EGCR-4

# RADIOLOGICAL HEALTH MANUAL FOR THE EXPERIMENTAL GAS-COOLED REACTOR

Experimental Gas-Cooled Reactor Operated By
The Tennessee Valley Authority at Oak Ridge

UNITED STATES ATOMIC ENERGY COMMISSION
Division of Technical Information

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EGCR-4

REACTOR TECHNOLOGY
(TID-4500, 29th. Ed.)

# RADIOLOGICAL HEALTH MANUAL

# FOR THE EXPERIMENTAL GAS-COOLED

# REACTOR

RADIATION PROTECTION
STANDARDS AND REGULATIONS

March 26, 1964

Contract TV-21280A
Interagency Agreement AT-(40-1)2742

Experimental Gas-Cooled Reactor Operated By
The Tennessee Valley Authority at Oak Ridge

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Larry E. Williams
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RADIOLOGICAL HEALTH MANUAL

EXPERIMENTAL GAS-COOLED REACTOR

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You are charged with the responsibility for this copy of the Radiological Health Manual. As changes are made to parts of the Manual, you are responsible for:

1. inserting new pages, and

2. removing and destroying superseded pages.

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## PREFACE

The Tennessee Valley Authority, through its Division of Health and Safety, provides occupational and industrial health services for all its employees. To provide guidance for the protection of employees and the public from ionizing radiation, there is a Radiological Health Staff in the Office of the Director of Health.

In preparation of this Radiological Health Manual, the latest recommendations of the Federal Radiation Council have been incorporated. For those phases of the program where FRC recommendations have not been released, the pertinent recommendations of the National Committee on Radiation Protection and Measurements have been followed. Existing requirements of the Atomic Energy Commission and regulations of the Interstate Commerce Commission have been considered.

From time to time, sections of this Manual may be revised or supplemented as needed to conform to revised or new regulations of recognized authorities or to provide for improved protection for employees and the public.

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# EGCR RADIOLOGICAL HEALTH POLICY

## POLICY

1. Plant operations are conducted so as to minimize exposure to ionizing radiation and to keep exposures accumulated by employees within the limits prescribed by the Federal Radiation Council.

2. Radioactive contamination is controlled so as to avoid hazards to people and to minimize the costs of decontaminating or replacing personal and plant property and the loss of plant operating time.

3. Excessive release of radioactive materials to the environment is avoided. Such releases shall not cause air and water contamination beyond the EGCR site to exceed maximum permissible values for persons living in the vicinity.

## RESPONSIBILITIES

1. Radiological Health Staff

   The Radiological Health Staff develops and applies radiation protection standards. Its Radiological Health Section provides continuous health physics coverage at EGCR, including radiation monitoring of site operations and the immediate environment, and advises management of hazardous conditions and their control. It periodically reviews the adequacy of protective measures and advises management when improved practices are needed. It collaborates in planning for radioactive waste management and disposal.

2. Hazards Control Staff

   The Hazards Control Staff provides the continuing evaluation of the design and operation of the plant so as to limit risks to acceptable levels, in accordance with the model described in the current version of the Hazards Summary Report and related documents.

3. Controls Engineering Section

   The Controls Engineering Section maintains fixed radiation monitoring instruments and performs maintenance work on portable instruments as requested.

4. Chemical Engineering Section

The Chemical Engineering Section advises the Operations Group on matters relating to radioactive waste management and disposal. It obtains and analyzes samples of gaseous and liquid wastes. It is responsible for storage and custody of radioactive sources and SS material. (See Appendix IV-2.)

5. Operations Group

The Operations Group is responsible for conducting all operating functions in a safe and orderly manner. The plant Operations Supervisor represents EGCR management in all phases of plant operation during his shift. He assumes full responsibility for the handling of emergencies occurring on his shift until relieved by higher authority. In performing these duties, he is guided by advice and assistance obtained from the Radiological Health representative on duty in matters relating to radiation and contamination control.

6. Individual Employees

Each employee is required to abide by the rules and regulations adopted by management. Failure to follow procedures for radiation protection may lead to disciplinary action, including termination.

# INDOCTRINATION AND TRAINING IN RADIOLOGICAL PROTECTION

## POLICY

Employees whose work involves potential exposure to ionizing radiation are adequately trained in radiation protection methods.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Provides training in radiation protection for all employees who work with ionizing radiation.

   b. Assists in the indoctrination of new employees, trainees, and visitors in the fundamentals of radiation protection.

2. Supervisors

   Each supervisor arranges for and ensures that each of his subordinates, trainees, and visitors is given proper training in radiation protection prior to assignment to work involving potential radiation exposure.

## REGULATIONS

1. All EGCR employees are given adequate training in the methods, practices, and procedures of radiation protection for the safe conduct of their work assignments.

2. All temporary employees and trainees assigned to the EGCR whose duties involve potential exposure to radiation are given adequate radiation protection training and are subject to the provisions of these regulations.

3. Short-term visitors to the EGCR are given basic orientation in radiation protection depending on their prior background and training.

4. A record is maintained of all formal training given each employee in radiation protection, including the names of instructors, subject matter included, and references.

# PLANT SAFEGUARDS REVIEW

## POLICY

Plant startups, operations, changes in operating procedures, maintenance work, tests, experiments, equipment changes, or other alterations are put into effect only after adequate hazards investigations have been made and the necessary safety limitations or protective measures provided.

## DISCUSSION

Standard procedures are established in the Operating Manual, Standard Practices Manual, Operations Section Instruction Letters, and Day Orders for the EGCR.

Any proposed change in plant equipment, plant design, or method of operation requires the review by appropriate staff members to determine that such changes do not introduce new hazards or increase the potential of hazards beyond those analyzed in the Hazards Summary Report. If the potential is increased, such changes may be made only with prior AEC approval.

## RESPONSIBILITIES

1. Project Manager

   a. Determines that the proper hazards investigations have been made and the required reviews and approvals are completed.

   b. Submits the proposal, together with the hazards report and TVA recommendations, to AEC (ORO) if the proposed authorization falls in a category requiring AEC approval.

   c. Issues the authorization only after the established procedural requirements have been met.

2. Review Group

The Technical Program Superintendent, the Operating Superintendent, and the Supervisor of the Radiological Health Section are responsible for initiating and reviewing proposed authorizations for changes in plant design or operating procedures. They recommend a course of action to the Project Manager.

3. Hazards Control Staff

The Hazards Control Staff participates in and coordinates the preparation of hazards analyses and reports pertaining to such changes and furnishes them to the Technical Program Superintendent.

4. Supervisors

Each of the supervisors of the several technical sections is responsible for having studies performed and for preparing the information for that portion of the analysis which is within his field of technical responsibility.

# RADIATION STANDARDS

## POLICY

Unnecessary exposure to ionizing radiation of regular employees and other persons subject to these regulations is avoided. Dose limits prescribed herein are not exceeded.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Establishes and applies radiation protection standards for the control of radiation exposures to personnel at EGCR.

   b. Informs management of the current radiation exposure status of each employee by means of daily, weekly, quarterly, and yearly reports.

   c. Compiles reports of excessive exposure, radiation and contamination incidents, and other special reports required.

2. Supervisors

   a. Ensure that all subordinates are informed of radiation hazards in their work area and that radiation protective measures are utilized.

   b. Take all reasonable precautions to avoid unnecessary exposure of employees and restrict operations performed by subordinates involving necessary exposure to or below prescribed limits.

   c. Limit the accumulation of high individual exposure by distributing work loads and assignments.

3. Individual Employees

   a. Take reasonable precautions to avoid unnecessary exposure and limit those exposures that are considered necessary.

b. Report to Radiological Health Section and to supervisor all known or suspected overexposures due to either external or internal radiation.

c. Report promptly to Radiological Health Section and to supervisor any injury involving radioactive contamination, sickness, or physical condition which might alter his capability for radiation work at EGCR.

d. Report to Radiological Health Section and to supervisor any extensive prior or concurrent exposures (i.e., medical or dental X-ray exposures) received at locations other than EGCR.

e. Report to Radiological Health Section and to supervisor any new or unusual situation which might lead to direct or indirect exposure.

STANDARDS

1. Occupational exposure as a result of ionizing radiation encountered at EGCR shall not exceed the values prescribed in Table II-1.1. (See Appendix A-II-1 for definitions, symbols, and abbreviations.)

STANDARDS (Continued)

TABLE II-1.1

Recommended Limiting Dose To

Body Organs Of Occupational Workers

| Body Organ | Average Weekly Dose in Rems | Limiting Dose in Rems: Quarterly (13 weeks) | Limiting Dose in Rems: Annual | Limiting Dose in Rems: Accumulation Total |
|---|---|---|---|---|
| Total body,[a] head and trunk, lens of eyes, blood-forming organs, or gonads | .1 | 3 | 12 | 5(N-18)[b] |
| Skin of whole body,[c] thyroid | .6 | 10 | 30 | |
| Hands and forearms, feet and ankles | 1.5 | 25 | 75 | |
| Bone | | $\frac{30}{4n}$[d] | $\frac{30}{n}$ | |
| Other body organs | | 5 | 15 | |

a. Any radiation with half value-layer > 1 mm of soft tissue.

b. N is attained age in years.

c. Any radiation with half value-layer < 1 mm of soft tissue.

d. n is the "relative damage factor" and applies to internal exposure. It is 1 for radium and gamma; otherwise, n is considered equal to 5 for all radionuclides in bone.

2. Nonoccupational exposures as a result of EGCR operations are controlled by limiting the concentrations and rates of release of radioactive materials discharged to the environment. The exposure values listed in Table II-1.2 shall be limiting in all phases of normal plant operation.

