1.49E+04

a. Only one of the four scenarios from the table is used to calculate an organ dose. The scenario choice depends on whether the worker could have been exposed to the fire between June 1 and June 11, 1948. The choice also depends on the organ of interest.

b. Not applicable.

4.0 ESTIMATION OF EXTERNAL EXPOSURE

Individual external dosimetry results for Chapman Valve are reported for the weeks beginning May 3 to November 1, 1948 (AEC 1948b). Exposures reported for the weeks beginning October 11, 18, and 25 are questionable, because one set of data indicates that no results were reported and another set indicates that results were all less than 50 milliroentgen (mR). This apparent discrepancy may be due to the practice of expediting data entry by marking multiple results that were "less than" with an x. When a whole page of results were "less than", the entire result section appears to have been marked with a large x. Lines marked with the word "None", indicate a badge was not worn. Reporting of numerical results on an x-marked page indicates positive results and these should be included in the record.

Because film badge data are available for Chapman Valve workers, this document does not attempt to address worker external exposures based on workplace data. When film badge results are available for a worker, the individual's dosimeter results can be used to estimate dose. This document also provides an upper estimate of external dose based on film badge dosimetry records.

The majority of photons from natural uranium metals are in the 30- to 250-keV energy range. Solid uranium objects provide considerable attenuation of the lower energy photons and harden the spectrum, causing the majority of photons emitted from a solid uranium object, such as a billet or a rod, to have energies greater than 250 keV. While it is recognized that solid uranium sources have a hardened photon spectrum, exposure to a thin layer of uranium on a surface results in a larger fraction of exposure to lower energy photons. This analysis assumed workers were exposed to photon energies in the 30- to 250-keV range, which is favorable to claimants. Nonpenetrating dose from natural uranium consists primarily of electrons with energies >15 keV. For consistent presentation, exposure or dose is reported as:

- Penetrating, assumed to be associated with photons of energies 30 keV or greater, and
- Nonpenetrating, assumed to be associated with photons of energies less than 30 keV or with electrons.

4.1 SUMMARY OF AVAILABLE FILM BADGE DATA

Chapman Valve (Musgrave 1948) reported the following ancillary information regarding film badge availability and use at Chapman Valve:

- February 2, 1948: received 50 (brass) badges from the University of Rochester.
- February 9, 1948: received duplicate shipment (with identical numbers) noted to be the pin-type.
- April 28, 1948: requested 100 badges and subsequently received 100 stainless steel snap-on badges from University of Rochester.
- May 10, 1948: returned the 50 used brass pin-type dosimeters and 50 used stainless steel snap-on badges to University of Rochester.
- May 18, 1948: received 100 stainless steel snap-on badges and noted that Chapman Valve would like to continue with this badge type.
- May 19, 1948: sent 50 brass pin-type and 50 stainless steel snap-on badges to AEC in New York per AEC request.

Less than 50 film badge results are included in each reporting period, most likely indicating that only some of the workers entered the AEC work area in a given week (AEC 1948b). A note at the bottom of some of the May reports states “Eastman Film” but does not mention the type of film. Exposure for both beta and gamma was reported in “mr” in 1948. The minimum reporting limit was 50 mR (though at least one report mistakenly lists the reporting limit as “0.50 mr”) for both beta and gamma. Some reports include names and some do not. Some external dosimetry report copies contain illegible entries. As of this writing, it has not been determined if a complete data set for a worker can be determined from the multiple copies of dosimetry reports. An entry of “None” is included on some reports, and this seems to indicate that the badge was not worn during the monitoring period. The handwritten response to the question, “Where were badges kept overnight?” was “No,” which probably indicates that workers left their badges on site at the end of the workday. There is no indication of where the badges were stored or that a control badge was used.

