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06/21/2005	00-A	New ORAU Team technical information bulletin to summarize 1948-1949 monitoring data for the Y-12 site. Initiated by George D. Kerr, William G. Tankersley, and Janice P. Watkins.
07/03/2005	00-B	Incorporates internal review comments. Initiated by George D. Kerr, William G. Tankersley, and Janice P. Watkins.
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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission, one of the predecessor agencies of DOE
COC	Cincinnati Operations Center
DOE	U.S. Department of Energy
EU	enriched uranium
eV	electron volt
hr	hour
ID	identification
keV	one thousand electron volts
MDL	Minimum Detectable Limit
MeV	one million electron volts
mm	millimeter
mR	milliroentgen, a unit of radiation exposure
mrem	millirem, a unit of radiation dose
NBS	National Bureau of Standards, now the National Institute for Standards and Technology
NIOSH	National Institute for Occupational Safety and Health
NR	no reading/no response
ORAU	Oak Ridge Associated Universities
ORAUT	ORAU Team
PIC	Pocket Ionization Chamber
R1	PIC reading
R2	sensitive film reading under open window
R3	sensitive film reading under 1 mm-thick cadmium shield
R4	insensitive film reading under 1 mm-thick cadmium shield
rem	roentgen equivalent man, a unit of radiation dose
SSN	Social Security Number
TEC	Tennessee Eastman Corporation
TIB	Technical Information Bulletin
UCC	Union Carbide Corporation

1.0 PURPOSE

Technical Information Bulletins (TIBs) are general working documents that provide guidance concerning the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained. TIBs may be used to assist the National Institute for Occupational Safety and Health (NIOSH) in the completion of individual dose reconstructions (NIOSH 2002).

The purpose of this TIB is to discuss and summarize the 1948-1949 external monitoring data that are now available for use in the NIOSH Dose Reconstruction Project for workers at facilities operated by the U.S. Department of Energy (DOE) and its predecessor agencies (NIOSH 2002). The 1948-1949 external monitoring data were previously made available to Oak Ridge Associated Universities (ORAU), along with other data for use in epidemiological studies of workers at Y-12 and other DOE sites in Oak Ridge, Tennessee (Watkins et al. 1993, 1997). These 1948-1949 data have been placed on the O: Drive of the secure data server at the ORAU Cincinnati Operations Center (COC) for use in dose reconstructions for workers at the Y-12 facility.

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” or a “Department of Energy facility” as defined in the Energy Employees Occupational Illness Compensation Program Act of 2000 (42 U.S.C. § 7384l(5) and (12)).

2.0 BACKGROUND

The Y-12 Plant, now the Y-12 National Security Complex, was first conceived in the fall of 1942 by engineers of the Manhattan Engineer District of the U.S. Army Corps of Engineers, and construction of the first building was completed in 1943 (Wilcox 2001). The Tennessee Eastman Corporation (TEC) operated Y-12 from 1943 to May 1947. During this period, operations at Y-12 primarily involved the use of the electromagnetic separation process to enrich uranium; the enriched product was shipped to Los Alamos for production of nuclear weapons. Until the latter part of 1945, Y-12 converted UO_3 to UCl_4, which was subsequently enriched by the electromagnetic separation process using two calutron stages (termed “alpha” and “beta”). In the latter part of 1945, Y-12 discontinued the use of the alpha calutron stage and began receiving UF_6 from the Oak Ridge Gaseous Diffusion Plant, also called the K-25 Plant. The UF_6 from K-25 was converted into UCl_4, enriched using the beta calutrons, converted to UF_4, and shipped to Los Alamos. In these early days of Y-12, TEC relied entirely on facility monitoring to measure and control both occupational external and internal radiation exposures to workers. The nature of the work at the Y-12 facility in these early years primarily resulted in occupational internal exposure from uranium dust particles, which was a greater potential hazard than occupational external exposure.

In May 1947, management of Y-12 was assigned to the Union Carbide Corporation (UCC), and emphasis was directed away from enrichment of uranium to the fabrication of parts for nuclear weapons. Numerous changes have occurred over the years in the fabrication procedures, but the general procedures have remained essentially the same. Enriched uranium (EU) typically was received at Y-12 in the form of UF_6, converted to UF_4, reduced to a metal, and then fabricated into weapon parts. These fabrication processes involved casting, rolling, forming, and machining of the EU metal and recycling of the EU salvage. In addition to facility monitoring to measure and control the radiation exposure to workers, an external dosimetry program was started in 1948 to monitor individual personnel working in the Assay Laboratories, Radiographic Shop, Spectrographic Shop, and the “Metal” Machine Shops. Other groups of workers were added in July 1948, January 1949, and July 1949. The occupational external monitoring since 1950 has previously been reviewed by Kerr (ORAUT 2003) and Kerr et al. (ORAUT 2005a,b).