TABLE II-1.2

Recommended Limiting Dose Of Ionizing

Radiation To Nonoccupational Groups

| Nonoccupational Group | Total Body Lens of Eyes Gonads | Air and Water Concentration |
|---|---|---|
| Adults who work in vicinity of the controlled area or who enter controlled area occasionally | 1.5 rems/yr | 30% of 40-hr/wk occupational MPC* |
| Persons living in neighborhood of controlled area | .5 rem/yr | 10% of 168-hr/wk occupational MPC |
| General population: | | |
| Individual (whole body) | .5 rem/yr or 5 rems in 30 yrs | 1% of 168-hr/wk occupational MPC |
| Average (gonads) | 0.17 rem/yr | |

Values based on average over 1 year

*Occupational MPC values are given in Section II-2, Tables 2.5 and 2.6.

STANDARDS (Continued)

3. In cases of nominal accidents involving short-term exposures to both occupational and nonoccupational groups, the values in Table II-1.3 may be used as guides.*

TABLE II-1.3

Accidental Exposure Limits* In Rems

(13-week maximum)

| Body Portion | Occupational Worker | Persons Living in Neighborhood of Controlled Area |
|---|---|---|
| Bone | 7.3 | .73 |
| Skin and thyroid | 10 | 1 |
| Total body and gonads | 3 | .3 |
| Other body organs | 5 | .5 |

*Single intakes or short-term exposures may occur during a short period of time due to an accident or a particular kind of operation that is not continually being performed. Such intake or exposure may be averaged over the 13-week quarter, provided the 13-week limit is not exceeded.

4. For extreme emergency situations involving possible loss of human life, extensive property damage, or both, it is necessary to have preestablished emergency exposure values. The values listed in Table II-1.4 may be used as guides, but only with the full knowledge and consent of the EGCR Project Manager or his duly authorized representative.

TABLE II-1.4

Maximum Limiting External Exposure[a]

To Be Used Only During Extreme Emergency

| Dose | Remarks |
|---|---|
| 12 rems | For planned exposure |
| 25 rems in 1 day[b] | Taken only if necessary to prevent serious damage to plant or personnel |
| 100 rems in 1 day[c] | To be taken to save a life (non-planned exposure) |

a. Adequate protective equipment must be provided so that the internal exposure can be considered negligible. Subsequent work assignments must be planned to permit the earliest possible return of the employee to a status consistent with a dose accumulation not exceeding 5(N-18).

b. Considered "once-in-a-lifetime" emergency dose, and the individual receiving such an exposure must be removed from areas where he could be exposed to another emergency dose.

c. Personnel so exposed should be made aware of the possible consequences such as vomiting and nausea in some cases, but no serious disability. They must be removed from areas where they could be exposed to another emergency dose.

REGULATIONS

1. Only those individuals qualified for radiation work by prescribed medical standards are allowed to perform work at EGCR. Criteria for disqualification for work in a radiation environment include:

   a. A known history of previous external or internal occupational radiation exposure in excess of maximum permissible limits.

REGULATIONS (Continued)

b. A known history of nonoccupational radiation exposure (diagnostic, therapeutic, etc.) significantly exceeding the maximum permissible limits for occupational exposure.

c. Other physical limitations specified by the Director of Health, TVA. (See Divisional Instruction VIII, "Health Services - Radiation Workers," Division of Health and Safety, TVA.)

2. Exposures at EGCR are kept as far below the maximum permissible dose limits as is feasible. The average limit of 100 mrems per week (total body exposure) is used as an operational limit, and any planned exposures in excess of this limit must be approved by the EGCR Project Manager in consultation with the Supervisor of the Radiological Health Section.

3. A Radiation Work Permit (see Section III-7), properly approved, is obtained prior to any assignment involving a single planned individual exposure greater than 20 mrems.

4. Before subjecting employees to a planned exposure, the supervisor obtains adequate Radiological Health consultation to evaluate dose rates and establish work limitations, time controls, and radiation protection procedures.

5. All potential exposure areas are zoned in accordance with the procedures described in Section III-2.

# CONTAMINATION STANDARDS

## POLICY

All significant quantities of radioactive materials are handled and controlled so that radioactive contamination in air, in liquids and on surfaces will not exceed the recommended maximum permissible limits.

## DEFINITION

A significant quantity of radioactive material is that amount requiring special handling in the form of containment, shielding, or work restriction.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Prescribes operational limits for radioactive contamination control.

   b. Assists management and individuals by locating, designating, and evaluating areas or sources of radioactive contamination.

   c. Recommends procedures and precautions to be taken before and during decontamination operations.

   d. Conducts follow-up evaluations and inspections of each contamination incident as required.

   e. Surveys articles for contamination clearance or transfer.

2. Supervisors

   a. Assure that subordinates are familiar with instructions for the handling of radioactive substances and for the control of contamination and that they follow the instructions.

   b. Bring to the attention of the Radiological Health Section potentially hazardous situations resulting from proposed changes in plant operations, maintenance, and design.

c. Institute decontamination procedures.

d. Assist in the evacuation of employees when required.

e. Initiate investigations to determine the cause of accidental releases of radioactive materials; take steps to prevent the recurrence of the accident or to control a continuing situation.

3. Individual Employees

a. Familiarize themselves with handling and control requirements and, when handling radioactive materials, take all precautions necessary to minimize accidental spillage or releases.

b. Report to the Radiological Health Section and to supervisor any new or unusual situation which might lead to the spread of radioactive contamination.

STANDARDS

1. Maximum contamination limits on persons, plant surfaces, clothing, shoes, and on items cleared for release to clean shops are given in the following tables.

a. Skin Surfaces

TABLE II-2.1

Maximum Contamination Limits

For Skin Surfaces

| Surface | Direct Survey Alpha (dpm/100 sq cm) | Direct Survey Beta-Gamma (mrad/hr) | Transferable (Smear) Alpha (dpm/100 sq cm) | Transferable (Smear) Beta-Gamma (dpm/100 sq cm) |
|---|---|---|---|---|
| General body | 150 | 0.06 | Nothing detectable | |
| Hands | 150 | 0.3 | Nothing detectable | |

STANDARDS (Continued)

b. Plant Surfaces

TABLE II-2.2

Maximum Contamination Limits

On Nonzoned Surfaces

| Type of Radiation | Direct Reading Surface Contamination | Transferable Surface Contamination |
|---|---|---|
| Alpha | 300 dpm/100 sq cm | 30 dpm/100 sq cm |
| Beta-Gamma | 0.25 mrad/hr | 1000 dpm/100 sq cm |

NOTE: When the contamination involves an extensive area (larger than a single room or a major portion of a building) and consists of extremely hazardous nuclides, such as $Pu^{239}$ or other long-lived alpha emitters of comparable toxicity, it may become necessary to reduce the listed maximum values for alpha contamination given in the above table. When decontamination efforts involved in cleaning a large area or room are considered to be economically unfeasible, the values given above for fixed and transferable alpha contamination may be increased by a factor of 10, provided the contaminated surface is sealed by an approved bonding material such as Amercoat. Surveillance of the area must be maintained as long as the contamination remains in excess of the levels given in Table II-2.2. Any subsequent work which might result in damage to the coating must have Radiological Health surveillance.

c. Clothing and Shoes

TABLE II-2.3

Maximum Contamination Limits

On Clothing And Shoes

| Item | Direct Survey Alpha (dpm/100 sq cm) | Direct Survey Beta-Gamma (mrad/hr) | Transferable (Smear) Alpha (dpm/100 sq cm) | Transferable (Smear) Beta-Gamma (dpm/100 sq cm) |
|---|---|---|---|---|
| Contamination Zone | | | | |
| Shoes | | | | |
| Inside | 300 | 1.0 | 30 | 1000 |
| Outside | 300 | 2.5 | 30 | 1000 |
| Clothing | 150 | 0.6* | Not applicable | |
| Personal | | | | |
| Shoes | | | | |
| Inside | 300 | 0.3 | 30 | 200 |
| Outside | 300 | 0.6 | 30 | 200 |
| Clothing | 150 | 0.25 | Not applicable | |

*The average reading shall not exceed 0.6 mrad/hr in any 644-sq cm (100-sq in.) area.

NOTE: Whenever personal clothing or shoes become contaminated to levels in excess of values in this table and decontamination is not feasible or possible, the contaminated item is confiscated. (See EGCR Standard Practices Manual.)

STANDARDS (Continued)

d. Contamination Clearance

TABLE II-2.4

Criteria For

Contamination Clearance*

| Direct Survey | | Transferable (Smear) | |
|---|---|---|---|
| Alpha (dpm/100 sq cm) | Beta-Gamma (mrad/hr) | Alpha (dpm/100 sq cm) | Beta-Gamma (dpm/100 sq cm) |
| 300 | 0.05 | 30 | 200 |

*"Clearance" as used here applies to transfer of items to clean shops, storerooms, offices, etc., within the plant site; transfer of such items within the controlled area; and release of items to the general public. Each item being transferred must be accompanied by a Contamination and Radiation Clearance Tag signed by a Radiological Health representative. (See Figure III-3.12.)

