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PERSONNEL-EXPOSURE AND CONTAINMENT CONTROL IN THE ROUTINE OPERATION OF THE ORNL RESEARCH REACTORS

T. M. Sims

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INTRODUCTION AND SCOPE

"Safety" as applied to the operation of a research reactor involves a wide variety of factors and a number of areas of concern. In addition to those measures taken to prevent or minimize the effects of serious accidents, two other aspects of the safety of a reactor operation are:

1. Those measures taken to control occupational radiation exposure incurred in the routine operation of a reactor and in the conduct of activities associated with its operation.
2. Those measures taken to minimize the frequency and effects of minor radiation and contamination incidents.

This paper is concerned largely with these two aspects of safety as they are applied in the operation of research reactors at ORNL. Emphasis is placed on some of the specific factors (procedures, practices, techniques, etc.) involved. Some overlapping into areas of safety other than the two specified is unavoidable in that measures aimed at controlling minor incidents and exposures usually contribute to the prevention of more serious ones.

GENERAL ROLE OF INVOLVED GROUPS

At the ORNL research reactors, the two groups most directly involved in the control of occupational exposure and minor radiation and contamination incidents are the operating group (the Reactor Operations Department) and the area Health Physics group. The success of their efforts is largely dependent upon the adequate discharge of certain responsibilities on the part of each group and on the degree to which they cooperate in their respective activities.

In keeping with the Laboratory policy, prime responsibility for effective control in these two areas of safety rests with the operating group. Important factors contributing to the satisfactory discharge of this responsibility include:

1. Proper consideration of personnel exposure data provided by Health Physics.
2. Adequate planning of jobs where significant personnel exposure may be a factor.
3. The establishment of, and adherence to, adequate procedures for the safe execution of operations involving potential hazards.
4. Close cooperation with the area health physics group in the conduct of all activities involving potential radiation exposure hazards.
5. The establishment of routine survey practices sufficient to ensure that radiation and contamination hazards are recognized and located without undue delay.
6. The determination of the radiation-detection instrument requirements of the reactors.

7. Adequate employee training in radiation safety.

Effective personnel-exposure control in the operation of the reactors requires competent and effective health-physics coverage. An area group of eight health physicists is stationed in one of the reactor buildings. In addition to providing health-physics coverage for the ORR, the OGR, and the LITR, this group provides coverage for several other nearby facilities; but essentially the entire complement is available in case of a local radiation emergency. Although the day-to-day requirement for coverage at the three reactors varies somewhat, the effort of approximately three health physicists is required on the average for day-shift coverage. This is broken down by reactor according to the following estimate:

Reactor	Man-days/day
ORR	1.25
OGR	0.9
LITR	0.7

Night shift coverage for the entire Laboratory is provided by two health physicists.

A listing of some of the specific functions of this group and the services they perform which are related directly to the control of personnel exposure and the handling of radiation and contamination incidents is given below:

1. Each area health physicist is charged with maintaining an intimate knowledge of the radiation-safety aspects of the work performed in his area so that he may assist in the assessing of the radiation hazards of each operation, advise on the radiation safety aspects of operating procedures, and recommend radiation

control and protection measures for particular jobs. Each job requiring health-physics surveillance is assigned to a competent surveyor. To discharge these responsibilities properly, the area health physicists must be kept informed by the operating group of the radiation safety problems in current or proposed operations.

2. The area health physics group acts somewhat as an inspection group, reporting periodically on the status of the radiation protection program in the reactor area to the Operations Division Director.

3. Health Physics provides operating supervision with daily reports on the accumulated radiation exposure received by individual operating personnel. This information provides a basis upon which operating supervision may control the radiation dosage received by individuals to within acceptable working limits.

4. The area health physics group serves in an advisory capacity in recommending to the operating group the numbers and types of health physics instruments to be used at the reactors. Portable instruments are assigned to the area health physics group leader and furnished, through him, to the operating group. Periodic maintenance, inspection, and calibration of these instruments are scheduled by the area health physics group. Nonportable health physics instruments are primarily the responsibility of operating supervision. Field servicing, checking, and inspection of these instruments are, however, handled by the area health physicists.

5. In addition to providing continuous health physics surveillance for specific jobs as required, the area health physics group perform numerous routine and special radiation and contamination surveys throughout the reactor area. One of the most important services of this group is the assistance they provide in the handling of unusual occurrences involving radiation or contamination. For example, in the case of an unusual incident involving airborne contamination, they provide assistance in locating the source, in determining and carrying out immediate steps to confine the source, as well as other protective measures required by the situation.

ADMINISTRATIVE MEASURES IN PERSONNEL EXPOSURE AND CONTAMINATION CONTROL

Electronic, mechanical or other type safety devices find extensive application in reactor subsystems, components, and reactor experiments as safeguards aimed at preventing or minimizing the effects of serious accidents. In the control of occupational exposure and in the prevention and handling of minor radiation and contamination incidents, the usefulness of such devices (radiation detection instruments excluded) is somewhat more limited. Administratively established and enforced control measures are relatively much more important. Such control measures include specific procedures, practices, work methods, checks, inspections, regulations, etc. Several factors determine the degree to which such measures are successful in accomplishing these desired objectives. Common sense must be exercised in making rules. While strict controls must be established when the situation requires, there should be a real need for any specific control measure established; i.e. it should, in fact, contribute to

safety. Of equal importance is the degree to which such controls are understood and conscientiously applied and enforced by operating and other involved personnel.

Radiation Control Zoning Practices[1]

A formal radiation control zoning program is used throughout the Laboratory. Its basic objectives are:

1. To control personnel radiation exposure through the establishment of appropriate control zones in areas where significant radiation fields or contamination levels are present.
2. To reduce the spread of radioactive contamination by confining it to the smallest space possible.