3.0 EXTERNAL RADIATION MONITORING DEVICES

Doses to the whole body from external radiation exposure at the Y-12 facility during 1948-1949 were measured using Victoreen pocket ionization chambers (PICs) exchanged on a daily basis and film badge dosimeters exchanged on a weekly basis (Souleyrette 2003; ORAUT 2003). The minimum detectable limits (MDLs) for these dose measurements during this period were approximately 5 mrem for the PICs and 30 mrem for the film badge dosimeters.

3.1 POCKET IONIZATION CHAMBERS

The Victoreen PICs were condenser-type ionization chambers that were used with a separate charger and charge reader (Price 1958; Handloser 1959). The PICs were charged to a known voltage by inserting them into the charger, which connected an internal power supply across the chambers. The charge reader, a string electrometer, indicated the charge. The PICs were the size of fountain pens and had clips similar to those on fountain pens so they could be carried securely in the pocket of a shirt or coverall. Exposure to ionizing radiation discharged the chamber, and the decrease in voltage provided a measurement of a worker’s radiation exposure. The PICs were calibrated using integrated exposures of 100, 200, and 300 mR from a radium source (Struxness 1948a).

Properly operating PICs were not bothered by charge leakage over a period of a few days, but their use was generally restricted to 1 day (Price 1958; Handloser 1959). At Y-12 and most other DOE sites, it was general practice to provide each worker with two PICs, and the lower exposure reading was taken as the significant reading because any malfunction of a PIC resulted in a charge decrease indicating a higher exposure. Malfunctions of a PIC were usually due to either charge leakage across the insulators or mechanical shock such as being dropped on the floor.

The energy response of the PICs, like film, was not flat but peaked at low X-ray energies (Price 1958; Handloser 1959). At gamma-ray energies of approximately 0.3–1.2 MeV, the energy response was linear, but it was about 1.4 times the linear response at an energy of approximately 0.1 MeV. Below 0.1 MeV, the response dropped rapidly because the photons (X-rays or gamma rays) underwent significant attenuation in the walls of the PICs. The readings indicated by the PICs were much less than the actual doses at energies below about 40 keV. The walls of the PICs were thin enough to allow some response to beta particles with energies of approximately 1 MeV or more.

3.2 FILM BADGE DOSIMETERS

The film badge dosimeter used at Y-12 was the same badge used at the Oak Ridge National Laboratory in 1949 (ORAUT 2005a) and described by Thornton, Davis, and Gupton (1961). This film badge was an AEC Catalog Number PF-1B film badge manufactured by the A. M. Sample Machine Company in Knoxville, Tennessee (ORAUT 2005a). The photographic film in the badge was encased in a protective cover of stainless steel with a clip for attachment to the pocket or collar of a shirt or coverall. One portion of the film (shielded window) was covered by a 1-mm-thick cadmium filter to determine the penetrating whole-body dose from gamma rays. The uncovered portion of the film (open window) was used to determine the skin dose from beta particles and low-energy X-rays (Handloser 1959).

The film badge dosimeters used at Y-12 from 1948 to 1963 contained DuPont type 552 film packets (Souleyrette 2003). These packets contained two film emulsions: (1) a so-called sensitive 502 emulsion with an effective dose range of approximately 30 mrem to 10 rem, and (2) a so-called insensitive 510 emulsion with an effective dose range of approximately 500 mrem to 20 rem (Craft, Ledbetter, and Hart 1952; Thornton, Davis, and Gupton 1961; Parrish 1979). Film badge dosimeters typically exhibited about the same sensitivity to beta and gamma radiation; that is, a 1-rem dose of beta particles yielded about the same response in the film as 1 rem of gamma rays (Auxier 1967). Thus, the MDLs of the film badge dosimeters were approximately the same for beta particles and gamma rays (ORAUT 2005a).

The DuPont 552 film packets were calibrated using X-rays, beta particles from a uranium slab, and gamma rays from a radium source (Struxness 1949). The gamma-ray calibrations used integrated exposures of 100, 250, 500, 750, and 1,000 mrem from the radium source (Struxness 1948a). The film badges were calibrated for beta particles by placing the film badge face down on the slab of natural uranium (Struxness 1949). The dose rate to skin from the beta particles at the surface of the natural uranium slab was taken to be 270 mR/hr (Murray 1948). The currently accepted value for the dose rate to skin from beta particles at the surface of a natural uranium slab is approximately 235 mrem/hr (DOE 2004). If one makes the common assumption that 1 mR/hr is approximately equal to 1 mrem/hr (Whyte 1959; NBS 1962), the beta-particle calibrations during the 1948-1949 period provide conservative estimates of a Y-12 worker's exposure to beta particles during that period.