2. The following tables prescribe maximum operating limits for radioactive contamination in air and water.

a. Air

TABLE II-2.5

Maximum Permissible Concentration Of Unidentified Radionuclides

In Air* For Occupational Exposure

$(MPCU)_a$

| Limitations | $(MPCU)_a$ (μc/cc of air) 168-hr/wk** | 40-hr/wk |
|---|---|---|
| If there are no α-emitting radionuclides and if no one of the β-emitting radionuclides $Sr^{90}$, $I^{129}$, $Pb^{210}$, $Ac^{227}$, $Ra^{228}$, $Pa^{230}$, $Pu^{241}$, and $Bk^{249}$ is present, then the $(MPCU)_a$ is | $10^{-9}$ | $3 \times 10^{-9}$ |
| If there are no α-emitting radionuclides and if no one of the β-emitting radionuclides $Pb^{210}$, $Ac^{227}$, $Ra^{228}$, and $Pu^{241}$ is present, then the $(MPCU)_a$ is | $10^{-10}$ | $3 \times 10^{-10}$ |
| If there are no α-emitting radionuclides and if the β-emitting radionuclide $Ac^{227}$ is not present, then the $(MPCU)_a$ is | $10^{-11}$ | $3 \times 10^{-11}$ |
| If no one of the radionuclides $Ac^{227}$, $Th^{230}$, $Pa^{231}$, $Th^{232}$, Th-nat, $Pu^{238}$, $Pu^{239}$, $Pu^{240}$, $Pu^{242}$, and $Cf^{249}$ is present, then the $(MPCU)_a$ is | $10^{-12}$ | $3 \times 10^{-12}$ |
| If no one of the radionuclides $Pa^{231}$, Th-nat, $Pu^{239}$, $Pu^{240}$, $Pu^{242}$, and $Cf^{249}$ is present, then the $(MPCU)_a$ is | $7 \times 10^{-13}$ | $2 \times 10^{-12}$ |
| If no analysis of the air is made, then the $(MPCU)_a$ is | $4 \times 10^{-13}$ | $10^{-12}$ |

*These $(MPCU)_a$ values are permissible levels for occupational exposure for any radionuclide or mixture of radionuclides where the concentration

STANDARDS (Continued)

of the indicated radionuclide in air is small compared with the $(MPC)_a$ value for this specific radionuclide. NCRP limits are given in National Bureau of Standards Handbook 69 and Addendum I, Health Physics, Volume 9, No. 6, June 1963; and ICRP limits are given in Report of Committee II on Permissible Dose for Internal Radiation (1959), Health Physics, Volume 3, June 1960. The $(MPCU)_a$ value may be much smaller than the more exact maximum permissible concentration of the material, but the determination of the $(MPC)_a$ value requires identification of the radionuclides present and the concentration of each.

**Use one-tenth of these values for interim application in the neighborhood of an atomic energy plant.

b. Water

TABLE II-2.6

Maximum Permissible Concentration Of Unidentified Radionuclides

In Water* For Occupational Exposure

$(MPCU)_W$

| Limitations | $(MPCU)_W$ ($\mu c$/ml of water) 168-hr/wk** | 40-hr/wk |
|---|---|---|
| If no one of the radionuclides $Sr^{90}$, $I^{126}$, $I^{129}$, $I^{131}$, $Pb^{210}$, $Po^{210}$, $At^{211}$, $Ra^{223}$, $Ra^{224}$, $Ra^{226}$, $Ra^{228}$, $Ac^{227}$, $Th^{230}$, $Pa^{231}$, $Th^{232}$, and Th-nat is present, then the $(MPCU)_W$ is | $3 \times 10^{-5}$ | $9 \times 10^{-5}$ |
| If no one of the radionuclides $Sr^{90}$, $I^{129}$, $Pb^{210}$, $Po^{210}$, $Ra^{223}$, $Ra^{226}$, $Ra^{228}$, $Pa^{231}$, and Th-nat is present, then the $(MPCU)_W$ is | $2 \times 10^{-5}$ | $6 \times 10^{-5}$ |
| If no one of the radionuclides $Sr^{90}$, $I^{129}$, $Pb^{210}$, $Ra^{226}$, and $Ra^{228}$ is present, then the $(MPCU)_W$ is | $7 \times 10^{-6}$ | $2 \times 10^{-5}$ |
| If neither $Ra^{226}$ or $Ra^{228}$ is present, then the $(MPCU)_W$ is | $10^{-6}$ | $3 \times 10^{-6}$ |
| If no analysis of the water is made, then the $(MPCU)_W$ is | $10^{-7}$ | $3 \times 10^{-7}$ |

*These $(MPCU)_W$ values are permissible levels for occupational exposure for any radionuclide or mixture of radionuclides where the concentration of the indicated radionuclide in water is small compared with the $(MPC)_W$

STANDARDS (Continued)

value for this specific radionuclide, see footnote, Table II-2.5. The $(MPCU)_W$ may be much smaller than the more exact maximum permissible concentration of the material, but the determination of this $(MPC)_W$ requires identification of the radionuclides present and the concentration of each.

**Use one-tenth of these values for interim application in the neighborhood of an atomic energy plant.

REGULATIONS

1. Contamination limits are established by the Radiological Health Section and are observed in all plant areas and operations.

2. Operations which result in appreciable dusting or turbulent air movement and which could lead to excessive contamination of persons, plant areas, and the environment are restricted and require Radiological Health evaluation.

3. Appropriate zoning and personnel exposure controls shall be established for any area where sustained or frequently repeated operations encounter contamination levels in excess of operating limits. (See Section III-2.)

4. Internal deposition of radionuclides is not permitted to exceed the maximum permissible body burdens as recommended in NBS Handbook 69.

# RADIATION SURVEYS

## POLICY

Routine and special radiation surveys are conducted to delineate and evaluate radiation and contamination hazards and to determine the necessary work limitations and physical safeguards.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Performs radiation surveys and related inspections of all accessible areas in which exposure of personnel to radiation or contamination is likely to occur.

   b. Conducts periodic monitoring surveys on the site and in the surrounding area to determine the adequacy of in-plant controls of radioactive materials.

   c. Makes routine and special reports of radiation surveys and the effectiveness of the radiation protection program.

   d. Maintains a permanent record of all pertinent survey data and evaluates the data routinely as a means of improving radiation protection at EGCR.

2. Supervisors

   a. Ensure that all subordinates are properly informed of radiation and contamination conditions with regard to the use of radiation surveys as a protective measure.

   b. Follow the radiation protection procedures specified by the Radiological Health Section.

3. Individual Employees

   Through his supervisor, the employee requests a radiation survey prior to performing work in any area or on any object where he suspects the presence of a radiation or contamination hazard or where a significant change in radiation and contamination levels may occur.

REGULATIONS

1. The Radiological Health Section determines radiological conditions in plant areas and in the immediate environment, and evaluates, records, and reports the findings to appropriate individuals on a current basis.

2. In certain special cases, employees other than members of the Radiological Health Section may use portable radiation detection instruments; however, radiation conditions must be clearly understood by the person concerned and by the Radiological Health Section.

3. Radiation surveys shall be made routinely to evaluate the normal background radiation levels in areas which may be affected by EGCR operations.

# CONTROL ZONES

## POLICY

Control zones are utilized in limiting radiation exposure and minimizing the spread of radioactive contamination.

## DEFINITIONS

1. Radiation Zone - A zone established to prevent or minimize the exposure of personnel to external radiation.

2. Contamination Zone - A zone established to prevent or minimize the contamination of employees, equipment, and the environs.

3. Regulated Zone - An area where operations are restricted for the purpose of radioactive contamination control. Such a zone may contain radiation zones, contamination zones, or both, and may range in size from a small spot to a large area.

4. Control Zone Signs - Standard signs used to identify zone boundaries. (See Section III-3.)

5. Contamination Zone Clothing and Equipment - Special wearing apparel and equipment provided for use in a contamination zone. (See Section III-5.)

6. Zone Portal - A designated point on the boundary of a control zone through which entry and exit are permitted.

7. Contamination Zone Change Facility - Located within a regulated zone and adjacent to a contamination zone portal, a facility equipped with adequate monitoring devices, protective clothing and equipment, decontaminating materials, and space for storage of personal effects. (See Section III-6.)

8. Contamination Zone Vehicle - A distinctly marked vehicle used to transport radioactive materials, contaminated equipment, and personnel wearing contamination zone clothing within or between contamination zones.

9. Transferable Contamination - Unconfined contamination that can be easily dislodged from a surface and transferred to other locations.

RESPONSIBILITIES

1. Radiological Health Section

   a. On the basis of radiation and contamination surveys, indicates the location and boundaries of each type zone.

   b. Specifies the protective clothing and equipment required.

   c. Monitors clothing, equipment, tools, persons, etc., at zone portals and specifies decontamination or other protective action.

2. Operations Group

   a. Installs zone portals and monitoring instruments and maintains supplies for zone control.

   b. Enforces zone control by use of signs, barricades, and administrative bulletins.

3. Supervisors

   a. Instruct subordinates in the use of zones and ensure that all procedures are followed.

   b. Request surveys, when necessary, to locate potential radiation and contamination zones.

4. Individual Employees

   a. Request surveys upon entry into and exit from radiation and contamination zones or, when necessary, while in such zones.

   b. Use the prescribed protective clothing and equipment and abide by all pertinent regulations.

AUTHORIZATION

No person may enter radiation or contamination zones unless provided with Radiological Health surveillance, special instrumentation, protective clothing, and related equipment, as required.

AUTHORIZATION (Continued)

TABLE III-2.1

Requirements For Entry Into A Radiation Zone[a]

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| | | | Administrative Authority | | |
| Dose Rate Range (rem/hr) | Direct Reading Monitoring Instruments Required | Radiological Health Surveillance Required | Employee's Supervisor[b] | Supervisor Radiological Health Section | Project Manager |
| 0.003 - 5[c] | X | X | | | |
| 5 - 20 | X | X | X | | |
| 20 - 50 | X | X | X | X | |
| Over 50 | X | X | X | X | X |

a. For limitations on work in radiation zones, see Section III-7.

b. Trainees, personnel on loan to the plant, and visitors must have approval of the appropriate technical or operating staff supervisor sponsoring their EGCR activities.

c. In the exposure range 0.003 - 5 rems/hr, the requirements specified in columns 2 and 3 may be modified if the anticipated exposure time is such as to result in an accumulated daily whole body dose of less than 20 mrems. (See Section III-7.)

REGULATIONS

1. Radiation zones are established by the Radiological Health Section wherever an employee may encounter significant external dose rates. Dose rates given in Table III-2.2 are used as criteria for establishing radiation zones.