Three type zones are involved, (1) regulated zones, (2) contamination zones, and (3) radiation zones. A regulated zone is an area where operations are restricted for the purpose of radioactive contamination control. A regulated zone may contain radiation zones, contamination zones, or both. The entire reactor area is so zoned. A radiation zone is an area where control measures are established to prevent or minimize <u>external</u> radiation exposure to personnel. A contamination zone is an area where control measures are established to prevent the contamination of employees, equipment, or the environment and where there is a possibility that radioactive materials may become deposited inside the body leading to <u>internal</u> radiation exposures.

Guides used in the establishment of radiation and contamination zones are illustrated in Tables 1 and 2.

Table 1. Procedure for Posting and Establishing Radiation Zones[2]

Dose Rate Range	Immediate Action	Follow-Up Action
3 mrem/hr to 6 mrem/hr	Post low-level tags if the accumulated daily dose to Personnel may be 20 mrem.	Periodic review.
6 mrem/hr to 1 rem/hr	Post warning signs or tags.	Rope off the area if the accumulated weekly dose may be 1 rem.
1 to 3 rem/hr	Post warning signs or tags. Rope off.	Erect a barricade which provides absolute exclusion of personnel if the accumulated weekly dose in the area may be 12 rem. Lock or block entrance.
Over 3 rem/hr	Post warning signs, tag, and erect a temporary barricade. Lock and/or block all entries.	

Table 2. Contamination Levels to be Used as a Guide[2] in the Establishment of Contamination Zones

Type of Radiation	Airborne Contamination ($\mu c/cc$ air)	Direct Reading Surface Contamination	Transferable Surface Contamination ($d/m/100/cm^2$)
Alpha	2×10^{-12}	300 $d/m/100\ cm^2$	30
Beta-Gamma	3×10^{-10}	0.25 mrad/hr	1000

The levels shown in this table are, in some instances, subject to adjustment when the specific contaminant is known.

The control measures for the various types of zones are established on the basis of the degree of hazard associated with each zoned area. That is, the more hazardous the radiation or contamination conditions in a particular zoned area, the more stringent are the control measures specified for that particular zone. Such control measures include:

1. The establishment of the zone boundary, the posting of warning tags and appropriate zone identification signs.
2. The establishment of designated zone portals at each zoned area where entry and exit of personnel and equipment are permitted and controlled. Specific regulations governing a particular zone are posted at the zone portals. Such regulations include:
   a. Requirements for protective clothing and other items of protective equipment required for entering the zone.
   b. Applicable radiation survey and dosimetry requirements.
   c. Required contamination surveys of personnel and equipment leaving contamination zones.
   d. Any other specific instructions, pertaining to entry or exit, applicable to the particular zone.

In effect, an attempt is made to provide all necessary information relative to entry, exit, and any other applicable requirements at the zoned area, itself.

There are many such zoned areas at the reactors. Of necessity, many of these are more or less permanent. Special effort is made to limit the number of contaminated areas existing. Prompt clean-up contributes; but preventive measures such as the judicious use of blotter paper, wet rags, vacuum, pre-establishment of contamination zones, and

adequate planning of specific jobs involving potential sources of contamination are much more important.

General Area Radiation-and-Contamination-Survey Practices

Each operating group is responsible for insuring that adequate radiation and contamination surveys of areas and activities under its direction are performed. Such surveys should be sufficient in both extent and frequency such that the following objectives are met.

1. Prompt detection of radiation and contamination associated with or resulting from the performance of "short-term" jobs or the conduct of "short-term" activities.
2. Prompt detection of new or unsuspected radiation sources and contaminated areas.
3. Prompt detection of significant changes (in the direction of increasing hazard) in the radiation or contamination level associated with recognized existing or potential sources.

The first objective must be met primarily through sufficient monitoring and surveillance <u>during</u> the conduct of the job itself and through follow-up surveys at the work site upon completion of the job. A number of factors must be considered in determining the requirements for a particular job. These include: the nature of the job, the degree and type of hazards expected, how well the hazards are understood, conditions at the work site, and similar factors. Requirements applicable to a specific job are usually established through consultation between the interested parties (operating supervision, health physics, and any third parties involved) using guides established by the Laboratory and experienced judgment and common sense. The operating group retains prime responsibility for the adequacy of measures so established.

In order to help meet the second and third objectives, certain routine radiation and contamination survey practices have been established at the reactors. Current practices in force at the ORR are described briefly below. In addition to the practices outlined, the judicious use of continuous monitoring devices (as discussed in a later section) is an important factor in meeting the third objective.

Standard Radiation-Survey Practices

Most reactor shields contain a number of access facilities which may be opened for various reasons during shutdown. Certain changes may be made which affect the degree of shielding afforded. It is recognized then that the startup of a reactor may present dangerous radiation hazards attributable to these factors even though every effort is made to ensure otherwise. During startup of the ORR, it is standard practice to have Health Physics personnel closely monitor critical areas, including the horizontal beam holes and the north and south facilities, for β-γ and neutron beams. The installation of new experiments or experiment components may require special surveys during reactor startup. Shortly after attaining full power a general area radiation survey is made by operating personnel using a check sheet, attached as Appendix 1. This check sheet is also used in making routine area radiation surveys on a weekly basis. Similar practices are in force at the other two reactors.

Routine Contamination Surveys

To assist in the prompt location of contaminated areas, routine contamination survey practices are standard at the reactors. They may be outlined as follows:

1. Areas where specific jobs likely to result in contamination of the work area have been performed are smear checked shortly after completion of the job.
2. Contamination surveys of certain areas are routinely made on a recurring basis by health physics personnel as follows:
   a. A general smear check of the entire reactor building is made on a monthly basis.
   b. Lunch rooms, offices, and other areas where the presence of contamination is exceptionally undesirable are routinely smeared on a weekly basis.
   c. Established contamination zones are smeared on a two-week frequency. This is done primarily as a check to ascertain whether contamination levels are significantly changing.
   d. Certain areas subject to a large volume of personnel traffic and/or an "above average" possibility of becoming contaminated are smeared once every two weeks or, in some instances, more often.