4.0 Y-12 EXTERNAL DOSE DATABASE

External monitoring records for 1950 to 1988 were provided by the Y-12 staff from 1978 through the 1980s for use in epidemiologic studies by the Center for Epidemiologic Research of the Oak Ridge Associated Universities (ORAUT 2005a). These records contained beta, gamma, and neutron results for individuals, summarized by quarters. For some time, it was assumed that no external monitoring records were available prior to 1950. Following considerable investigation, including interviews with knowledgeable Y-12 staff members, it was discovered that a limited set of external monitoring data did exist for 1948 and 1949 (West 1980). Further investigation resulted in the retrieval of a single electronic file with 11,492 records. Each record in the file included film badge ID, date of weekly readings, four dose fields, and descriptive comments. The four dose fields consisted of the PIC reading and three photographic film dose readings. Efforts were made to link the film badge ID in the Y-12 pre-1950 external monitoring file with Y-12 worker names and departments in the ORAU DOE facility database.

Basic characteristics of the dataset are as follows. Each film badge ID in the file had 26, 52, 78, or 104 records, corroborating that monitoring results were recorded on a weekly basis during this period. A total of 240 distinct film badge IDs were identified among the 11,492 records in the dataset. As listed in Table 5-1, 3,599 of the records were reported for 1948, and 7,893 were reported for 1949. Table 5-1 indicates that the total number of monitored Y-12 workers was approximately 26 during the first half of 1948, 107 during the second half of 1948, 141 during the first half of 1949, and 168 during the second half of 1949. Although each record in the dataset had a value for all four dose fields, many of the results were recorded as "NR" (i.e., "no reading" or "no response"). In fact, 7,876 of the total 11,492 records reported NR in each of the four dose fields. Therefore, only 3,616 of the records supplied any information on external occupational doses. The information provided by these 3,616 records is summarized in the next section.

5.0 EVALUATION OF 1948-1949 EXTERNAL DOSE DATA

The doses listed as PIC readings are referred to as R1. Doses from readings of sensitive film with open window, sensitive film shielded, and insensitive film shielded are designated R2, R3, and R4,

Table 5-1. Number of Y-12 monthly external monitoring records for 1948-1949.

Month	Monthly external monitoring records		
	1948	**1949**	**Total**
January	130	564	694
February	104	564	668
March	104	564	668
April	130	705	835
May	104	564	668
June	104	564	668
July	535	840	1,375
August	428	672	1,100
September	428	840	1,268
October	535	672	1,207
November	428	672	1,100
December	569	672	1,241
Total	3,599	7,893	11,492

respectively. All results in this section are based on all records occurring in a month, although an individual worker could provide multiple records each month.

Figure 6-1 shows the total number of records per month, along with the number of blanks (i.e., NR) for each of the four dose fields. From January through March 1948, all dose field readings were blank. Figure 6-2 shows the sum of all the records in each dose field by month. In 1948, the monthly dose sums were nearly identical for R2, R3, and R4, with the exception of a slightly lower R4 dose in July. The monthly sums for the PIC readings starting in July 1948 were generally about one-third as large as film badge sums in the fields R2, R3, and R4. In 1949, the monthly PIC sums were about one-third or less of the R2 sums, with the exception of the period from March through June, when the R2 sums dipped much lower.

Figures 6-3 through 6-6 show monthly descriptive statistics for R1, R2, R3, and R4, respectively, where statistics were based on only nonblank values (i.e., excluding the NRs). The 75th percentile for R1 was near 30 mrem for the entire period (April 1948-December 1949), indicating that approximately three-fourths of the PIC readings each month had a value of 30 mrem or less. However, maximum R1 readings were generally above 60 mrem after October 1948. For R2 from July 1948 through 1949, the 25th percentile, median, and 75th percentile were all 30 mrem, suggesting that a dose of 30 mrem might have been assigned if all weekly badge readings in the month fell below MDL. For R3 from July 1948 through March 1949, it appears that a dose of 30 mrem was assigned if all weekly badge readings in the month were below MDL, and from April 1949 to December 1949, it appears that a dose of zero was assigned if all week badge readings in the month were below MDL. For R4, the MDL was 500 mrem, but it appears that much lower dose values were assigned for the month based on the lowest recorded value of either R1 or R3 for the same monthly period. Several very high maximum doses were recorded for R2, including 760 mrem in July 1948 and 2,500 mrem in both January and February 1949 (see Figure 6-4). With the exception of one R3 dose of 640 mrem in July 1948, R3 and R4 have only doses of 30 mrem from July 1948 through March 1949 and then no additional dose records except one R4 dose of 30 mrem in November (see Figures 6-5 and 6-6). No doses above 30 mrem were recorded for R4 in either 1948 or 1949 year.