Because it might not be possible to associate results with individuals because of the poor copies or the censored identifiers, the data have been reviewed to identify the maximum recorded beta and gamma doses for each week. The median beta result for May (115 mR) and the minimum reporting limit specified on the Chapman Valve reports for gamma (50 mR) were used to estimate the exposure for other weeks when film badges were not in use or for weeks when the data were suspect, e.g., the three noted weeks in 1948 beginning October 11, 18, and 25. Exposures during unmonitored weeks were likely to be lower, because according to records, the majority of processing occurred between May and November. Some of the results for the weeks of May 17 and 24, 1948 were combined in some of the original records. No attempt was made to unfold the combined results; instead, the maximum reported results for May 17 and 24, 1948, and the May 24, 1948 report were assumed to be the maximum results for the week of May 17 and the week of May 24, respectively. For the weeks May 10 to September 27, 1948, the gamma reporting limit (0.05 R) was used to estimate the maximum exposure when it was reported as <0.05 R. For the weeks May 31 to June 14, 1948, inclusive, the maximum result for the three weeks was assumed for each of these weeks, because of the uncertainty in determining which result applied to which week. When the period of the exposure is less than that included in Table 4-1, the exposure should not necessarily be reduced by the ratio of the actual to the total exposure period. Because recorded maximum external exposures were larger during the weeks beginning May 10 through October 4, 1948, this needs to be taken into account when estimating doses for shorter exposure periods.

Table 4-1. Maximum film badge results.[a]

Week Beginning	Non-penetrating R	Penetrating R	Week Beginning	Non-penetrating R	Penetrating R
1/5/1948	*0.115*	*0.050*	**7/5/1948**	0.225	*0.050*
1/12/1948	*0.115*	*0.050*	**7/12/1948**	0.240	*0.050*
1/19/1948	*0.115*	*0.050*	**7/19/1948**	0.260	*0.050*
1/26/1948	*0.115*	*0.050*	**7/26/1948**	0.320	*0.050*
2/2/1948	*0.115*	*0.050*	**8/2/1948**	0.240	0.085
2/9/1948	*0.115*	*0.050*	**8/9/1948**	0.360	0.110
2/16/1948	*0.115*	*0.050*	**8/16/1948**	0.260	0.085
2/23/1948	*0.115*	*0.050*	**8/23/1948**	0.260	*0.050*
3/1/1948	*0.115*	*0.050*	**8/30/1948**	0.260	*0.050*
3/8/1948	*0.115*	*0.050*	**9/6/1948**	0.440	0.070
3/15/1948	*0.115*	*0.050*	**9/13/1948**	0.500	0.075
3/22/1948	*0.115*	*0.050*	**9/20/1948**	0.650	*0.050*
3/29/1948	*0.115*	*0.050*	**9/27/1948**	0.320	*0.050*
4/5/1948	*0.115*	*0.050*	**10/4/1948**	0.160	0.055
4/12/1948	*0.115*	*0.050*	**10/11/1948**	*0.115*	*0.050*
4/19/1948	*0.115*	*0.050*	**10/18/1948**	*0.115*	*0.050*
4/26/1948	*0.115*	*0.050*	**10/25/1948**	*0.115*	*0.050*
5/3/1948	0.065	0.070	**11/1/1948**	0.085	0.070
5/10/1948	0.100	*0.050*	**11/8/1948**	*0.115*	*0.050*
5/17/1948	0.115	*0.050*	**11/15/1948**	*0.115*	*0.050*
5/24/1948	0.140	*0.050*	**11/22/1948**	*0.115*	*0.050*
5/31/1948	*0.165*	*0.050*	**11/29/1948**	*0.115*	*0.050*
6/7/1948	*0.165*	*0.050*	**12/6/1948**	*0.115*	*0.050*
6/14/1948	*0.165*	*0.050*	**12/13/1948**	*0.115*	*0.050*
6/21/1948	0.130	0.060	**12/20/1948**	*0.115*	*0.050*
6/28/1948	0.265	*0.050*	**12/27/1948**	*0.115*	*0.050*
			Totals	**9.110**	**2.830**

a. Numbers in italics are assumed. The bases for the assumptions are presented in the text above.

An additional period of external exposure is assumed from January 3, 1949 through May 1, 1949. The median weekly beta result for May 1948 (0.115 R) and the gamma reporting limit of 0.050 mrem were used to estimate exposure during this period. The results are shown in Table 4-2.

4.2 OCCUPATIONALLY REQUIRED MEDICAL X-RAY

Information regarding whether or not occupationally required medical X-ray examinations were performed at Chapman Valve is unavailable. AEC usually, but not always, required preemployment and periodic medical examinations of workers involved in the larger uranium processing programs. The term *preemployment* as used here means prior to performing AEC-contracted radiological work. The typical AEC medical program included preliminary and annual chest X-ray examinations. This analysis assumed that workers received a preemployment X-ray examination of the chest in 1947 and a second X-ray examination a year later. The method of X-ray examination should be based on the current guidance for 1948 exposures. Organ doses can be obtained from the latest revision of ORAUT-OTIB-0006, *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT c).