TABLE III-2.2

Criteria For Establishing

Radiation Zones

| Dose Rate Range | Immediate Action | Followup Action |
|---|---|---|
| 3 mrems/hr to 6 mrems/hr | Post low-level tags. | Periodic review. |
| 6 mrems/hr to 1 rem/hr | Post warning signs or tags. Rope off if weekly accumulation may equal or exceed 1 rem. | Periodic review. |
| 1 rem/hr to 3 rems/hr | Post warning signs or tags. Rope off. | Erect a barricade which provides absolute exclusion of unauthorized personnel if the weekly accumulated dose in the area may equal or exceed 12 rems. |
| Over 3 rems/hr | Post warning signs or tags. Erect temporary barricade. Lock or block all entrances. | |

REGULATIONS (Continued)

2. Contamination zones are established by the Radiological Health Section wherever personnel, equipment, or the environs may become significantly contaminated with radioactive materials. Table III-2.3 is used as a guide in the establishment of contamination zones.

TABLE III-2.3

Criteria For Establishing

Contamination Zones

| Type of Radiation | Airborne Contamination (μc/cc air) | Surface Contamination | |
|---|---|---|---|
| | | Direct Reading | Transferable (dpm/100 sq cm) |
| Alpha | $5 \times 10^{-11}$ | 300 dpm/100 sq cm | 30 |
| Beta-Gamma | $3 \times 10^{-10}$ | 0.25 mrad/hr | 1000 |

NOTE: Nonzoned areas conform to these limits, are decontaminated to these limits, or--in the case of alpha surface contamination where decontamination to these limits is not economically feasible--may have the contamination permanently fixed to the surface by an approved bonding material, provided the contamination before bonding does not exceed 10 times the values listed for alpha in Table III-2.3.

3. Regulated zones may be established in work areas surrounding, adjacent to, within, passing through, or connecting contamination zones. Regulated zones are accessible to all authorized plant personnel with restrictions only on contamination zone personnel and equipment as defined in No. 4.

4. Entrance into and exit from contamination zones are made only through specified portals. Personnel and equipment are permitted to pass from a contamination zone into a regulated zone only when approved monitoring techniques indicate no transferable contamination.

5. Signs at contamination zone portals provide up-to-date information on requirements and conditions relative to entry, work limitations, and exit.

6. If, in the absence of Radiological Health surveillance, operating supervisors find it necessary to enter a radiation zone where Radiological Health surveillance is required, the Office of the Supervisor, Radiological Health Section, is notified of the action taken.

7. Contamination zone clothing and equipment are not used outside a contamination zone or a regulated zone except when in a contamination zone vehicle.

8. Regulated zone vehicles in transit between contamination zones shall follow prescribed routes.

9. No lunchroom is permitted within a contamination zone or regulated zone. Eating, smoking, and drinking are prohibited in contamination zones.

10. Open cuts, puncture wounds, skin rashes, and infections must be adequately protected prior to entering a contamination zone. (See Section VI-2.)

11. The method of cleanup or decontamination prior to leaving a contamination zone or regulated zone is prescribed by the Radiological Health Section.

12. Trainees, personnel on loan to EGCR, and visitors are subject to these regulations.

# WARNING SIGNS, TAGS, AND LABELS

## POLICY

The presence of radiation or radioactive materials is denoted by standard warning signs, tags, and labels.

## DISCUSSION

The standard radiation symbol (Figure III-3.1) adopted March 1, 1960, by the American Standards Association signifies the presence of radiation or radioactive materials.

R = Radius of central disc

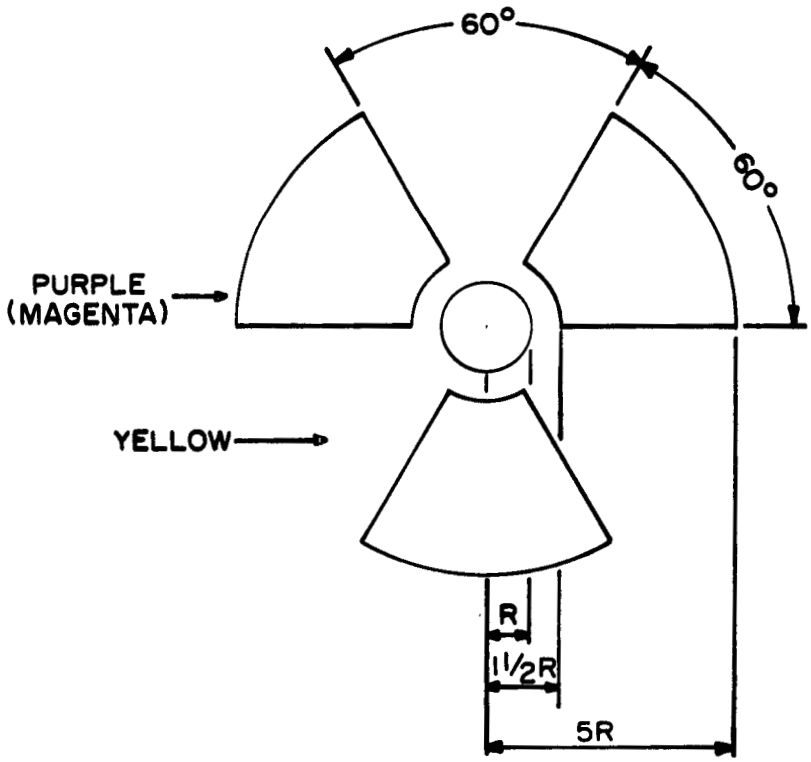


Figure III-3.1

Standard Radiation Symbol

RESPONSIBILITIES

1. Radiological Health Section

   a. Establishes the need for and the application of radiation and contamination signs, tags, and other identification.

   b. Ensures that all hazardous areas are zoned, that such areas are conspicuously identified by standard signs, tags, or labels, and that these are up to date and are removed when no longer applicable.

   c. Designs new signs and tags as required for specific cases not covered by existent forms.

2. Operations Group

   a. Maintains an adequate supply of signs, tags, and labels to fulfill operating requirements.

   b. Installs permanent signs and tags when requested by the Radiological Health Section.

   c. Notifies the Radiological Health Section when it becomes necessary to alter or to remove a permanent sign, tag, or label.

REGULATIONS

1. Signs, tags, and labels bearing the standard radiation symbol in magenta on a yellow background are used to denote the actual or potential presence of radiation or radioactive materials. They shall not be used for any other purposes.

2. All hazards from ionizing radiation (including confined contamination) which are zoned for the purpose of radiation and contamination control are clearly identified by approved signs, tags, and labels.

3. Warning tags and labels installed or prescribed by the Radiological Health Section are clearly recognizable from a safe distance and have the following information thereon.

   a. Description of radiation or contamination hazards.

   b. Dose rates at specific locations and distances.

REGULATIONS (Continued)

c. Type and degree of contamination--surface, air, direct reading, etc.

d. Date of survey.

e. Special instructions and precautions.

f. Signature of the Radiological Health Section representative.

4. Information on warning tags and labels may be changed only by authorized persons.

5. Warning signs, tags, labels, etc., are removed by Radiological Health Section when no longer applicable.

6. Other identification systems approved by the Operating Superintendent and the Radiological Health Section may be employed to supplement standard warning signs, tags, and labels.

7. Approved warning signs, tags, and labels in use at EGCR include:

a. Radiation Hazard Tag (Figure III-3.2)

b. Radioactive Contamination Tag (or Material Transfer Tag) (Figure III-3.3)

c. Low-Level Radiation Tag (Figure III-3.4)

d. Radiation Zone Sign (Figure III-3.5)

e. Radiation Zone Tape (Figure III-3.6)

f. Contamination Zone Sign (Figure III-3.7)

g. Contamination Zone Tape (Figure III-3.8)

h. Regulated Zone Sign (Figure III-3.9)

i. Radiation Hazard - Keep Out Sign (Figure III-3.10)

j. Bull's Eye Radiation Hazard Sign (Figure III-3.11)

k. Contamination and Radiation Clearance Tag (Figure III-3.12)

DESCRIPTION

Figure III-3.2

Radiation Hazard Tag

This tag identifies a radiation hazard where external dose rates to personnel may be > 3 mrems/hr.

DESCRIPTION (Continued)

Figure III-3.3

Radioactive Contamination Tag

(or Material Transfer Tag)

The Radioactive Contamination Tag identifies an area or object which may involve contamination of personnel or large areas, and in which one or all of the following conditions may apply.

| | |
|---|---|
| Surface Contamination | $\alpha$ (direct reading) > 300 dpm/100 sq cm<br>$\alpha$ (transferable) > 30 dpm/100 sq cm<br>$\beta, \gamma$ (direct reading) > 0.25 mrad/hr<br>$\beta, \gamma$ (transferable) > 1000 dpm/100 sq cm |
| Airborne Contamination | > $(MPC)_a$ for 40-hour week |