As previously discussed, an effort is made to prevent the spread of contamination from one area to another, primarily through the zoning practices described. The routine contamination surveys outlined above serve, in part, as a check on the effectiveness of such efforts.

Occupational Exposure Control

The success of any effort aimed at effectively controlling occupational radiation exposure is dependent on several factors. Of these, one of the most significant is the emphasis which is placed by operating supervision on the importance of limiting such exposures. Experience

has shown that best results are obtained when each individual is made clearly aware of his own responsibilities in limiting his own exposure. Individuals who receive exposures in excess of limits established by the department are "re-educated" in their responsibility for limiting their own exposure by the department supervisor.

The official record of each individual's occupational exposure is normally obtained from his film badge which is developed on a quarterly basis. Effective control of exposure requires more frequent feedback to the operating group of information relative to the exposure status of all operating personnel. The basic source of this information comes from indirect reading pocket electrometers which all operating personnel* are required to wear. These electrometers are read daily by Health Physics. Any individual exposure in excess of 20 mrem received in one day is reported to Operations supervision the following day or sooner if this seems advisable. Accumulated exposure for the current week is also reported in these cases. The daily reports from the pocket electrometers are posted in the reactor control rooms. These records show daily exposures in excess of 20 mrem for the current week and the cumulative total exposure for the current quarter for each individual. This information provides the basis for future permissible exposures and permits individual

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*This includes all operators, shift supervisors, shift formen, and certain other individuals.

accumulated exposures to be kept within the established working limit. While this exposure information is after the fact, it serves as a means of detecting, on a daily basis, significant (>~10 mrem) unanticipated exposures as well as daily exposure up to ~200 mrem (the approximate upscale limit of the type of dosimeters used). In the event an individual's pocket meter reading is off-scale (indicating an exposure in excess of ~200 mrem) his film badge is developed to determine the exact exposure. The amount of exposure so determined then dictates the extent to which future exposure of the individual must be limited.

In the Reactor Operations Department an attempt is made to limit individual weekly exposures, as determined from pocket electrometer readings, to a value of approximately 50% of the current recommended weekly exposure limit established by the Laboratory. This policy has been adopted primarily to ensure that personnel exposures within the department are kept well below the Laboratory exposure limits. The personnel exposure experience of the department is illustrated in part, by Figures 1 and 2. Figure 1 shows exposure data for the fifteen individuals in the department having the highest average yearly exposure rates. Total 1961 exposures as well as fourth quarter 1961 exposures for these individuals is also shown. Figure 2 shows exposure data for the fifteen individuals in the department who accumulated the highest exposures in 1961. The average exposure accumulated in 1961 by shift supervisors, foremen, and reactor operators was 0.98 rem. Average 1961 exposures by subgroups are given in Table 3.

