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Mr. C. N. Rucker, Executive Director

Subject: The Exposure of Employees to Radiation.

The following information is submitted by the Division of Health Physics of this laboratory for your information and use.

1. Types of Radiation Hazards Existent in Oak Ridge National Laboratory

Employees of the Laboratory, under certain conditions, be exposed to gamma radiation, beta radiation, neutron radiation and alpha radiation. Except for a few workers doing intensive work of a special nature, exposure of employees to alpha and neutron radiations is considered to offer no significant hazard. Those few workers especially subject to alpha and neutron hazards are shown by special methods of monitoring for alpha and neutron exposures to be well within limits of safety for such radiations.

2. Protection of Laboratory Employees from Radiation Exposures.

Employees of the Laboratory are protected from dangerous amounts of radiation by three methods:

(a) Experimental scientists, specializing in a study of the properties

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of these radiations and their effects, devote their major effort to considerations of personnel safety in the Laboratory. In cooperation with these men, processes and equipment are designed to make the hazards due to radiations less than those commonly due to other industrial hazards. Protective clothing and other safety devices are furnished wherever needed.

(b) Trained junior scientists, commonly called health physics surveyors, are assigned to the various operations areas. It is the duty of each surveyor to keep himself sufficiently informed as to the nature of the operations planned for each area so that he can prevent the persons working in the area from unknowingly exposing themselves to any significant amounts of radiation. In the event of operations involving unusual radiation hazards, the health physics surveyor customarily works with other employees, monitoring the rate of radiation exposure and giving such advice as the situation may warrant. In the event that operation conditions develop radiation levels that might be expected to produce exposure above that considered tolerable for a day's work, the area in which such conditions exist is evacuated. In some cases, it is desirable to have personnel work in such areas in shifts of from a few minutes to a few hours each. Such practice

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controlling exposure to radiation is no different than that employed by a physician in controlling exposure to X-radiation for diagnostic purposes, except that the permissible individual (daily) exposures under the operating conditions of our Laboratory are much less than those used in diagnostic X-ray work. (The maximum daily exposure under such circumstances is limited to about one half of that involved in a chest X-ray and to about 1/50 of that frequently involved in a hip X-ray).

(c) Each employee entering the operations area is provided with two types of radiation monitoring instruments to record the dosages of gamma and beta radiations he may receive. Where the exposure of parts of the body may be significantly different from that of the portion of the body on which the meters are customarily worn, additional meters are provided. For example, for certain types of work, rings containing X-ray film are worn on the fingers to monitor exposure to the hands. The radiation exposures indicated by these meters are recorded in a permanent radiation file maintained on each such employee.

These radiations records provide a basis for correcting any working conditions which might, if maintained over long periods of time, result in injury

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to the employee; and provide the Medical Department with any significant data bearing on the health or welfare of the employee.

3. Personnel Monitoring Instruments, Procedures and Records.

The monitoring of exposures of personnel to the radiations frequently encountered in significant amounts -- gamma radiation and beta radiation -- is generally accomplished with the use of two types of exposure meters. These are herein referred to as pocket meters and film meters. The pocket meter is a small ionization chamber, about the size of a fountain pen, which when electrically charged becomes discharged in a field of gamma radiation by an amount which depends upon the radiation dosage. The film meter consists of an X-ray film in a suitable metal container which, in a field of gamma or beta radiation, becomes exposed by an amount which depends upon the radiation dosage. A pocket meter may occasionally be discharged as a result of dropping or other improper handling, but no mechanism is known by which the charge may be accidentally increased except by wilfully opening the meter and placing it on a battery or other charging device. Because of this characteristic of pocket meters, they are worn in pairs as insurance against loss of data in event of complete or partial accidental discharge of one of them. Standard equipment for the monitoring of exposure to radiation for

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persons working in radiation is, then, two pocket meters and one film meter.

Exposure to gamma radiation is measured in milliroentgens, customarily abbreviated mr. Exposure to beta radiation is measured in milliroentgens equivalent physical, abbreviated mrep. One mrep of beta radiation is considered as approximately equivalent, in terms of biological damage to the surface of the body, to one milliroentgen of gamma radiation. In the United States, it is the consensus of opinion of radiologists that radiation dosages up to 3,000 mr per month (that is, 3 roentgens per month) may be tolerated by the body without permanent damage to the tissues. For purposes of control and for increased safety, within the Atomic Energy Commission an effort is made to keep the radiation exposure to any individual less than 100 mr per 24 hour period. Operating on this basis, monthly totals are almost invariably much lower than the limiting value of 3,000 mr considered tolerable by radiologists.

Pocket meters are read daily. In the event that a pair of pocket meters indicates an exposure of 100 mr or greater, the employee's film badge is processed immediately to confirm the validity of the exposure. Readings of pocket meters and film badge are sent on the following day to the area health physics surveyor for an investigation and correction of the condition from which the exposure or

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indication of exposure resulted. Such incidents are comparatively rare, and many of them are found to have resulted from tampering with the meters or wilfull exposure of the meters by placing them near known sources of radiation.

Exposure Record for members of the Bargaining Unit for the six months period ending December 31, 1947.

For the purpose of this report, a summary of the gamma and beta exposure records of all members of the bargaining unit, on record as members of the plant roll as of March 1, 1948, has been prepared and is submitted herewith. The data submitted for each employee is based on original records contained in his radiation record folder for this six months period, and is believed to be essentially correct and entirely representative of the radiation conditions under which members of the bargaining unit work. This report has been prepared by the trained technicians who handle the details of processing personnel monitoring meters and maintaining exposure records. The complete radiation record for each individual contains daily pocket meter readings for those days on which his work required him to wear radiation meters, weekly film meter readings if he is subject to radiation hazards in his job; together with data from other sources, indicating significant exposure to radiation, and records of investigations of any suspected

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exposure exceeding 100 mr or 100 mrep for any one day or exceeding 250 mr or 250 mrep for any one week. For the purpose of this report, it is not considered practical to reproduce the detailed radiation exposure record of each member of the bargaining unit. However, a detailed exposure record of any member can be produced upon request.