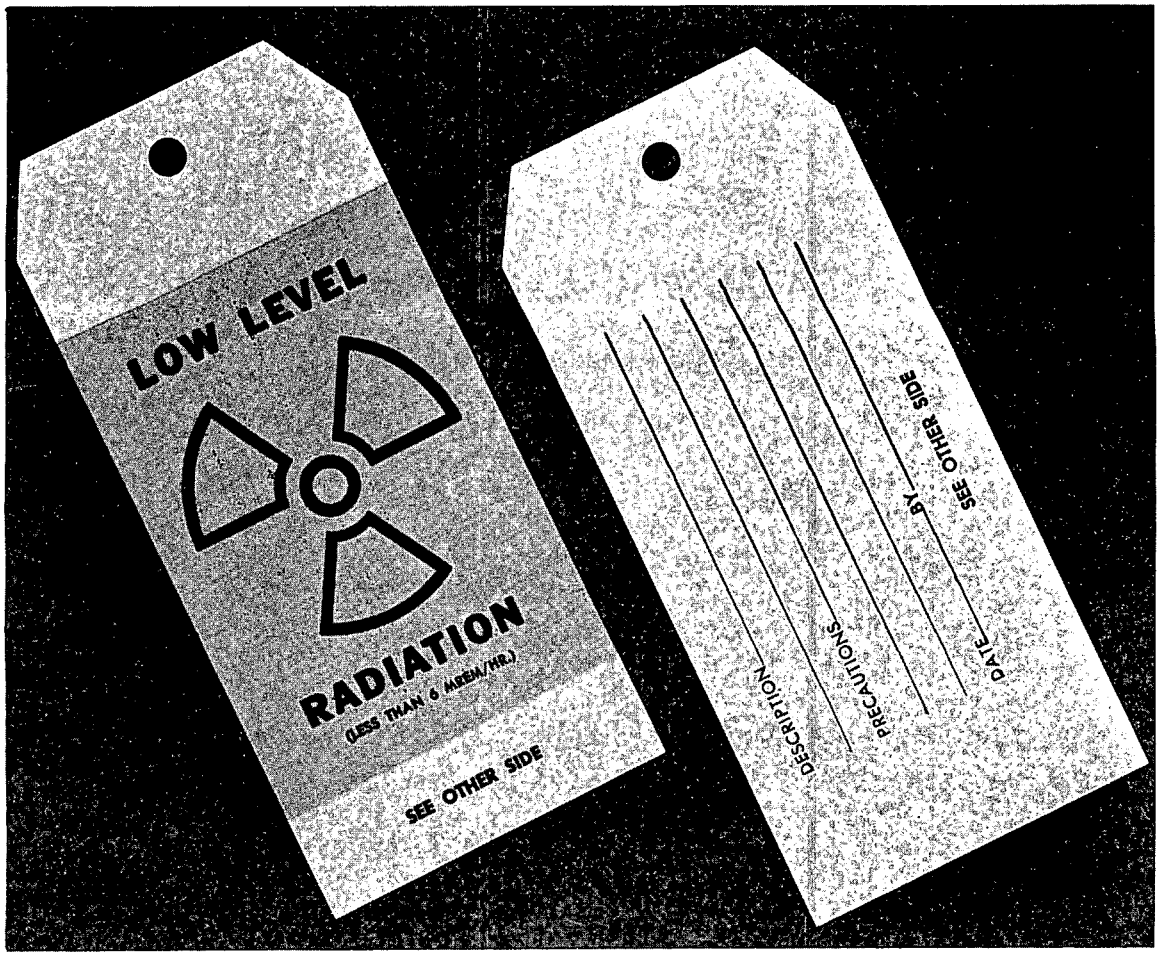


Figure III-3.4

Low-Level Radiation Tag

The Low-Level Radiation Tag identifies a radiation zone where the dose rate is less than 6 mrems/hr. (See Section III-2.)

DESCRIPTION (Continued)

Figure III-3.5

Radiation Zone Sign

A permanent sign is used to identify a radiation zone. (See Section III-2.)

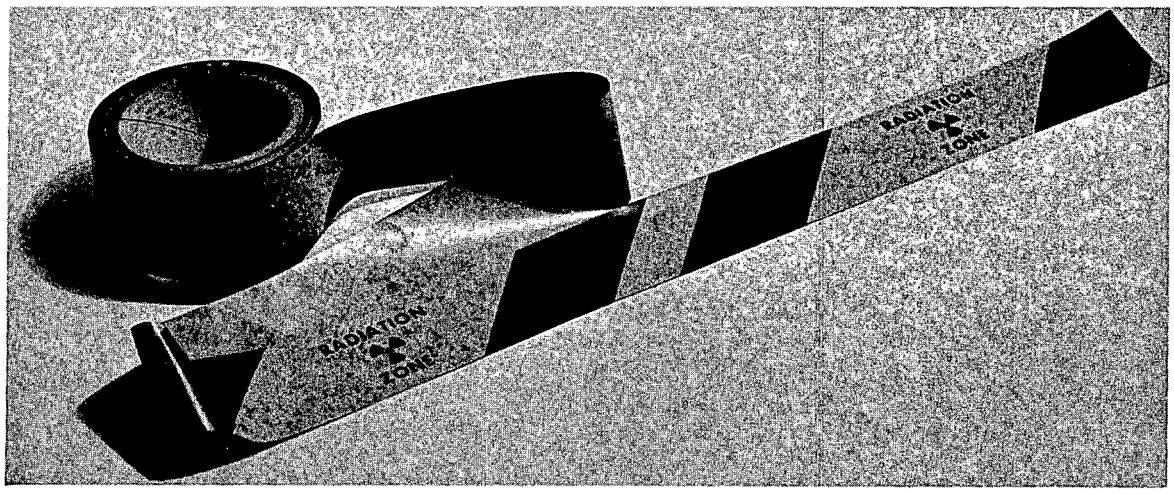


**Figure III-3.6**

Radiation Zone Tape

Radiation Zone Tape may be used with or without adhesive backing to delineate a radiation zone. (See Section III-2.)

DESCRIPTION (Continued)

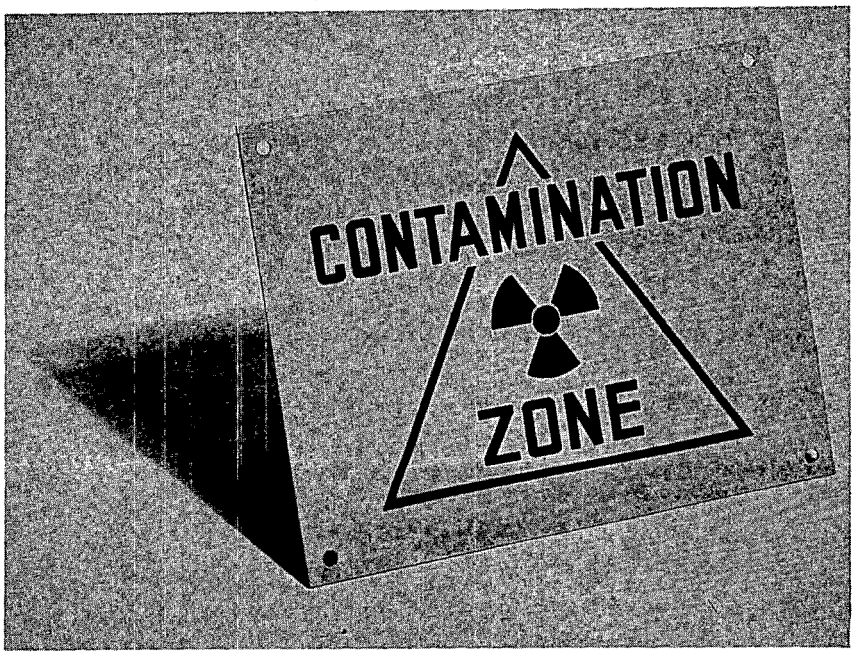


Figure III-3.7

Contamination Zone Sign

A permanent sign is used to identify a permanent contamination zone. (See Section III-2.)

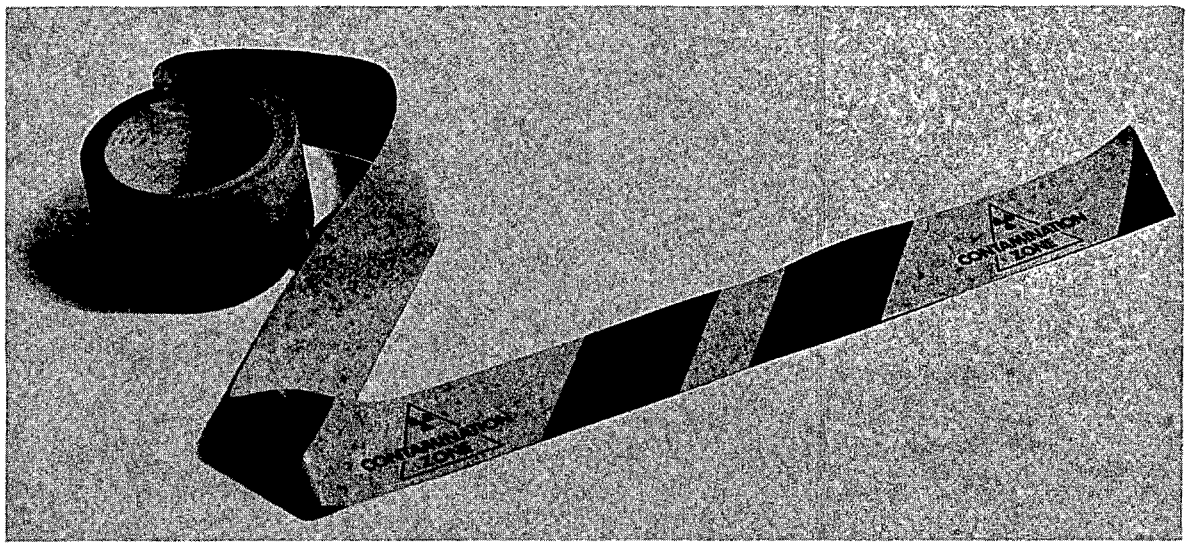


Figure III-3.8

Contamination Zone Tape

Contamination Zone Tape may be used with or without adhesive backing to delineate a contamination zone. (See Section III-2.)

DESCRIPTION (Continued)

Figure III-3.9

Regulated Zone Sign

A permanent sign identifies a regulated zone. (See Section III-2.)