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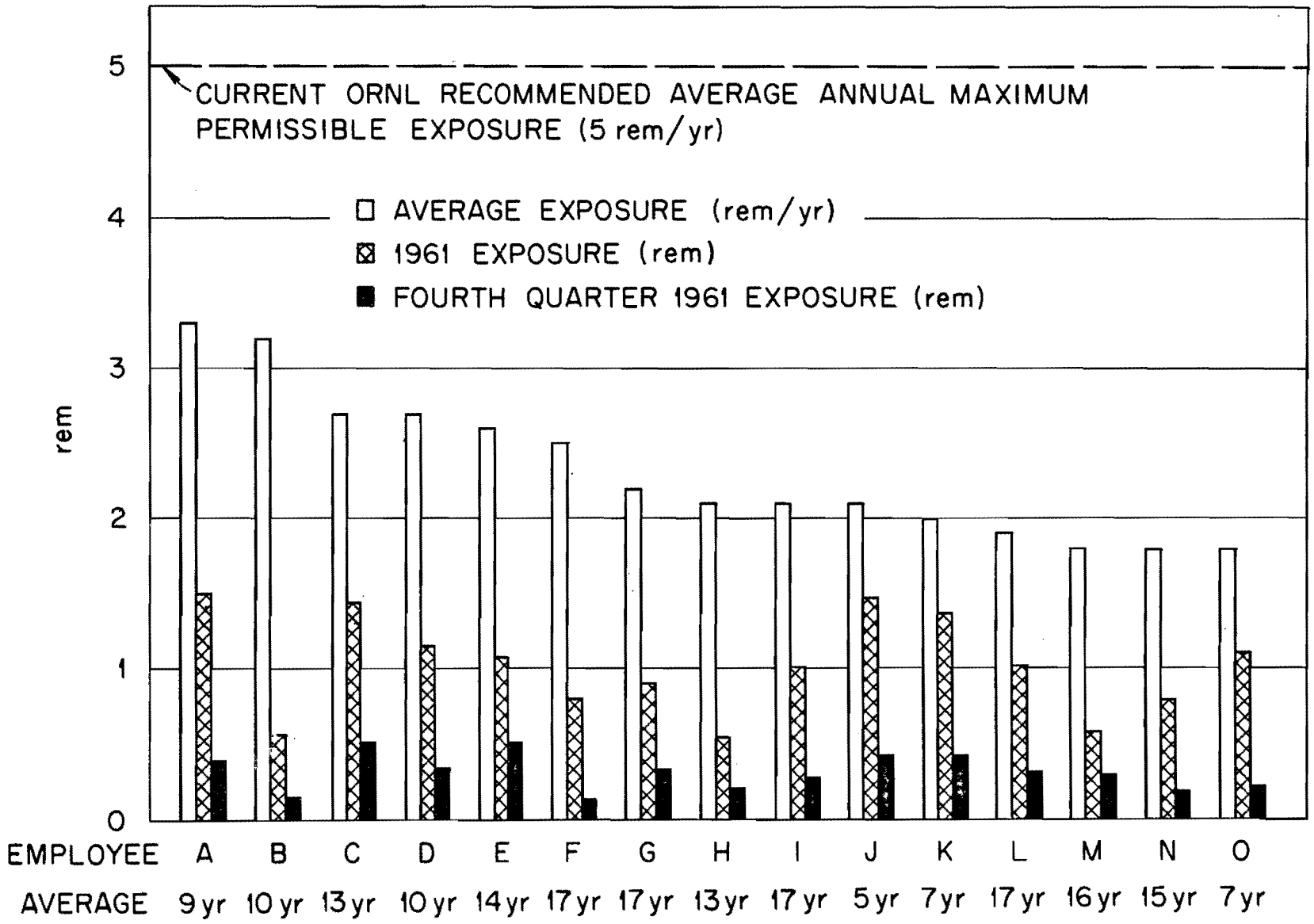
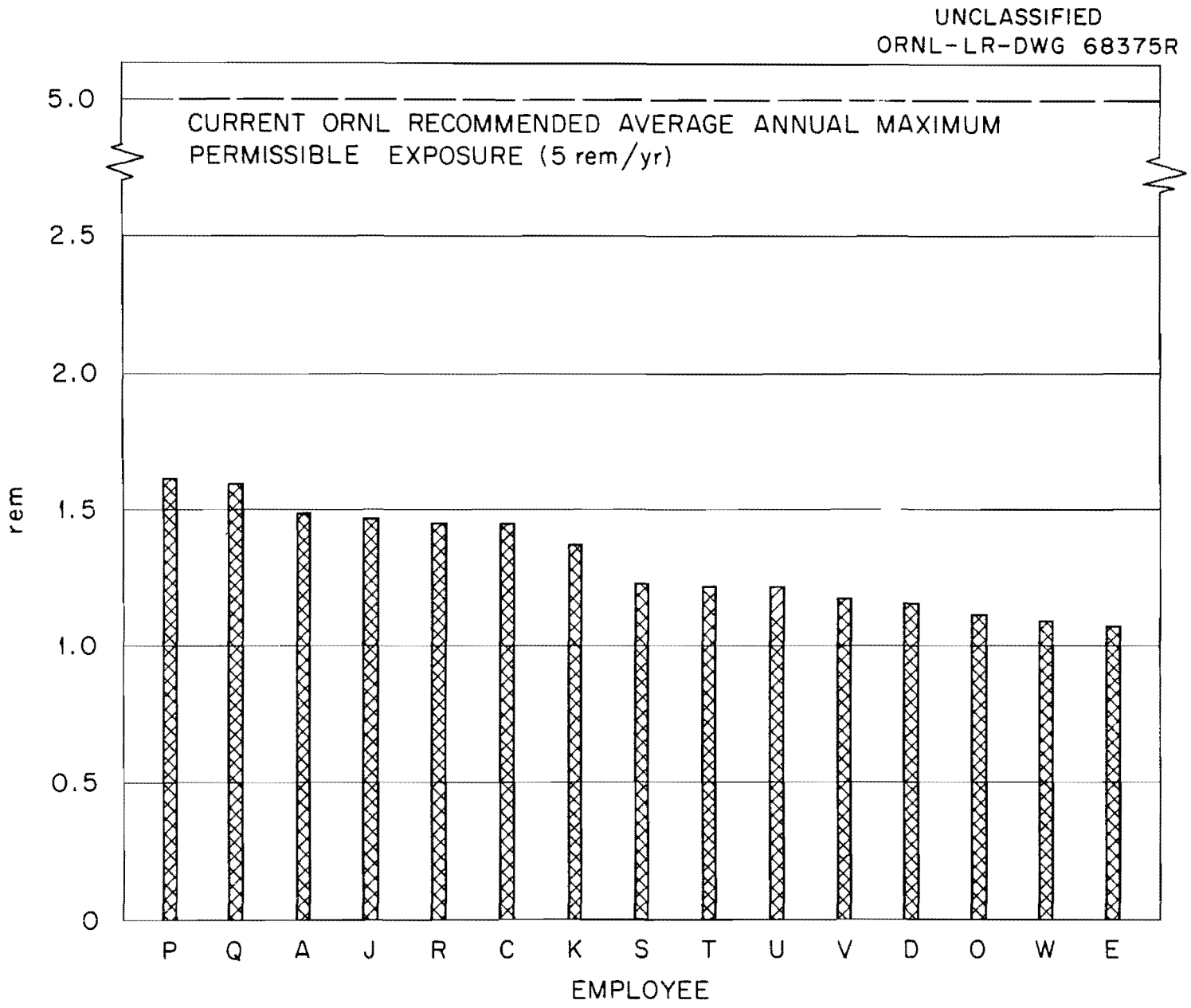


Average Yearly Occupational Exposures (15 Highest).

FIGURE 1



1961 Total Individual Occupational Exposures (15 Highest).

FIGURE 2

Table 3. Average 1961 Accumulated Exposure to Operating Personnel

Group	No. of Individuals	Average 1961 Accumulated Exposure (rem)
Shift Supervisors	4	0.81
Foremen	6	0.88
Operators	22	1.05

Considering the wide variety of activities at the reactors having significant and, in some cases, very serious exposure potential, personnel exposure history of the department is remarkably good.