Explanation of Entries in Summary of Exposure Records submitted herewith.

TSR
(mr) Total significant reading.

Under this heading is presented the sum of all significant pocket meter readings, measured in millicoentgens, recorded during the six months period. (In the small percentage of cases in which the two pocket meters indicate different exposures, the larger of the two is considered accidental. This procedure can be fully justified on the basis of principles of operation of the pocket meter.) If the employee faithfully carried pocket meters whenever working in the operations area, this represents fairly accurately the total exposure to penetrating gamma radiation during the six months period.

No. E - Number of Entries in pocket meter record of individual. Pocket meters are available conveniently on a "serve yourself" basis in the clock alleys. On days for which no entry exists, it cannot be determined whether the employee did not enter the operations area or whether he wilfully refrained from picking up

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his pocket meters.

ADE
(mr) Average Daily Exposure

This is an average of the exposures recorded, found by dividing the total exposure recorded during the six months period by the number of pocket meter entries. If the employee faithfully carried pocket meters whenever working the operations area in compliance with Laboratory regulations, this is the average of the exposures indicated for those days on which the employee may have been exposed to measurable radiation.

TOW
(Red) - Total open window readings accumulated during the six months period, measured in milliroentgens physical. A portion of the X-ray film used in the film meter is shielded by a thin sheet of cadmium. The unshielded portion, referred to here as the open window portion, is subject to exposure to very low energy gamma radiation and to beta radiation, as well as to the high energy gamma radiation indicated by exposure of the shielded portion of the film. In general, it is difficult to give a unique interpretation of an open-window indication, since on milliroentgen of low energy gamma radiation may produce up to fifty times the effect on the film that is produced by one milliroentgen equivalent of beta radiation. It is the practice in this laboratory to report all open window exposures as if they were due to

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beta radiation, which means that the reported value is never less than the actual exposure may be as much as fifty times greater than the actual exposure, depending upon what part of the exposure is due to low energy gamma radiation.

ADOW (mrep) - Found by dividing the total exposure recorded for six months by the number of work days in a six months period. Average daily open window exposure. If it is assumed that the employee wore his film meter faithfully when working in the operations area and as required by the Laboratory regulations, this represents the average exposure per work day during the six months period.

MAX OW - The maximum open window exposure recorded for any one week of the employee's exposure record. (This value is given for one week since the films are processed weekly.) As in TOW above, the reported value may be much higher than the exposure, but it is believed that it cannot be lower.

TS Total Shield Exposure.

This represents the total dosage of penetrating gamma radiation as indicated by the film meter, since the shield filters out the beta radiation and the gamma radiation of extremely low energy. This is the portion of the radiation which would be chiefly responsible for any tissue damage other than that produced in the skin of the person exposed.

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ADS- The average exposure per work day over the period of six months is obtained by dividing the accumulated shield exposure for this period by the normal number of work days in a six months period.

Max S - The maximum exposure to penetrating gamma radiation recorded for any
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one week of the employee's record. (This value is given for one week since the films are processed weekly.)

Discussion of Radiation Records Submitted.

The highest exposures recorded for the six months period are those of , Badge No. 6712 (List C 13), , Badge No. 6655, (List E 43), and , Badge No. 6229, (List K 53).

The badge meter record of shows an average exposure to penetrating gamma radiation of 15 mr per day for the 118 days on which the meters were worn. This is about 15% of the value accepted as a tolerable maximum. The film meter records indicate an average exposure to penetrating gamma radiation of 11 mr per day for the normal number of work days in a six months period. These values are in good agreement. The unshielded portion of the film indicates a possible exposure of the skin to an average of 50 mrep per day for the normal number of work days in the six months period. This is about

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50% of the value accepted by radiologists as an acceptable maximum, but much higher than the goal sought by the Oak Ridge National Laboratory. The highest possible exposure to beta and low energy gamma radiation indicated for one week in record is a possible 735 mrep. As nearly as one can compare beta radiation exposure with X-ray exposure, this is about 40% of the minimum surface dosage involved in an X-ray of the spine (Typical surface exposures resulting from diagnostic X-rays are given by J. H. Martin in the British Journal of Radiology, July, 1947, pages 279 to 284. He states that the mean dosage for chest X-rays is about 200 mr; that spine X-rays vary from 2,000 to 34,000 mr, and that gastro-intestinal examinations involve surface exposures ranging from 1,000 mr to 8,000 mr per film, with an average value of 5,000 mr per film.)

The record of requires no discussion in addition to that given The exposures are generally lower. The record of is noteworthy only on account of a single OW exposure, which interpreted as a beta exposure, would indicate a dosage of 1,800 mr. However, an investigation of the film indicates that the exposure was due to X-rays. According to a statement by , the film meter was worn in his shirt

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pocket while he was given a series of six x-rays (elbow, knee and pelvis) in a search for the cause of a case of arthritis. The OW reading recorded here in no way represents the actual X-ray exposure since the film was not in the maximum intensity of the beam and since the film was not calibrated for low-energy X-rays.

Accuracy of Summary of Exposure Records Presented Herewith.

This summary was prepared by health physics technicians trained in the handling of health physics records and typed by stenographers from the Laboratory Personnel Department. The condition under which it was prepared preclude an absolute check of accuracy. While it is inevitable that errors have crept into the preparation and transcription, it is believed by the undersigned to be essentially accurate and to be typical of the radiation exposures to which these workers are subjected.

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