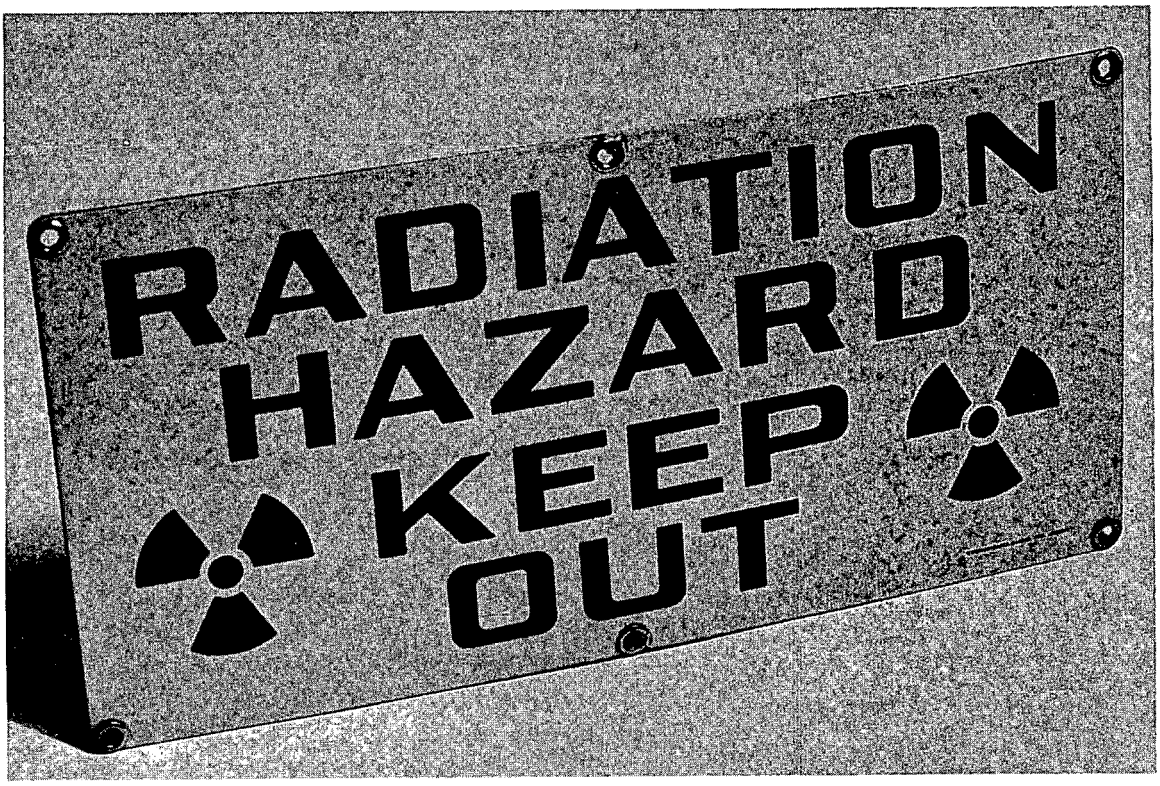


Figure III-3.10

Radiation Hazard - Keep Out Sign

The Radiation Hazard - Keep Out Sign is used within radiation and contamination zones to designate a specific hazardous area or object.

DESCRIPTION (Continued)

Figure III-3.11

Bull's Eye Radiation Hazard Sign

The Bull's Eye Radiation Hazard Sign is used to identify hazardous areas or conditions which may be encountered by fire-fighting personnel (see Section VI-4). Special instructions as to type of radiation or radioactive material, anticipated dose rates, etc., may be included on the face of the sign.

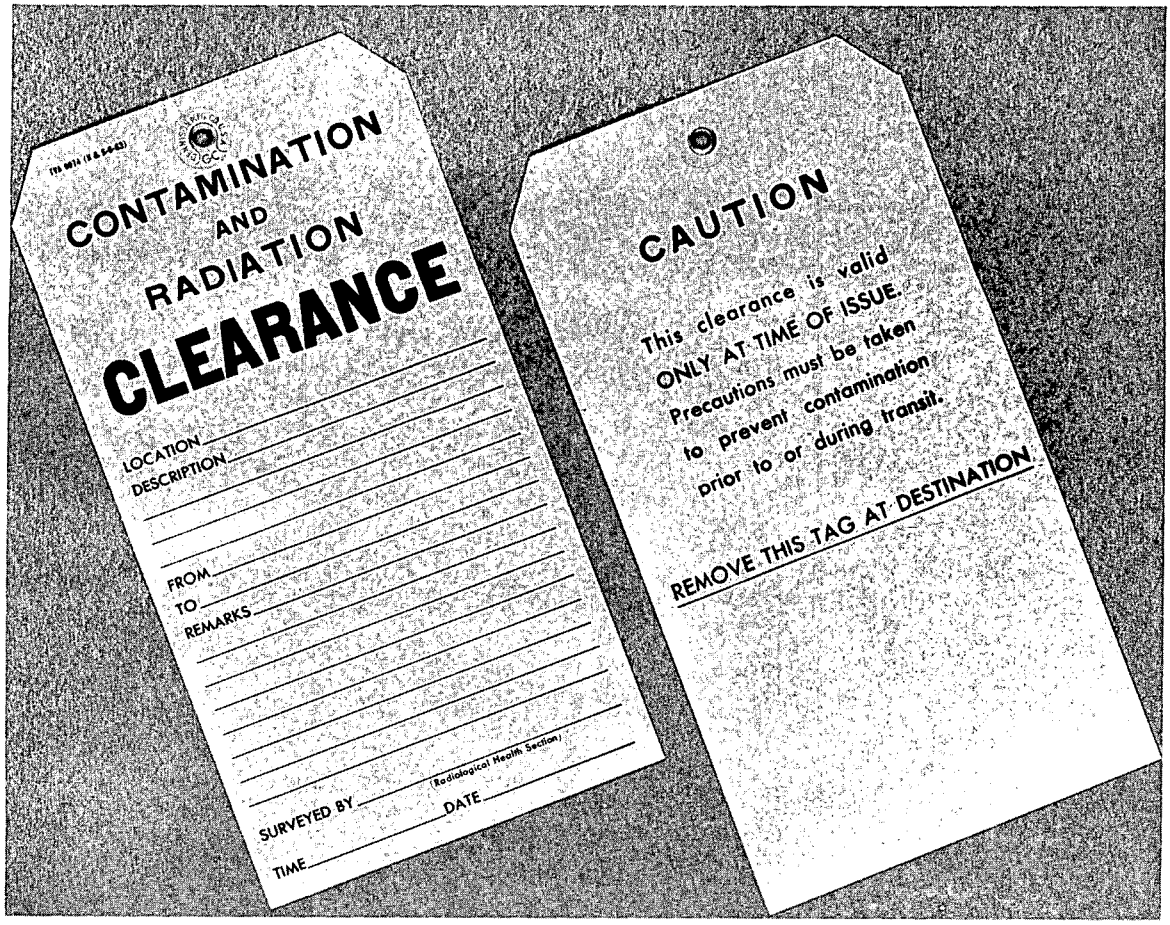


Figure III-3.12

Contamination and Radiation Clearance Tag

A clearance tag is attached to an item which has been surveyed and found free of detectable radiation or excessive contamination. The object may be released as a clean item.

# ZONE ENTRY AND EXIT

## POLICY

Each radiation and contamination zone at EGCR has one or more designated portals for the purpose of controlling entry and exit of personnel and equipment.

## DEFINITION

Zone Portal - A designated point on the boundary of a controlled zone through which entry and exit are permitted.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Designates need and location for zone portals and posts each with the necessary entrance and exit requirements.

   b. Specifies instrumentation and protective measures.

2. Management

   Management provides the necessary equipment and supplies at portals.

3. Supervisors

   a. Exclude unauthorized persons.

   b. Ensure that all entries into and exits from controlled zones are made through designated portals.

   c. Enforce protective clothing and equipment requirements and work limits.

## REGULATIONS

1. Portals are established at specific locations on the boundaries of zoned areas.

2. Entrance into and exit from controlled zones may be made only by authorized personnel and through designated portals.

3. The number of portals for a given zone is kept at a minimum, consistent with operating conditions.

4. Portals are provided with barricades, rope, signs, warning devices, monitoring instruments, and other equipment, as required for radiation control purposes.

5. All persons and equipment leaving contamination zones must be monitored at the zone portal (see Section III-2, Regulation 4) before proceeding to clean areas.

# CONTAMINATION ZONE CLOTHING AND EQUIPMENT

## POLICY

Approved contamination zone clothing and equipment are provided by the project and are always used for contamination zone work.

## DEFINITIONS

1. Contamination Zone Clothing - Protective apparel provided by EGCR management for the use of employees performing work in contamination zones. Contamination zone clothing includes:

   Coveralls (marked with the word "CONTAMINATION" across the back)
   Jackets (marked with the word "CONTAMINATION" across the back)
   Laboratory coats (marked with the word "CONTAMINATION" across the back)
   Canvas caps
   Canvas hoods
   Yellow shoes
   Shoe covers
   Plastic suits
   Rubber overshoes
   Rubber boots
   Plastic bootees
   Rubber gloves
   Cotton gloves
   Rubberized gloves

2. Equipment - For example: Respirators, tongs, masking tape, etc.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Evaluates hazards and prescribes contamination zone clothing and equipment compatible with specific work functions within contamination zones.

   b. Instructs employees in the proper use of contamination zone clothing and equipment and assists supervisors in the enforcement of clothing regulations.

c. Monitors clothing and equipment for contamination at portals and change facilities and prior to release of clothing for laundering.

2. Warehouse Supervisor

a. Requisitions, stocks, and issues contamination zone clothing and equipment upon authorized requests.

b. Marks contamination zone clothing and equipment, as specified.

3. Supervisors

a. Maintain an adequate supply of contamination zone clothing and equipment at each change facility and portal.

b. Enforce the proper use of contamination zone clothing.

REGULATIONS

1. Coveralls, jackets, and coats designated as contamination zone clothing are predominantly white and are marked across the back with the word "CONTAMINATION" in large black letters.

2. Contamination zone clothing may be worn only in a contamination zone or a regulated zone and in the latter area only when free of transferable contamination.

3. Unauthorized alteration of contamination zone clothing is prohibited.

4. Requirements concerning use of contamination zone clothing within a contamination zone are posted at zone portals. Requirements concerning contamination zone clothing and respiratory equipment are posted in change rooms and at a location convenient to the Main Control Room.