Some procedures and practices aimed primarily at exposure and contamination control have been established by the Laboratory. One such practice is the Laboratory-wide radiation control zoning program, previously discussed. Another such practice is the use of Radiation Work Permits.(3) This permit constitutes authorization for one or more individuals to do a particular job which may involve exposure to a specified amount of radiation or contamination. The permit describes the proposed work site and the protective measures required in performing the particular job covered. Circumstances requiring the use of a work permit are specified in the cited reference. Operations supervision determines the need for and issues the Radiation Work Permit. Area Health Physics certifies the radiation survey data and protective requirements set forth on the permit. Special approvals are required under the following conditions:

1. Planned expsoures to radiation fields in excess of 5 rem/hr require approvals as shown in Table 4.

Table 4. Special Approvals Required for Radiation Work Permits Involving Planned Exposure to Dose Rates >5 rem/hr

Total Body Dose Rate (rem/hr)	Special Approvals Required
> 5	Division Director in charge of work area
> 20	Above and Director of Health Physics Division
> 50	Above and Deputy Laboratory Director

2. Planned exposures in excess of certain specified amounts require approvals as shown in Table 5.

Table 5. Special Approvals Required for Radiation Work Permits Where the Planned Dose Exceeds Specificied Limits

Authorized Dose Accumulations (Total Body)	Special Approvals required
>60 mrem/single day to non-operating* personnel, and/or >300 mrem/single week to operating personnel	Division Director in charge of individual
Single exposure >1 rem	Division Director in charge of individual and Laboratory Deputy Director

*Refers to personnel who are members of one division but are involved in work at an area controlled by another division; e. g., Engineering and Mechanical personnel working at one of the reactors.

A copy of the form used is attached as Appendix 2.

In certain recurring activities, experience has required the establishment of rather rigid personnel-exposure and contamination control measures. An example of this is maintenance work done in the ORR reactor pool during the end-of-cycle shutdowns. Some of the factors involved in this activity which required the establishment of such controls include:

1. The relatively high general radiation level in the work area.
2. The general contamination level of the work area.
3. The significant contamination potential associated with many of the jobs performed.
4. The possibility of a significant change in the general radiation background in the work area.
5. The large volume of personnel traffic into and out of the work area. Access to the area is required by a large number of personnel from different groups, many of whom may not fully understand the potential hazards.

As an illustrative example the specific controls applicable to this activity are enumerated in Appendix 3.

As discussed at length in another paper,[4] written procedures are required for the conduct of certain phases of reactor experiments. For many experiments, an important objective of such procedures, particularly those concerned with installation, test specimen removal and handling, sampling, maintenance, and repair, is the prevention of personnel exposure and establishment of contamination control. A significant portion of the "minor" radiation and contamination incidents experienced has resulted from operations of this nature.

Criticality Safeguards and Exposure Controls in the Handling of Fissionable Materials

In the handling of fissionable materials adequate safeguards must be provided for the prevention of accidental criticality. Also storage and handling must be accomplished in a manner which affords minimization of personnel exposure. An obvious factor in criticality control is accurate accountability of on-hand fissionable material. In addition, consideration must be given to the criticality problem in the design and construction of storage and handling facilities and equipment. A perhaps less obvious factor is that care must be exercised in the usage of fuel-handling facilities and equipment to ensure that criticality safeguards are not subverted through misuse or nonuse. The role of administrative control in this factor is readily apparent. Administrative controls also find application in the second area of concern; i.e., minimization of personnel exposure in handling irradiated fuel elements. Their handling is subject to the usual practices and safeguards employed in the handling of any radioactive material; however, their extremely large source strength makes them items of special concern. Specific administrative controls* relative to fissionable material handling at the reactors are established in operating manuals and procedure memoranda. As an illustrative example, a partial list of such controls applicable to ORR fuel handling is included below:

1. Storage of shim rods and fuel elements is permitted <u>only</u> in specific facilities especially designed for that purpose.

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*Procedures, work methods, requirements, regulations, limitations, etc.

2. Any movement of ORR fuel elements or shim rods must be authorized in writing by the ORR Supervisor. All such movements must be directly supervised by the shift engineer or the shift foreman. Each fuel element and shim rod must be positively identified each time it is moved. In loading the core the shift engineer or foreman must personally verify the core position receiving each previously identified fuel element. Observation of the count rate meter is required during the insertion of each fuel element.
3. All fuel movement (except for loaded storage racks and carriers) must be made manually without the use of the power crane. When using the power crane for moving loaded storage racks, an operator must be stationed at the master switch box to shut off power to the crane in case the control switch malfunctions.
4. As a criticality safeguard the four elements adjacent to a shim rod must be removed prior to removal of that rod.
5. Continuous radiation monitoring of all irradiated fuel-element movements is required.

Detailed written procedures concerning all phases of fuel handling have been established.

Training of Operating Personnel in Radiation Safety

The increasing emphasis placed on up-grading the training and knowledge level of reactor operating personnel has been paralleled by an increased emphasis on the radiation safety training of personnel throughout the Laboratory. It is highly desirable that in so far as possible a continuing sense of "radiation awareness" be instilled in all reactor

operating personnel. It is equally important that operating supervisors feel a personal sense of responsibility for the radiation safety aspects of jobs performed under their supervision and for the enforecement of appropriate control measures in the conduct of activities under their direction. The success of efforts in this direction markedly influences the degree to which personnel exposure and radiation and contamination incidents can be minimized. Radiation control training within the Reactor Operations Department may be described somewhat as follows:

Formalized Training

A section on radiation control has been included as one phase of the "formalized" training given reactor operators as described in another paper.(5) The subject content of this phase, outlined in that paper, includes elementary presentations of: the basic physical phenomena involved in the interaction of radiation and matter, the biological effects of various types of radiation, methods for safely working with sources of radiation and contamination, radiation detection instrumentation, and a survey of the more frequently applied rules, regulations, limits, etc. General training programs conducted by the Laboratory supplement training given to operating supervisors by division personnel.