The two very high R2 doses in January and February 1949 to a worker in the Chemical Department (Dept. 2619) suggest a large skin dose that may not have been detected by the PICs. These two high

R2 doses do not appear to be due to beta particles because the ratio of R2 to R3 of approximately 100:1 is much larger than the expected beta-to-gamma dose ratio from exposure to uranium. The two high R2 readings in January and February 1949 are more likely the result of exposure to very-low energy photons leaking from an X-ray spectrograph or other devices, a problem that was noted in

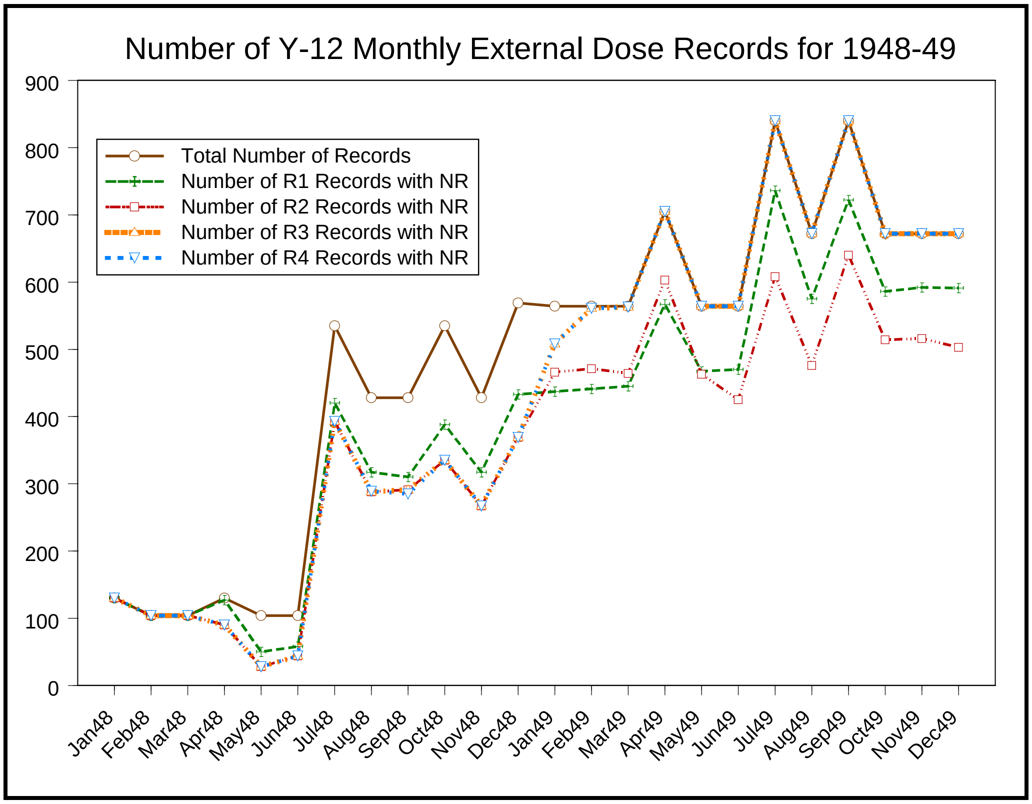

Figure 6-1. Number of Y-12 monthly external dose records for 1948-1949.