5. Contamination zone clothing is monitored as needed during work and upon completion of work with radioactive materials.

6. Used contamination zone clothing must be segregated from clean clothing and not be allowed to accumulate for extended periods of time.

REGULATIONS (Continued)

7. Unused contamination zone clothing must be surveyed by the Radiological Health Section and tagged with a green Contamination and Radiation Clearance Tag before being returned to the storeroom.

8. Contamination levels for laundered contamination zone clothing or clothing being returned to the storeroom conforms to the limits prescribed by the Radiological Health Section. (See Section II-2.)

9. Clothing that cannot be economically decontaminated or stored for radioactive decay must be considered solid radioactive waste and must be disposed of accordingly. (See Section IV-1.)

# CONTAMINATION ZONE CHANGE FACILITIES

## POLICY

As an aid in the control of radioactive contamination, adequate clothing change facilities are provided adjacent to contamination zones.

## DEFINITION

Contamination Zone Change Facility - A facility where employees change into contamination zone clothing before entering and remove the clothing upon leaving a contamination zone.

## RESPONSIBILITIES

1. Radiological Health Section

   a. At routine intervals, surveys and inspects clothing change facilities for radiation and contamination.

   b. Performs personnel monitoring functions as required.

   c. Assists supervisor in planning and establishing clothing change facilities.

2. Supervisors

   Each supervisor ensures the proper use of the clothing change facility to minimize the possibility of spread of contamination.

## REGULATIONS

1. Only contamination zone change facilities are used for clothing changes when preparing for or leaving work in contamination zones.

2. Each contamination zone change facility is equipped with the following items as applicable.

   a. Signs and instructions.

b. Monitoring equipment.

c. Storage space for personal effects.

d. Contamination zone clothing and equipment.

e. Receptacles for used contamination zone clothing, protective equipment, and related items.

f. Provisions for personnel and equipment decontamination as specified by the Radiological Health Section, including a suitable sink or lavatory for disposal of contaminated effluents.

3. Contamination zone change facilities are used for no other purpose.

a. No food, beverage, or eating utensils may be brought into the change facility.

b. Only those items required in contamination control may be stored in the facility.

c. Contaminated tools and equipment are not permitted to accumulate.

4. Each contamination zone change facility is routinely surveyed by the Radiological Health Section. Contamination and external radiation hazards are kept at the lowest practicable radiation level.

# RADIATION WORK PERMIT

## POLICY

Radiation Work Permits are required for all work where employees may be exposed to radiation or contamination exceeding prescribed limits.

## DEFINITIONS

1. Radiation Work Permit - A combination application and permit on which the appropriate supervisor describes the location and type of work to be done and the Radiological Health Section prescribes the work limitations and radiation protective measures to be applied. (See Figure III-7.1.)

2. Extended Time Sheet - A supplement to the Radiation Work Permit for use in extending the time of a Radiation Work Permit or listing additional names, time limitations, and other applicable information. (See Figure III-7.2.)

## RESPONSIBILITIES

1. Operations Supervisor

   The Operations Supervisor reviews and approves Radiation Work Permits.

2. Supervisors

   a. Consult with the Radiological Health Section when work is to be performed in a radiation or contamination zone and complete the application part of the Radiation Work Permit.

   b. Ensure that work is performed in accordance with the instructions prescribed by the Radiological Health Section on the Radiation Work Permit.

   c. Inform the Radiological Health Section of any changes in work conditions which might affect the requirements previously established by a Radiation Work Permit.

3. Radiological Health Section

   a. Determines the need for Radiation Work Permits and Extended Time Sheets.

   b. Performs radiation surveys and prescribes the protection requirements.

   c. Maintains a record file of all completed Radiation Work Permits.

REGULATIONS

1. A Radiation Work Permit is required:

   a. In advance of any work assignment where it is anticipated that an employee may receive a radiation exposure greater than 20 mrems total body or 300 mrems to the extremities.

   b. In advance of work involving dose rates greater than 5 rems/hr to the total body.

   c. For work in an area having airborne radioactivity greater than $(MPC)_a$ for a 40-hour week.

   d. When radiation or contamination hazards for a particular job are unknown or for other reasons for which the Radiological Health Section requires special precautions.

2. Each Radiation Work Permit and Extended Time Sheet requires:

   a. The supervisor's description of the work to be performed, including location, list of employees involved, duration, and special tools or equipment required.

   b. Reference, by number, to related Radiation Work Permits.

   c. Specification by the Radiological Health Section of protective clothing and equipment, work limitations, and time restrictions.

   d. Signature of the supervisor seeking the Radiation Work Permit, a representative of the Radiological Health Section specifying the limitations, and the Operations Supervisor.

REGULATIONS (Continued)

3. The Radiation Work Permit is prominently displayed or readily available at the work site and is valid for only the shift during which it was issued. A new or extended permit must be obtained for work continuing into another shift.

4. Revisions in a Radiation Work Permit may be made only with the approval of a Radiological Health representative and the appropriate supervisors for the shift during which the revisions are made.

5. Special approvals are required on Radiation Work Permits when any of the conditions in Tables III-7.1 and III-7.2 are encountered.

TABLE III-7.1

Limitations On Work

In High-Radiation Areas

| Dose Rate (rem/hr to total body) | Special Approval Required |
|---|---|
| > 5 | Employee's supervisor<br>Radiological Health representative<br>Operations Supervisor (regularly) |
| > 20 | Above and Supervisor, Radiological Health Section |
| > 50 | Above and EGCR Project Manager |

TABLE III-7.2

Limitations On Planned

Radiation Exposure

| Total Body Dose | Special Approval Required |
|---|---|
| > 60 mrems/ single day or<br>> 300 mrems/single wk | Supervisor, Radiological Health Section and employee's supervisor |
| Single exposure > 1 rem | Above and EGCR Project Manager |

REGULATIONS (Continued)

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## RADIATION WORK PERMIT

DATE AND TIME
From ____ a.m. ____ p.m. To ____ a.m. ____ p.m.

EXTENDED BY ____ To ____ a.m. ____ p.m.

RWP NO. ____

LOCATION AND JOB DESCRIPTION ____

RADIATION SURVEY DATA (By Health Physicist)

| Code * | Location — Distance from Source | Type Radiation | Rate mrem/hr | Time For ____ mrem | Contamination Survey Type | Meas. | By | Hour | Date |
|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | | |
| B | | | | | | | | | |
| C | | | | | | | | | |
| D | | | | | | | | | |

*Work location marked with code

PROTECTION REQUIREMENTS

Rad. Health Surveillance: ☐ Start ☐ Intermittent ☐ Continuous ☐ End of Job

- ☐ Contact Rad. Health before work in new area
- ☐ Standby companion required
- ☐ Monitor breathing zone
- ☐ Tape gloves-booties to coveralls
- ☐ Provide timekeeper
- ☐ Monitor tools and equipment — end of job
- ☐ Monitor area — end of job
- ☐ Provide assistance for removal clothing
- ☐ Obtain nasal smears ☐ Other

PROTECTIVE CLOTHING

| | | | | |
|---|---|---|---|---|
| Body | Coverall — 1 pr | | Feet | Yellow Shoes |
| | Coverall — 2 pr | | | Shoe Covers |
| | Plastic Suit | | | Plastic Booties |
| | | | | Canvas Booties |
| Head | Canvas Cap | | | Rubber Overshoe |
| | Canvas Hood | | | Rubber Boots |
| | Plastic Hood | | | |
| | | | Respir. | Dust Respirator |
| Hands | Canvas Gloves | | | Assault Mask |
| | Leather Gloves | | | Self-Contained |
| | Rubber Gloves | | | Supplied Air |
| Eyes | Safety Glasses | | | Film Badge |
| | Eye Shield | | | Supplied Film |
| | | | | Pocket Meter |
| | | | | Dosimeter |
| | | | | Audible Alarm |
| | Protect Cuts | | | |

SPECIAL INSTRUCTIONS:

APPROVALS

| | Regular | Special |
|---|---|---|
| Rad. Health | | |
| Supervisor | | |
| Oper. Supv. | | |
| Proj. Mgr. | | |

| Name of Worker | Badge | Code | Rate Used | Work Time | TIME RECORD In | Out | In | Out | In | Out | Total | MREM Dosimeter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

1 — White - Work Location
2 — Yellow - Radiological Health
3 — Pink - Control Room

Figure III-7.1

Radiation Work Permit

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# EXTENDED TIME SHEET

For RWP No.

Shift | From a.m. p.m. Date | To a.m. p.m. Date

Foreman or Supervisor:

LOCATION AND JOB DESCRIPTION:

RADIATION SURVEY DATA (By Health Physicist)

| Code * | Location — Distance from Source | Type Radiation | Rate mrem/hr | Time For mrem | Contamination Survey | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Type | Meas. | By | Hour | Date |
| A | | | | | | | | | |
| B | | | | | | | | | |
| C | | | | | | | | | |
| D | | | | | | | | | |

*Work location marked with code

SPECIAL INSTRUCTIONS:

| APPROVALS | Regular | Special |
|---|---|---|
| Rad. Health | | |
| Supervisor | | |
| Oper. Supv. | | |
| Proj. Mgr. | | |

PERSONNEL EXPOSURE CONTROL

| Name of Workskr | Badge | Code | Work Time | Est. Exp. | TIME KEEPING | | | | | MREM (Dosimeter) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | In | Out | In | Out | Total | |
| 1. | | | | | | | | | | |
| 2. | | | | | | | | | | |
| 3. | | | | | | | | | | |
| 4. | | | | | | | | | | |
| 5. | | | | | | | | | | |
| 6. | | | | | | | | | | |
| 7. | | | | | | | | | | |
| 8. | | | | | | | | | | |
| 9. | | | | | | | | | | |
| 10. | | | | | | | | | | |

Time keeping by:

Approved by:

1 — White - Work Location
2 — Yellow - Radiological Health
3 — Pink - Control Room

Figure III-7.2

Extended Time Sheet

# RADIATION PROTECTION RECORDS

## POLICY

Records are maintained to provide for a continuing evaluation of employee exposures to ionizing radiations.