Practical Training

New operators and operating supervisors spend a certain length of time in on-the-job training under the direction of experienced operating supervisors. Here they learn the less glamorous, but by no means less important, every-day techniques for safely handling radiation sources through working in a fairly wide variety of radiation and contamination situations. It is in this phase of training that new operating personnel

develop specific knowledge of the systems they are to operate, learn to recognize those areas and activities requiring protective measures, and gain practical experience in using methods for limiting occupational exposure and minimizing the frequency and effects of radiation and contamination incidents. Toward these aims, practical experience has no satisfactory substitute. Any tendency to minimize the importance of such experience should be guarded against.

Continual Training

In line with the view that "radiation awareness" on the part of operating personnel must be continual, each shift holds regularly scheduled safety meetings. The subject matter discussed in these meetings is not strictly limited to, but does include, radiation safety and control. It may include:

1. The implications of minor radiation incidents occurring at, and publicized within, the Laboratory.
2. Discussion of any recent minor radiation or contamination incidents within the reactor area; causal factors, preventive measures, etc.
3. Any features or practices appearing questionable from the standpoint of safety (radiation safety included) which come to the attention of any of the operating personnel during the normal conduct of their activities. In this manner safety hazards which might otherwise be overlooked are brought to the attention of the proper people for appropriate action.

HEALTH PHYSICS INSTRUMENTATION COMPLEMENT

Each operation group at the Laboratory is responsible for determining its requirements for radiation detection instruments. Determining the quantities and types of such instruments required for adequate coverage at a particular facility cannot generally be accomplished by the application of a set of standards. Features peculiar to the particular facility and the nature of the involved activities must be considered. Whether or not a given complement of health physics instrumentation is adequate is largely a matter of subjective judgment on the part of operating and health physics personnel familiar with both the facility itself and the activities involved in its operation.

Nonportable Instruments

Nonportable health physics instruments used at the reactors include: monitrons, continuous air monitors (CAM's), α and β-γ smear counters, and hand and foot counters.[6] Characteristics of these instruments are summarized in the cited reference.

Monitrons are stationary, AC powered, alarming type, β-γ sensitive detecting instruments.* These instruments are widely used for continuously monitoring "populated" locations within the reactor areas, for continuously monitoring recognized existing or potential radiation sources, and for obtaining continuous general area coverage.

Continuous air monitors (CAM's) are used for monitoring the particulate radioactive contaminant level in the reactor building air. These are β-γ sensitive instruments which draw a continuous sample of air through a filter surrounding a G-M tube. Airborne particulate contami-

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*Also sensitive to thermal neutrons if the chamber is boron coated.

nants are concentrated on the filter. A significant rapid increase in the airborne concentration level of particulate β-γ emitters is indicated by an increase in the count rate which is continuously recorded. Quantitative concentration levels of long-lived alpha and β-γ emitters are determined through counting techniques using the CAM filters.

The number and location of the instruments of these two types utilized at a facility usually represents a compromise between the following factors:

1. Adequate general area coverage. Instruments should be used in sufficient number and should be located so that, in so far as is practical, no large unmonitored areas exist.
2. Adequate monitoring of populated areas. The frequency of personnel access and the volume of personnel traffic in specific areas should be considered in choosing the locations of such instruments.
3. Adequate monitoring of recognized existing or potential radiation sources. The necessity for continuously monitoring recognized existing or potential radiation sources, particularly those which under likely or possible circumstances can increase to dangerous levels, must be considered.

Threshold-detector units for the purpose of determining neutron energy distribution are located throughout the reactor buildings. These units have been provided at the reactors for several years, and increased emphasis has been placed on providing means for their remote removal. At present three of these units at the ORR can be removed from outside the reactor building. Current plans call for similar provisions for the other reactor buildings.

The current nonportable health physics instrument complement of the ORR is listed in Table 6.

Table 6. ORR Nonportable Health Physics Instrument Complement

Instrument Type	Location	Number of Instruments
Monitrons	Third Level	3 (including 1 in control room)
	Second Level	4
	First Level	4
	Basement	2
Total		13
Continuous Air Monitors	Third Level	1
	Second Level	1
	First Level	1
	Basement	3
Total		6
Threshold Detector Units	Third Level	1 (outside entrance to control room)
	First Level	4 (including 3 which are recoverable from outside the building)
Total		5
Hand and Foot Counters	Southwest Building Entrance	1
Total		1
Smear Counters	Health Physics Office	1 alpha
		1 beta-gamma
Total		2

Portable Instruments

Portable health physics instruments are assigned to the area health physics group leader who supplies them to the operating group. The complement assigned to the reactor area health physics group also supplies the needs of facilities other than the reactors which are served by this

group. However, the existing complement would probably not be substantially reduced if no facilities other than the three reactors were involved.

Portable instruments are located as follows: A certain portion of the more frequently used β-γ detectors (Geiger-Mueller survey meters and cutie pies) are placed in "field" locations throughout the reactors, primarily in areas where usage requirements are high. For example, at the ORR seven cutie-pies and four G-M survey meters are kept in stands located throughout the building. A certain portion of the complement is in the shop for periodic inspection, maintenance, and calibration. For most portable instruments this is accomplished on a 4-to 8-week basis. The remaining instruments including essentially all alpha, neutron and special-purpose instruments are kept in the area health physics office when not in use.

The portable health physics instrument complement of the reactor area health physics groups is listed in Table 7.