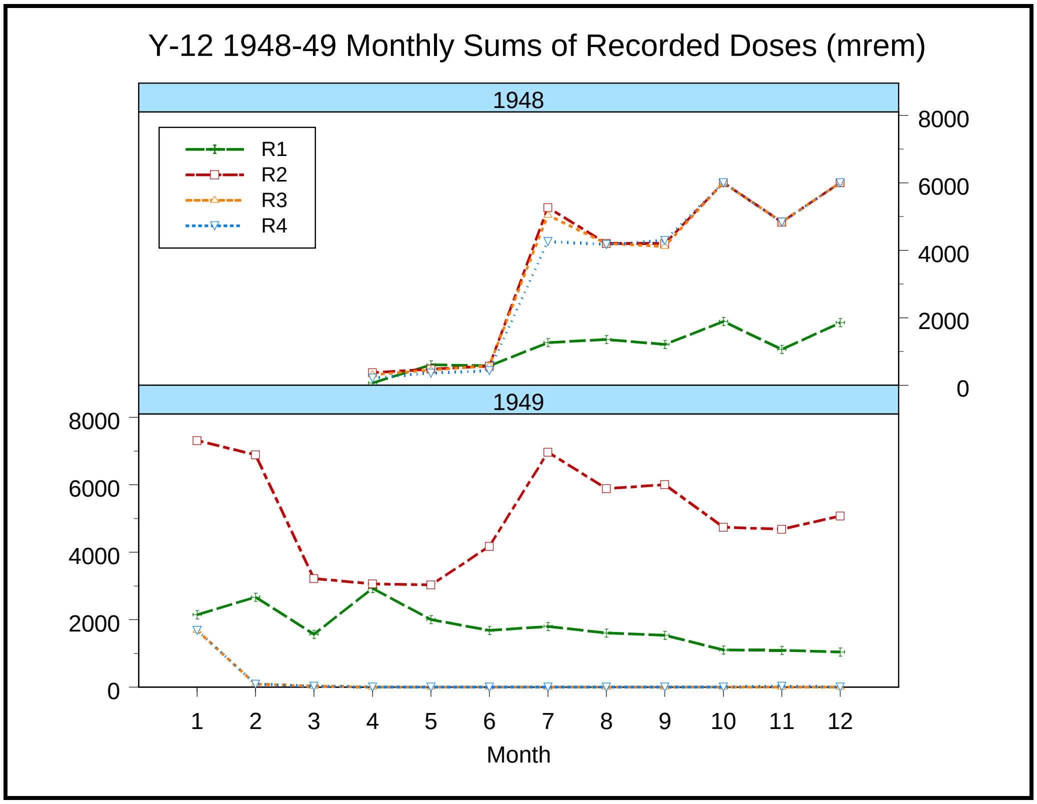

Figure 6-2. Y-12 1948-1949 monthly sums of recorded doses (mrem).

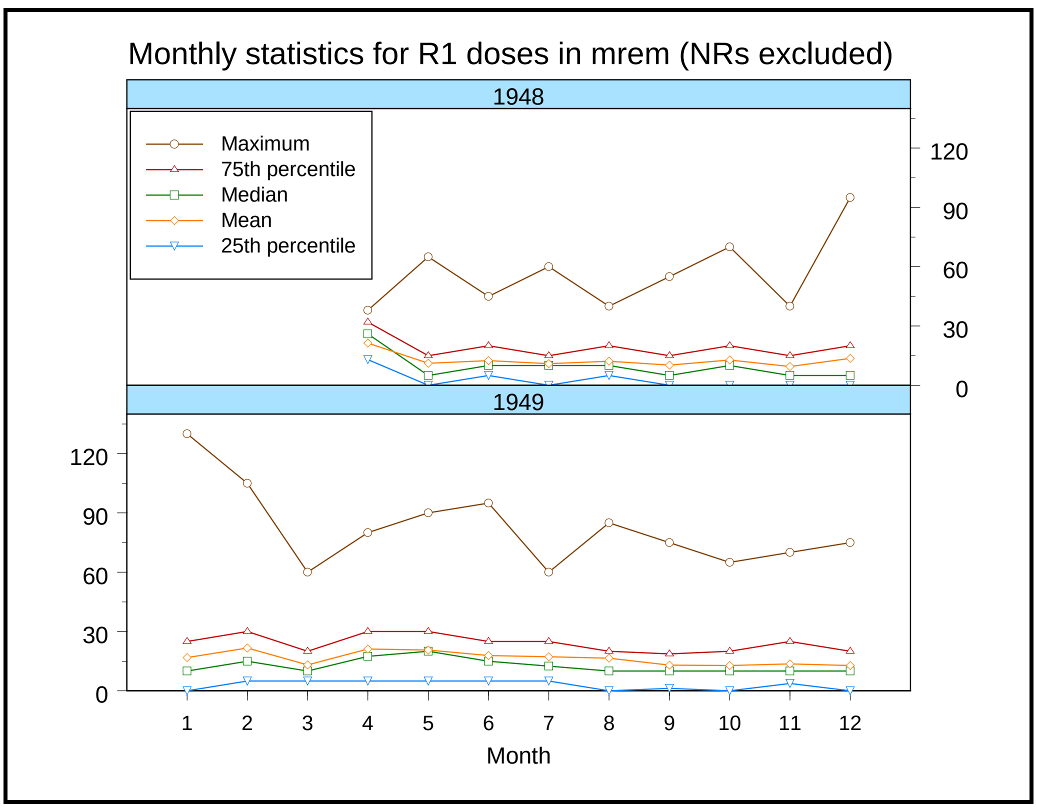

Figure 6-3. Monthly statistics for R1 doses in mrem (NRs excluded).