4.3 MISCELLANEOUS INFORMATION RELATED TO EXTERNAL DOSE

This section includes external dose information that might be of interest for specific dose reconstructions. This analysis did not consider such information generically because of its limited applicability or because of limited information.

A fire involving uranium occurred sometime between June 1 and 11, 1948. The fire and subsequent cleanup activities could have increased the likelihood of uranium skin contamination on some workers. Film badges were worn by Chapman Valve workers during this period, but it has not yet been verified that the workers who fought the fire or were involved in cleanup were monitored for external radiation exposure.

4.4 OCCUPATIONAL EXTERNAL DOSE RECONSTRUCTION ASSUMPTIONS AND SUMMARY

Individual film badge results are available to determine doses. The reporting limit for beta and gamma was 50 mR. Table 4-2 provides overestimating assumptions that can be used to estimate doses for some Chapman Valve claims including Interactive RadioEpidemiological Program (IREP) distribution information. Prorating of the exposure to a shorter period should be based on the information in Table 4-1.

Table 4-2. External exposure summary.

Exposure category	Exposure type	Basis	Year	Annual exposure	IREP distribution
Overestimate of external dose	Penetrating	Maximum film badge results	1948 1949	2.830 R 0.850 R	Constant
	Nonpenetrating	Maximum film badge results	1948 1949	9.110 R 1.955 R	Constant
Medical X-ray	Current guidance for 1947 and 1948	Initial exam in 1947 plus one exam in 1948	1947 1948	See ORAUT-OTIB-0006, (ORAUT 2005c)	

5.0 ESTIMATION OF RESIDUAL EXPOSURE

The residual dose period is assumed to begin on May 1, 1949, the day after the month that Electro Metallurgical (1949) noted processing of Chapman Valve material and scraps, and is assumed to continue through December 31, 1993. The radiation exposures during cleanup operations in 1994 and 1995 are not assessed in this document.

In 1987, Department 40 and its perimeter were surveyed with a Victoreen Model 492 ionization chamber, and no elevated radiation levels were detected (Sedelow 1987). The detection threshold of a Victoreen 492 is likely to be about 0.1 mR/hour.

ORNL (1992) conducted a survey in August 1992 under the FUSRAP program. The reported radiation levels at various locations in the facility are summarized in Table 5-1. Elevated radiation and contamination levels were found in the western portion of Building 23. The survey of Chapman Valve included:

- a gamma and beta/gamma scan of the floor and walls and gamma scan of the ground surface in selected outdoor areas.
- Measurement of surface and 1-m exposure rates at the center of the north and south section of main-bay survey blocks.

- Measurement of alpha activity levels at selected locations.
- Analysis of 30 dust and debris samples (26 from overhead beams).
- Direct and removable alpha and beta/gamma measurements at 31 locations.
- Analysis of 2 soil samples.

Table 5-1. Radiation/radioactivity levels in August 1991.[a]

Measurement type	Range	MDA
Gamma exposure (µR/hr)	5–32	--[b]
Direct beta/gamma (mrad/hr)	0.02–4	0.01
Direct alpha (dpm/100 cm^2)	<MDA –2,900	25
Removable beta/gamma (dpm/100 cm^2)	all <200	200
Removable alpha (dpm/100 cm^2)	14–90	10
Soil concentrations (pCi/g)[c]	0.33–1.9	--
Dust samples (pCi/g)[c]	0.2–36,000	--

a. ORNL (1992).
b. -- = not available.
c. Includes Ra-226, Th-232, and U-238.

All results in the ORNL reports, except those from the smears, were reported as gross results; background values were not subtracted from the results. ORNL (1992) included brief information regarding their survey methods and instrumentation.