Table 7. Reactor Area Portable Health Physics Instrument Complement

Instrument Type	Quantity
Cutie Pies	57*
Geiger-Mueller Survey Meters	51
Fast Neutron Instruments	7
Thermal Neutron Instruments	7
Juno Survey Meters	8
Portable Alpha Instruments	8

*Includes two 1000 r/hr cutie pies

REFERENCES

1. Radiation Safety and Control Training Manual, Oak Ridge National Laboratory, Section 9.1.

2. Radiation Safety and Control Training Manual, Oak Ridge National Laboratory, Section 9.1, p 61 and 62.

3. "Procedures and Practices for Radiation Protection", Health Physics Manual, Oak Ridge National Laboratory, Procedure No. 26, (August 4, 1961) (To be published).

4. C. D. Cagle, Standards for Experiments at ORNL.*

5. E. N. Cramer, An Analysis of Training Programs in the Operations Division at ORNL.*

6. Radiation Safety and Control Training Manual, Oak Ridge National Laboratory, Section 4.

*Papers presented at the "Conference on Light-Water-Moderated Research Reactors," ORNL (June, 1962).

BACKGROUND SURVEY

PERFORMED BY	REASON	DATE	TIME

NOTE: This Survey is to be performed each Saturday and after the startup of the reactor at the beginning of a cycle. A survey meter (G-M Counter) shall be used for this Survey, with a Cutie Pie used when survey meter goes off scale.

AREA		mr/hr MAXIMUM BACKGROUND	mr/hr PRE-SET LOCATION
1. POOLS:			
a. East	TAKEN AT SURFACE NEAR POOL WALLS		
b. Center			
c. West			
d. Top of Bridge			
e. Above Hydraulic Tube			
2. HOT CELL:			
a. North Cell			
1. Window			
2. Access Holes (Not Including Top of Cell)			
3. Walls (Up To Height of 6 Feet)			
b. South Cell			
1. Window			
2. Access Holes (Not Including Top of Cell)			
3. Walls (Up To Height of 6 Feet)			
3. WALKWAYS:			
a. Third Level, South			
b. Third Level, North			
c. Second Level, South			
d. Second Level, North			
e. Second Level, West			
f. First Level, South			
g. First Level, East			
h. First Level, North			
i. First Level, West			
4. EXPOSED EXPERIMENTAL EQUIPMENT (PIPING, ETC.) ON 2nd. LEVEL BALCONY:	NORTH		
	SOUTH		
5. FACILITIES:			
a. North Facility			
b. South Facility			
c. HB-1			
d. HB-2			
e. HB-3			
f. HB-4	1		
	2		
g. HB-5			
h. HB-6			
6. BASEMENT:			
a. Pipe Tunnel			
b. Sub-Pile Room Door			
1. Near Reactor Bottom Plug			
c. North Walkway			
d. South Walkway			
e. Pool Heat Exchanger Area			
f. Beam Hole Plug Storage Area			

	mr/hr	
AREA	MAXIMUM BACKGROUND	PRE-SET LOCATION
6. BASEMENT (Continued)		
g. Degasifier		
1. Air Separator		
2. Water Tank		
h. Pneumatic Tube Laboratory		
i. Reactor North Demineralizer		
1. Anion		
2. Cation		
3. Mixed Bed		
j. Reactor South Demineralizer		
1. Anion		
2. Cation		
3. Mixed Bed		
k. Pool Demineralizer		
1. Anion		
2. Cation		
7. PUMP HOUSE:		
a. #1 Pump Cell		
b. #2 Pump Cell		
c. #3 Pump Cell		
d. Shutdown Pump (Electric) Cell		
e. Emergency Pump (Gasoline) Cell		
8. REACTOR HEAT EXCHANGER PIT:		
a. Entrance		
b. North Side of Pit		
c. South Side of Pit		
9. REACTOR WATER ACTIVITY		
10. POOL WATER ACTIVITY		
11. SUMP COUNTS		
a. #5 (Decay Tank)	c/m/ml	
b. #4E (Expansion Pit)	c/m/ml	
c. #4W (Expansion Pit)	c/m/ml	
d. #6 (3042)	c/m/ml	

RADIATION WORK PERMIT (RWP)

DATE AND TIME	EXTENDED BY	WORK PERMIT NO.
FROM AM PM TO AM PM	TO AM PM	R-

LOCATION & JOB DESCRIPTION

RADIATION SURVEY DATA (To be filled in by Health Physics)

LOC. CODE	SPECIFIC LOCATION AND DISTANCE FROM SOURCE	TYPE OF RADIATION	mrem/hr.	WORKING TIME FOR _____ mrem	CONTAMINATION		RADIATION SURVEY	
					TYPE	MEASUREMENT	BY	DATE AND TIME
A								
B								
C								
D								

INSTRUCTIONS*

HEALTH PHYSICS MONITORING REQUIRED: ☐ START OF JOB ☐ INTERMITTENT ☐ CONTINUOUS ☐ END OF JOB

CONTACT HP FOR SURVEY BEFORE STARTING WORK IN A NEW LOCATION		PROVIDE ASSISTANCE FOR REMOVAL OF PROTECTIVE CLOTHING	
TAPE COVERALLS TO GLOVES AND FOOTWEAR		MONITOR BREATHING ZONE	
CHECK TOOLS AT END OF JOB		NASAL SMEAR REQUIRED	
CHECK PERSONNEL AT END OF JOB		BIOASSAY SAMPLE REQUIRED	
TIMEKEEPING REQUIRED		DO NOT WORK ALONE-STANDBY OBSERVER REQUIRED	