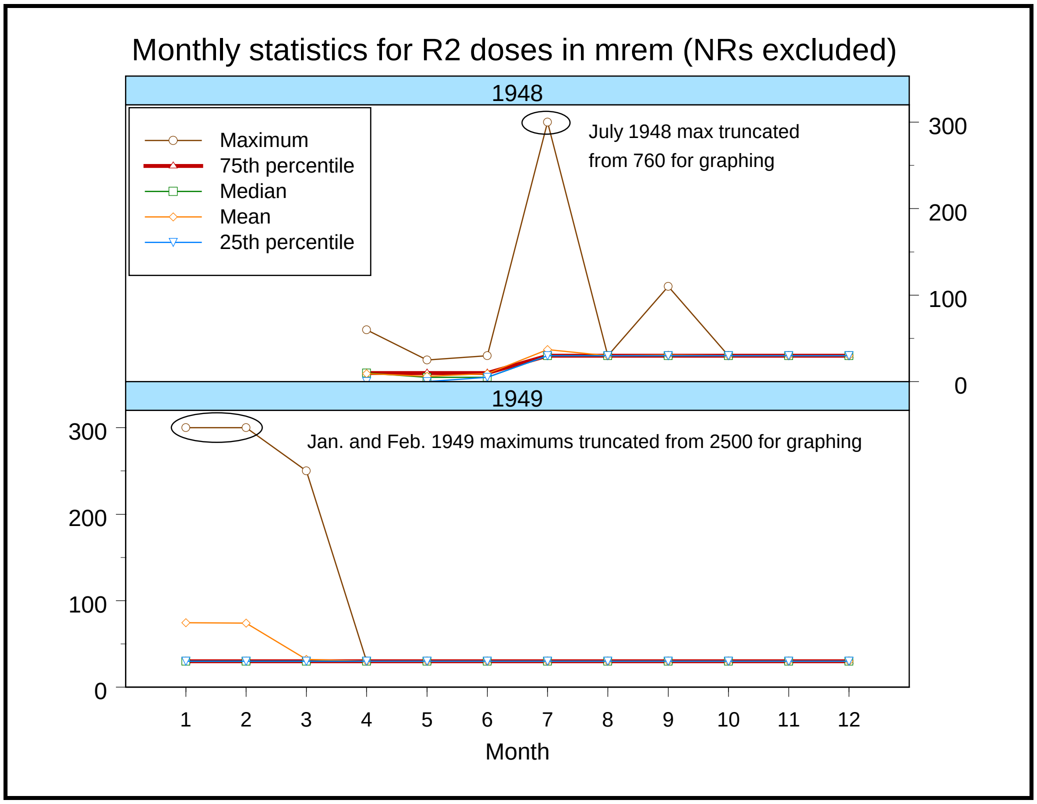

Figure 6-4. Monthly statistics for R2 doses in mrem (NRs excluded).