A sodium iodide scintillation probe and rate meter were used to detect gamma. Rates measured at 2 inches from a surface were converted to µR/hr. The method to measure the exposures at 1 meter, which are included in the report, was not explicitly stated. Gamma levels ranged from 4 to 32 µR/hr. The highest average reading for a grid block was 13 µR/hr. It was assumed that these measurements were made at 1 meter from the floor. To estimate the penetrating dose it was assumed the largest average result, 13 µR/hr, was the median and the largest result, 32 µR/hr, was at the 95th percentile. An associated geometric standard deviation (GSD) of 1.72 was calculated. The penetrating dose estimates are listed in Table 5-2.

A pancake Geiger-Mueller (GM) probe measured count rates, and these were converted to mrad/hr of beta/gamma. The minimum detectable activity (MDA) was reported as 0.01 mrad/hr. A pancake GM probe is an unusual choice for making dose measurements because of both its geometry and energy sensitivities. It is also sensitive to alpha radiation, which might have resulted in an over-response if a cover or some distance from a surface were not maintained to eliminate the alpha response. ORNL (1992, Figure 7) reported a range of dose rates for each grid block surveyed. The maximum dose rates in the range were used to determine a geometric mean, which was assumed to equal a median nonpenetrating dose rate of 0.12 mrad/hr. The GSD was calculated to be 2.9. The nonpenetrating dose is listed in Table 5-2.

A zinc sulfide scintillation detector and rate meter were used to detect alpha count rates. The count rates were converted to dpm/100 cm^2. The MDA was reported as 25 dpm/100 cm^2. The largest of 30 direct contamination measurements was reported as 2,900 dpm/100 cm^2. To calculate internal exposure from residual activity, this analysis assumed that the median uranium exposure was associated with uniform contamination of the buildings to a level of 2,900 dpm/100 cm^2, the maximum directly measured alpha contamination. Six of 23 dust samples from the overhead beams and crane exceeded this value and ranged from 3,500 dpm to 12,000 dpm/100 cm^2. Using a resuspension factor of 1×10^{-6}/m (NRC 2002) and an air intake rate of 2,400 m^3 per work year, the calculated annual inhalation intake was 314 pCi, and this was assumed to all be uranium. Using the method described in NIOSH (2004), the calculated annual ingestion intake was 6.53 pCi. GSDs of 3 are assumed. Table 5-2 summarizes residual period intake rates.

Samples of dust and debris, and soil were analyzed for Ra-226, Th-232 and U-238 by ORNL in the 1990s (ORNL 1992, 1997). Chapman Valve received essentially pure uranium metal (no radium) for processing. This is confirmed by the ORNL (1992) survey, which reported Ra-226 and Th-232 concentrations as consistent with background. The two soil samples were also consistent with background radioactivity concentrations. ORNL analyzed dust samples M10 and M31 for U-235. M31 was reported as 2.16% enriched. The Chapman Valve uranium processing was related to reactor needs, and the use of enriched uranium in reactors was rare until 1950. The only other mention of Chapman Valve and enriched uranium was in ORNL (1997), which reiterated ORNL's 1992 words. Unlike the ORNL 1992 report, ORNL 1997 included the actual U-235 and U-238 results for seven soil samples. The activity ratios seemed consistent with natural uranium. However, because the concentrations were close to background, the reported uncertainties were relatively large.

The estimated annual external exposures to residual radioactivity from AEC operations at the site, listed in Table 5-2, were calculated by assuming that workers were exposed for 2,000 hours per year. Assumptions regarding residual exposures should be consistent with assumptions from the operational period.

Table 5-2. Annual internal and external exposure to residual radioactivity.

Internal	**Start**	**End**	**Exposure**	**Absorption type**	**Intake (pCi/day)**	**IREP distribution**
Uranium	5/1/1949	12/31/1993	Inhalation	M, S	8.58E-01	Lognormal GSD 3
	5/1/1949	12/31/1993	Ingestion	(a)	1.79E-02	Lognormal GSD 3
External	**Start**	**End**	**Exposure**	**Basis**	**R/year**	**IREP distribution**
	5/1/1949	12/31/1949	Penetrating	Survey instrument	1.73E-2	Lognormal GSD 1.72
	1/1/1950	12/31/1993	Penetrating	Survey instrument	2.60E-2	Lognormal GSD 1.72
	5/1/1949	12/31/1949	Nonpenetrating	Survey instrument	1.57E-1	Lognormal GSD 2.9
	1/1/1950	12/31/1993	Nonpenetrating	Survey instrument	2.36E-1	Lognormal GSD 2.9

a. Choose same f_1-value as used for inhalation per NIOSH (2004).