REMARKS

PROTECTIVE EQUIPMENT AND MONITORING INSTRUMENTS

CAP		COVERALLS (1 PR.)		SHOE COVERS		POCKET METERS	
CANVAS HOOD		COVERALLS (2 PR.)		C-ZONE SHOES		DOSIMETER	
SAFETY GLASSES		GLOVES: CANVAS		RUBBERS		FILM RING	
EYE SHIELD		GLOVES: LEATHER		RUBBER BOOTS		DOSE-RATE ALARM	
HALF MASK		GLOVES: SURGEON'S		PLASTIC BOOTEES		DOSE ALARM	
ASSAULT MASK		GLOVES: PLASTIC		LAB COAT		CUTIE PIE	
CHEMOX MASK		GLOVES: RUBBERIZED CANVAS		SPECIAL FILM METER		GMS METER	
AIR-LINE HOOD		GLOVES: HOUSEHOLD RUBBER					
AIR-LINE SUIT							

REGULAR APPROVALS	SPECIAL APPROVALS
HEALTH PHYSICS CERTIFICATION	DIVISION DIRECTOR
SUPERVISION	H.P. DIVISION DIRECTOR
SUPERVISION	DEPUTY LAB DIRECTOR

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*Only items checked (√) apply.

(OVER)

APPENDIX 2

1. Health Physics shall be present for line breaks or removal of shielding.
2. Notify Health Physics of any deviations from instructions and changes in working conditions.
3. Personnel survey is required when leaving contamination zones.
4. Return work permit to Health Physicist upon completion of job or expiration of permit.

TIMEKEEPING BY _____

DEPT. _____

PERSONNEL AND EXTERNAL EXPOSURE CONTROLS						PLANNED EXPOSURE (mrem)	TIME RECORD							ESTIMATED EXPOSURE (mrem)
NAME	DEPT.	P.R. NO.	LOCATION CODE	DOSE RATE USED	WORKING TIME		BEGIN	END	BEGIN	END	BEGIN	END	TOTAL TIME	

1. **Radiation Work Permit is required* when:**
   (a) expected dose is > 20 mrem to the body or 300 mrem to extremities for an individual during a single work assignment;
   (b) dose rate > 5 rem/hr (total body);
   (c) airborne radioactivity is > $(MPC)_a$ for a 40-hr week;
   (d) specified by divisional operating rules and procedures or by posted regulations.
2. **Supplementary Time Sheet**
   To be used if extra space is needed for the timing of individuals into and out of an area, etc.
3. **Special Approvals**
   (a) Dose Rate rem/hr (total body)

> 5	Division Director in charge of work area	Oral or written; noted and initialed on the permit by the person obtaining the approvals.
> 20	Above and Health Physics Division Director.	
> 50	Above and Laboratory Deputy Director.	

   (b) Dose (total body)

> 60 mrem/day for nonoperating personnel, or > 300 mrem/wk for operating personnel	Division Director in charge of individual
> 1 rem	Above and Laboratory Deputy Director

4. **Copies**
   (a) The RWP must be posted or available at work site.
   (b) Health Physics maintains a copy for record and reference purposes.
   (c) A copy must be distributed to appropriate line supervision.

*Posted regulations may be used in lieu of an RWP for *operating personnel* under specified conditions. (See Regulation 3, Procedure No. 26, ORNL Health Physics Manual.)

APPENDIX 3

The personnel exposure and contamination control measures established for ORR in-pool shutdown and maintenance work referred to on page 18 are listed below:

1. The reactor pool, including the immediately adjacent access area, is designated as a radiation and contamination zone and usually remains so zoned during the entire shutdown (~ 1 week).
2. Access areas immediately adjacent to the pool are covered with taped-down blotter paper to minimize contamination of these areas.
3. Personnel access to and from the pool and adjacent area is strictly limited to a single zone portal.
4. A clothing change station is established at this portal. Included are supplies of C-zone coveralls, gloves, caps, shoe-covers and other items of protective clothing and equipment as required. Repositories for contaminated protective clothing are provided.
5. A portable survey instrument for contamination surveys of personnel and equipment leaving the zone is provided. A supply of self-reading pocket dosimeters is also provided.
6. A radiation work permit authorizing the performance of work in the pool is posted at the job site. The work permit must be approved by line supervision of all personnel requiring access to the pool.
7. General requirements applicable to entry to the zoned area immediately adjacent to the pool are posted at the zone portal. These requirements include:

a. Supervisor's approval

b. "C" zone clothing

c. Rubber gloves

d. Shoe covers

e. Cap

8. The detailed requirements for pool entry relative to (1) the required items of protective clothing and equipment, (2) the required personnel monitoring instruments, and (3) the Health Physics surveillance requirements are specified on the radiation work permit. These may vary dependent on the conditions within the pool, or the particular jobs involved, but generally are significantly more stringent than requirements for entry to the zoned area immediately adjacent to the pool.

9. A special alarming type monitron chamber is located in the reactor pool on top of the reactor tank. It is checked with a source each time it is installed in the pool. Its function is to provide warning in the event of a significant change in the radiation background.

10. A constant air monitor is provided for monitoring the air in the work area.

11. A general background survey of the work area is performed by Health Physics personnel at least once every 8 hours. An up-to-date "map" of the work area showing the results of the latest radiation survey is displayed at the zone portal.

12. A contamination survey of all personnel and equipment leaving the zoned area is required.

13. The presence of a member of the reactor operating group is required at all times as a standby observer whenever work is done in the reactor pool. His main functions are:

    a. To insure that exposed experiment access tubes, reactor components, etc., are not damaged.

    b. To assist in any way possible in case some incident or accident occurs in the pool.

14. A log is kept on all personnel entering and leaving the pool. A self-reading pocket dosimeter is required for pool entry. Individual exposures indicated by these dosimeters, which are read when personnel leave the zoned area, are recorded on a card file maintained at the zone portal as a means of maintaining a history of personnel exposure incurred in this activity.

DISTRIBUTION

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