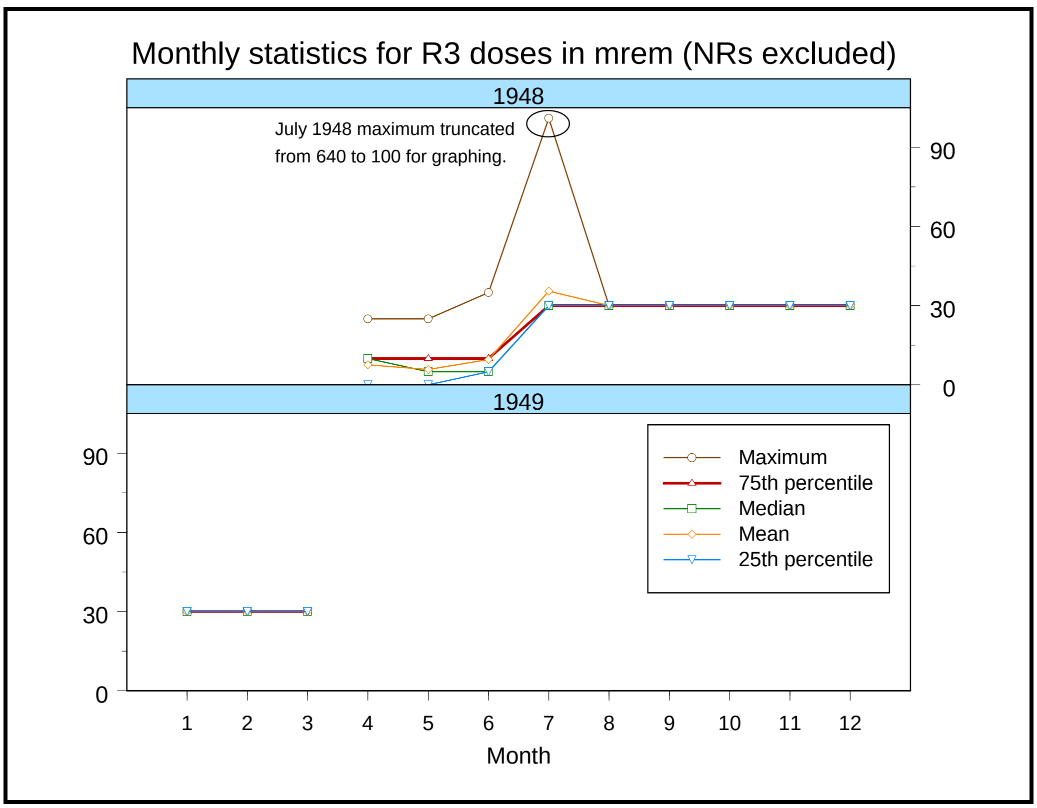

Figure 6-5. Monthly statistics for R3 doses in mrem (NRs excluded).

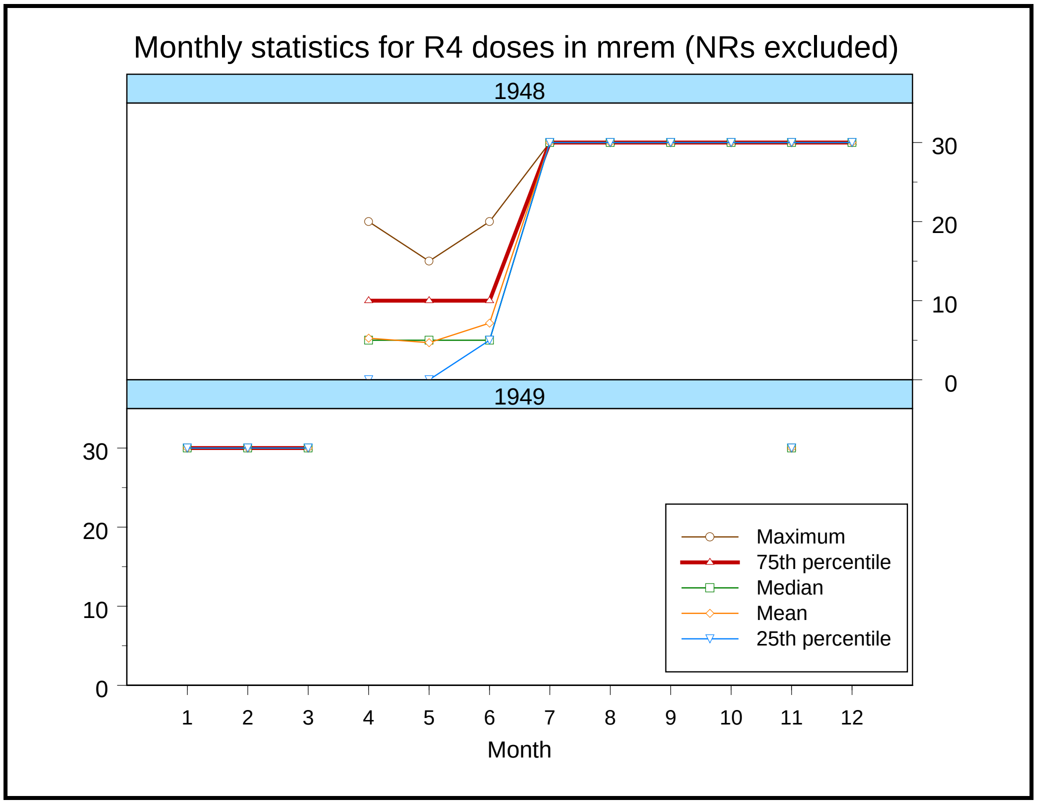

Figure 6-6. Monthly statistics for R4 doses in mrem (NRs excluded).

early Health Physics reports (Struxness 1948b,c). The R2 reading from the 502 sensitive film under the open window of a film badge show a response to photons with energies less than 0.1 MeV that is as much as 15-20 times greater than the response to photons of higher energies (Handloser 1959; Thornton, Davis, and Gupton 1961), whereas PICs have trouble detecting photons with energies less than 0.1 Mev because they are heavily attenuated in the wall materials of the PICs as discussed previously in Section 3.1. The high R2 reading for another worker in the Fire Department (Dept. 2093) in July 1948 appears to be an artifact for a couple of reasons: (1) the R2 and R3 readings for the skin and whole-body doses are nearly equal (see Figures 6.4 and 6.5), and (2) the high R3 reading for the whole-body dose is not observed in either the R1 or R4 readings for the worker (see Figures 6.3 and 6.6). The recorded R3 dose of 640 mrem was greater than either the R1 MDL of 5 mrem or the R4 MDL of 500 mrem.