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ATTACHMENT A
CHAPMAN VALVE BUILDING LAYOUT AND SOME SAMPLING LOCATIONS
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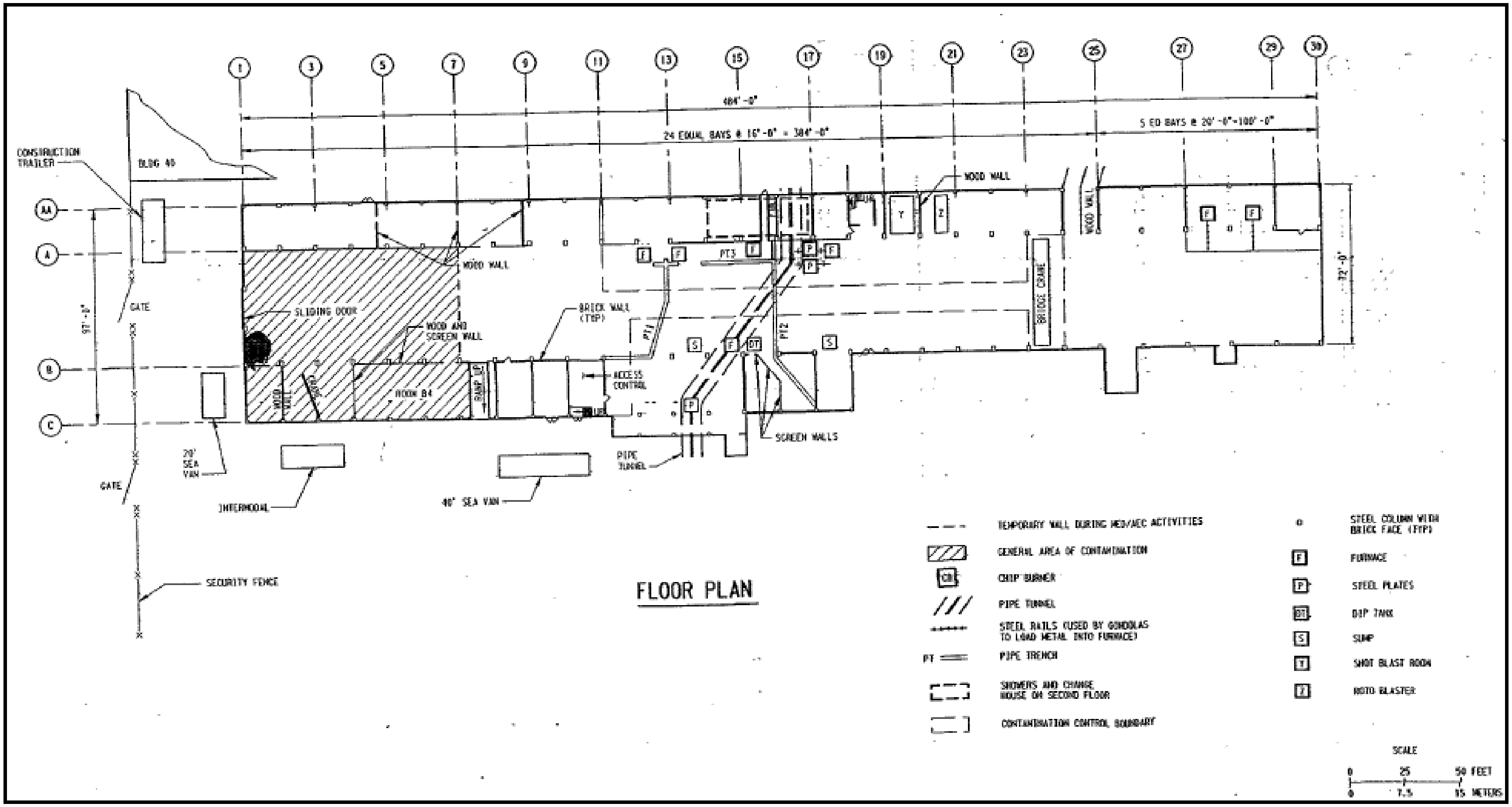

Figure A-1. Chapman Valve floor plan provided at 2005 Worker Outreach Meeting (Author unknown, ca 1996).