6.0 DISCUSSION

The external monitoring data for the 1948-1949 period at the Y-12 facility have been reviewed in this report. During the 1948-1949 period, both PICs and film badge dosimeters were used at Y-12 (Souleyrette 2003; ORAUT 2003). The PICs appear to provide the doses of record during this period. This is consistent with practices at other DOE facilities such as the Oak Ridge National Laboratory and Hanford Site (Ostrouchov, Frome, and Kerr 2000). Initially, PICs were considered the primary device for monitoring worker exposures, and film badge dosimeters were considered a valuable adjunct (Hart 1966). This practice was eventually reversed with the film badge dosimeters providing the dose of record, and the PICs became the day-to-day means of monitoring worker exposures (Wilson et al. 1990). The switch from PICs to film badge dosimeters to provide the doses of record at Y-12 occurred in 1950 (ORAUT 2005a).

Pre-1950 film badge data have been considered questionable because of frequently changed procedures and a perceived general lack of monitoring quality control during this period (Tankersley 1982). For example, for R2, R3, and R4 in the Y-12 data, it appears that either 0 or 30 mrem might have been assigned if all four weekly readings in the month fell below the MDL during certain periods of time. In addition, the very large doses observed in the R2 and R3 film badge responses were sometimes absent in the PIC data (see Figures 6-3 through 6-5). The PIC data were obtained with devices that were very simple to use; they should provide reliable data regarding whole-body doses from gamma rays and high-energy beta particles during the 1948-1949 period. Several R2 readings suggest high exposures to the skin from either beta particles or low-energy photons that may not have been detected by the PICs (see Figure 6.4). The 1948-1949 personnel dosimetry studies at Y-12 demonstrated that film badges provided a reliable and convenient method for monitoring the shallow doses to basal layer of the skin from both beta particles and low-energy photons and penetrating whole-body doses from gamma rays. In 1950, NTA film emulsions were also added to the film badge dosimeters to provide the capability of monitoring whole-body penetrating doses to workers exposed to neutrons (Souleyrette 2003; ORAUT 2003).

The 1948-1949 monitoring data appear to be useful in a variety of ways in dose reconstructions for Y-12 workers. In a prior study, for example, gamma-ray dose data for Y-12 workers from 1950 to 1979 were reviewed, and a method was developed for estimating gamma-ray dose starting with the UCC management change in the third quarter of 1947 (ORAUT 2005a). Doses estimated by this method for Y-12 workers during the 1948-1949 period are found to be very claimant-favorable in comparison to the actual external monitoring data reported herein obtained using PICs. The MDL for the PICs was approximately 5 mrem, and monitoring appeared to be inclusive because many NR doses were recorded for workers who were judged to have external exposure potential. Therefore, it is not likely that a substantial amount of external dose was unrecorded. The 1948-1949 monitoring data reviewed in this report are now available on the O: Drive of the secure data server at the ORAU-COC.

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It provides general guidance on the development of occupational radiation protection programmes as appropriate for the sources of radiation likely to be encountered in the workplaces in question to fulfil the managementâ€™s responsibility for protection and safety. Detailed guidance is also provided on the monitoring and assessment of workersâ€™ exposure due to external radiation sources and from intakes of radionuclides. The Safety Guide reflects the current internationally accepted principles and recommended good practices in occupational radiation protection, with account taken of the conceptua Ensuring radiation safety during construction of nuclear facilities and their decommissioning. The construction of new units of nuclear power plants on the territory of the Russian Federation is carried out on construction sites in the immediate vicinity of existing NPP and fall into the BA. Accordingly, the radiation monitoring at the nuclear power plant construction site is made by and at the cost of the customer (the NPP Radiation Safety department).Â Quarterly and annual doses as well as the total dose during the whole working period are accounted as well. Exposure doses of Group A* personnel. Subdivision. 12.1 Introduction 12.2 Description of Cyclotron Facility 12.3 Radiation Monitoring in the Cyclotron Facility 12.4 Safety Interlock and Warning System 12.5 Laboratory Safety Instructions 12.6 Personal Responsibilities 12.7 Records 12.8 Radiation Safety Check List 12.9 Procedures for Handling of Irradiated Targets 12.10 References. 13. Radiation Accident and Emergency Procedures. 13.1 General Principles 13.2 Accidents involving only external exposure 13.3 Contamination by nuclear substances 13.4 Contaminated patients who need medical attention 13.5 Fires involving radioactive material. 14. Educa...Â The organizational basis of radiation safety at the Montreal Neurological Institute and Hospital is as follows