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CHAPMAN VALVE BUILDING LAYOUT AND SOME SAMPLING LOCATIONS
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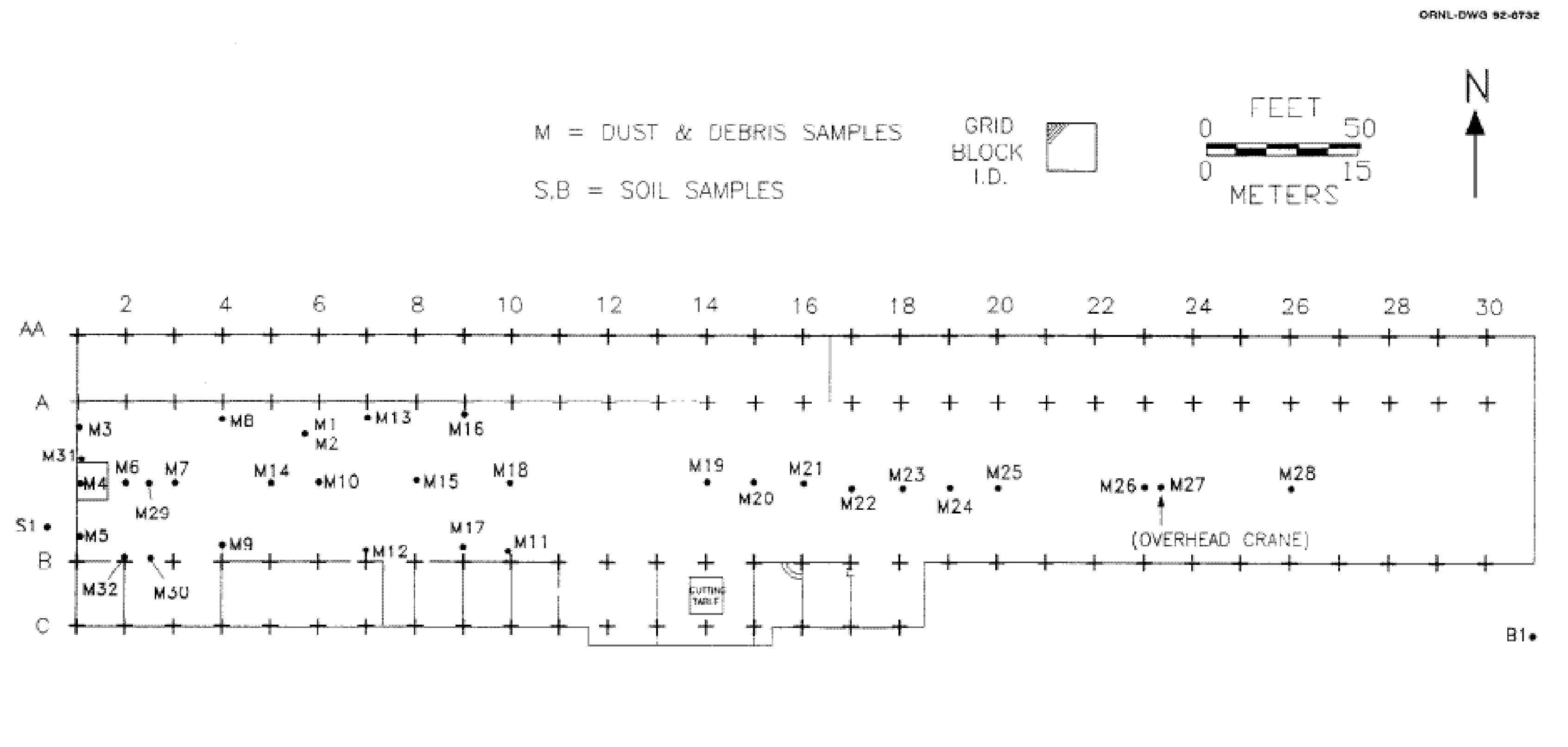

Fig. 8. Locations of soil, dust, and debris samples collected at the site of the former Chapman Valve facility, Indian Orchard, Massachusetts.

Figure A-2. Locations of dust and debris samples collected in 1992 in or near Building 23 (ORNL 1992).

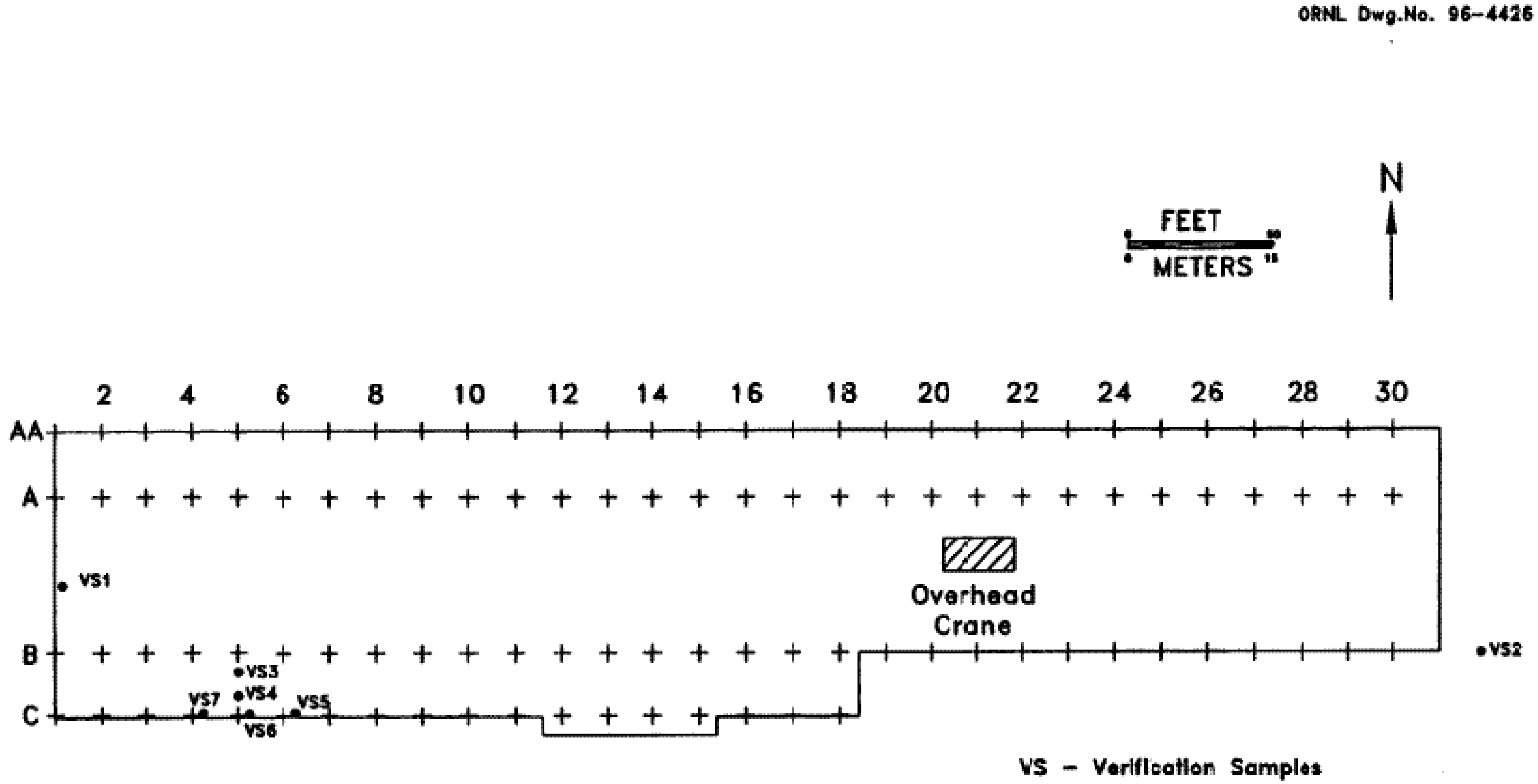

Fig. 10. Locations of soil samples collected at the site of the former Chapman Valve facility, Indian Orchard, Massachusetts.

Figure A-3. Locations of verification samples collected in 1996 in Building 23 (ORNL 1997).

ATTACHMENT B
COMPARISON OF AIR CONCENTRATIONS CALCULATED FOR CHAPMAN VALVE AND AEC MACHINING AND GRINDING OPERATIONS

Harris and Kingsley (1959) summarized uranium operational data in an article submitted for publication to the American Medical Association *Archives of Industrial Health* for June 6, 1958, (which was previously issued as AEC Health and Safety Laboratory (HASL) report HASL-39). The data appeared to be collected from several uranium metal handling facilities, which probably included Fernald, Mallinckrodt Chemical Works, Simonds Saw and Steel, Bridgeport Brass Company, and Sylvania-Corning Nuclear (Harris and Kingsley 1959, p. 113). Based on the references and the involved companies, it is likely that the data were collected before 1957 and perhaps as early as the late 1940s. Harris and Kingsley noted that the information was collected from both full-time operations at production plants, as well as from experimental runs on “production-sized” units, and included collection of data for both controlled ventilation and no mechanical ventilation conditions. The air concentrations reported as daily averages were based on time-weighting the measured air concentration by each incremental exposure period incurred by the operator in a workday. These HASL-collected numbers are compared with the air concentration rates that would result in the intake rates derived from Chapman Valve bioassay. For the non-fire scenarios, these air concentrations were calculated by multiplying the intake rate in pCi per day by 2.22 dpm/pCi, multiplying that result by 365 days per year and dividing it by 2,000 work-hours/year and the light-work breathing rate of 1.2 m^3/hr (ICRP 1995) to get the air concentration in dpm/m^3. To include the fire scenario, total intakes for the operational period were calculated and then averaged to a daily intake rate in pCi per day before calculating average air concentrations as stated above.

Table B-1 lists the calculated Chapman Valve air concentrations and the reported air concentrations from Harris and Kingsley (1959) and shows that the air concentrations derived for the Chapman Valve machining operation tend to be on the high side of the machining operations presented by HASL. The operation at Chapman Valve appeared to be primarily a machining operation and not so much a cutting and grinding operation, but a comparison with the abrasive operations can also be made, and shows that the Chapman Valve calculated air concentrations would be in similar range. It is likely that machining and abrasive operations at Chapman Valve were ongoing for less than 8 hours a day and 250 days a year during the period 1948 to April 30, 1949, and this gives assurance that the calculated air concentrations for Chapman Valve are bounding for this type of work.

ATTACHMENT B
COMPARISON OF AIR CONCENTRATIONS CALCULATED FOR CHAPMAN VALVE AND AEC MACHINING AND GRINDING OPERATIONS
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Table B-1. Comparison of air concentrations calculated for Chapman Valve and AEC machining and grinding operations (dpm/m^3).

Chapman Valve						
Machining operations	**160–5,000**					
AEC facilities[a]						
	Daily averages[b]		**Breathing zone**		**General area**	
	Ventilation	**No ventilation**	**Ventilation**	**No ventilation**	**Ventilation**	**No ventilation**
Machining[b]						
Lathing (optimal speed)	--[c]	--	<1	3–90	--	--
Lathing (cutting speed 200–300 surface ft/min, coolant rates up to 115 gallons/min)	--	--	--	--	12–48	120–240
Automatic lathe	30–70	200–300	--	--	--	--
Turret lathe[d]	40–50	150	--	1,750	--	--
Facing[d]	--	≈100	--	--	--	--
Cutoff[d]	20–30	≈100	--	--	--	--
Milling[d]	20–30	≈100	--	--	--	--
Slotting[d]	20–30	≈100	--	--	--	--
Drill	10	20	--	--	--	--
Radius cutting[d]	30	100–300	--	--	--	--
Milling	--	40	--	--	--	--
Shaping	--	<10	--	--	--	--
Planing	--	<10	--	--	--	--
Abrasive operations[e]						
Cut-off	<1	--[f]	--	--	--	--
Surface grinder	50–200	2,000–5,000	--	--	--	--
Portable grinder	50–200	400	--	--	--	--
Belt sander	<10	3,000	--	--	--	--
Centerless grinder	50–300	5,000–6,000	30–270	13,500	--	--

a. Harris and Kingsley (1959).
b. Daily averages are from Harris and Kingsley (1959, Table 5).
c. Not provided.
d. Values are for normal operations; with speeds of less than 100 surface ft/min and adequate coolant, all results are less than 10 dpm/m^3.
e. Harris and Kingsley (1959, Table 6).
f. "Never sampled, but very high" (Harris and Kingsley 1959).