## DEFINITIONS

1. Primary Exposure Records - Forms or material which constitute the original individual exposure records, such as developed film, pocket meter readings, and bioassay data.

2. Secondary Records - Forms or charts recording radiological conditions which supplement the primary exposure data. Examples are:

   Radiation Work Permits
   Air Sample Log Sheets
   Survey Log Sheets
   Fixed Instrument Charts
   Contaminated Injury Reports
   Personnel Decontamination Records
   Radiation Incident Records
   Radiation and Contamination Survey Sheets
   Radioactive Waste Release Records

3. Supporting Records - Records which are not associated primarily with measurement of personnel exposure, but which can be used effectively in the control of such exposure. Examples are:

   Radioactive Shipment Records
   Instrument Sensitivity and Calibration Checks
   New Instrument Evaluation Records

## RESPONSIBILITIES

1. Radiological Health Section

   a. Collects, evaluates, records, and files primary radiation exposure data and prepares routine and special reports concerning employee exposure, plant monitoring, and environmental surveys.

b. Assembles and evaluates secondary and supporting records.

c. Obtains and files records of exposure at EGCR for nonemployees.

2. Supervisors

Each supervisor utilizes information contained in both primary and secondary radiation exposure records in planning for employee work assignments.

3. Management

Management assembles all pertinent data and submits periodic and special reports to the Atomic Energy Commission on the status of employee exposure, unusual incidents, and serious accidents.

DISCUSSION

At EGCR there are four functional categories of radiation protection records.

1. Personnel Exposure Records (Primary) - Records which document the occupational exposure of persons to ionizing radiation. In general, these records contain the following.

   a. Period and extent of occupational exposure to sources of radiation external to the body (developed film and film readings, pocket meter readings, etc.).

   b. Estimates of external exposures received during a period when monitoring devices, such as the film badge, were damaged or could not be interpreted.

   c. Evaluation of exposure due to internal radiation exposure either known or suspected.

2. Radiation Monitoring Records (Secondary) - Records containing periodic and cumulative determinations of the radiological conditions in work areas, descriptions of radiation and contamination incidents, and summary-type reports indicating activities and progress in radiation protection.

DISCUSSION (Continued)

3. Environmental Monitoring Records (Secondary) - Documents showing periodic and cumulative determination of the radiological conditions off site.

4. Instrument Repair and Calibration Records (Supporting) - Records containing the operating history of fixed and portable radiation detection and measuring devices. These records note the routine and special calibration, maintenance, and repair of each instrument.

REGULATIONS

1. Primary radiation exposure records are contained in individual files of personnel exposure.

2. Primary radiation exposure records are kept confidential, but may be discussed with supervisors as an aid to scheduling work assignments.

3. Personnel exposure records for an individual are included in reports to AEC when required by AEC, but are released to other organizations or individuals only upon specific request or authorization from the person of record.

4. Secondary records relating to real or alleged radiation exposure, including medical exposure, may be integrated into individual exposure record files.

5. Schedules for the retention, storage, and disposal of inactive records shall be in accordance with standard TVA and AEC practices.

# WASTE DISPOSAL

## POLICY

The handling, storage, and disposal of radioactive wastes are controlled so as to assure the safety of the public and to cause no limitations on the use of adjacent land and water.

## DEFINITIONS

1. Radioactive Gaseous Wastes - Airborne radioactive wastes originating in the helium vent system, helium sampling system, ventilating systems, and other auxiliary systems within the plant.

2. Radioactive Liquid Wastes - Any solution, suspension, or sludge of radioactive materials in aqueous or organic form which--for reasons of economy--cannot be reused, recovered, or reprocessed. Wastes having activity concentrations $> 10^{-4}$ $\mu c/ml$ are identified as hot wastes and those having a concentration $< 10^{-4}$ $\mu c/ml$ are identified as warm wastes.

3. Radioactive Solid Wastes - Contaminated or irradiated bulk materials, including items such as graphite sleeves from fuel assemblies, blotter paper, shoe covers, used air filters, spent ion-exchanger resin, contaminated clothing, and broken glassware, scrap wood, or metal.

## DISCUSSION

There are no permanent storage facilities at EGCR for radioactive gaseous, liquid, or solid wastes.

Before being released to the atmosphere from the 200-foot stack, gaseous wastes are passed through various filters for the removal of airborne particulates and some radioactive gases. Continuous monitoring of the effluent stream gives an indication of the concentration of radioactive contaminants. The permissible rate of release of contaminated helium by venting to the stack can be calculated and then checked by monitoring. If, for any reason, the radioactivity in the stack gases exceeds preset levels, the releases can be reduced by discontinuing part or all of the

venting or can be stopped by isolating the containment vessel and recirculating the gases. Continued total containment requires the shutting down of reactor operation and, therefore, is not considered a routine waste disposal (or management) practice.

All liquid wastes having a concentration > $10^{-4}$ μc/ml and all radioactive solid wastes are transported to ORNL for treatment or disposal. Liquid wastes having a concentration < $10^{-4}$ μc/ml are pumped to the retention basin for temporary storage and radioactive decay. Final disposal is accomplished by regulated discharge to Melton Hill Lake.

RESPONSIBILITIES

1. Radiological Health Section

   a. Formulates standards and recommends precautions for the monitoring, handling, and disposal of radioactive wastes.

   b. Ascertains that solid radioactive wastes are properly segregated and packaged to adequately contain loose radioactive materials.

   c. Evaluates proposals and makes recommendations to management regarding special waste releases, such as gaseous and low-level liquid wastes, discharged to the environment.

   d. Coordinates with ORNL Health Physics and Laboratory Services representatives at the disposal site all routine and emergency waste disposal operations.

   e. Maintains complete and up-to-date records of all wastes discharged to the environment, including concentrations, quantities, and specific radionuclides (when known).

2. Chemical Engineering Section

   a. Reviews the equipment and system designs for handling radioactive wastes. Writes and revises, as needed, waste handling operating and test procedures.

   b. Ensures that, before handling or releasing wastes, adequate precautions are taken to prevent fire, explosion, or toxic exposure.

RESPONSIBILITIES (Continued)

c. Evaluates the performance of waste handling systems, equipment, and operations and recommends to management any necessary modifications and additions.

d. Samples gaseous and liquid wastes, analyzes samples, and consults with Radiological Health Section relative to results thereof.

3. Operations Group

a. Manipulates valves, piping, and tanks and controls pumps and blowers used in the transfer and disposal of liquid and gaseous wastes.

b. Upon advice from the Radiological Health Section, provides containers and establishes storage-pickup stations for solid and liquid wastes.

c. Packages, loads, and transports solid and liquid wastes to disposal site.

d. Provides and ensures the use of appropriate protective clothing and equipment necessary for personnel protection and contamination control.

e. Coordinates all craft assistance required in special cases of waste disposal operations.

REGULATIONS

1. Solid radioactive wastes are not allowed to accumulate at the EGCR site. All loose radioactive materials and items having excessive transferable contamination are appropriately packaged or otherwise fixed.

2. Containers for radioactive solid wastes are leakproof, yellow in color, and identified by the standard radiation symbol (see Section III-3). They have tight-fitting covers and are used for no other purposes. Hot cans are fitted with a plastic liner before the deposit of any radioactive material.

3. Solid and liquid wastes are handled, transported, and disposed of in a manner that precludes fire, explosion, the release of toxic fumes, or the spread of contamination.

4. Before leaving the EGCR site, liquid wastes are neutralized to the extent required by the recipient.

5. Radiation surveys are conducted prior to the transfer of solid and liquid wastes to the disposal site.

6. Vehicles used in the transportation of wastes are equipped with leakproof beds to control the spread of contamination and have appropriate shielding, covers, and tie-downs, as required. They travel only the routes specified by the Radiological Health Section. Remote handling devices are used, when required, to minimize employee exposure.

7. Drivers and occupants of waste transfer vehicles wear contamination zone clothing and observe contamination zone regulations (see Sections III-2 and III-5). They wear film badges and dosimeters at all times while transferring radioactive wastes to the disposal site.

8. After each transfer of solid or liquid wastes, the transfer vehicle, waste containers, handling equipment, and personnel are surveyed by Radiological Health personnel and decontaminated as required. Waste containers are removed from service when found unsuitable.

9. Solid and liquid wastes are disposed of <u>only</u> in approved disposal areas. No radioactive waste material will be incinerated on the EGCR site. Established health physics and operational procedures for the disposal site are followed in disposal operations.

10. The release of warm liquid wastes to the seal well is initiated only after adequately determining the concentration of the stored wastes and obtaining Radiological Health Section clearance for the release, which is regulated so that the concentration in the outfall after dilution with service and circulating water does not exceed $10^{-7}$ $\mu c/ml$.

11. Venting of contaminated helium is a normal operation; however, special venting may become necessary. Such venting is not initiated until the radioactivity concentration has been estimated or otherwise determined and the Radiological Health Section's advice and the Project Manager's approval have been obtained for the specific meteorological conditions and quantity of gases involved.

# HANDLING, STORAGE, AND TRANSFER OF RADIOACTIVE MATERIALS

## POLICY

Radioactive material handling operations are conducted so as to minimize personnel exposure and the release and spread of radioactive contamination. This includes storage on the EGCR site, transfers and use within the controlled area or site, and shipments of radioactive materials to off-area locations.

## DEFINITIONS

1. Controlled Area - The area immediately surrounding the site in which people enter occasionally or work. Waterways, highways, etc., may pass through the controlled area without changing the classification, provided there are adequate means of evacuation in case of an emergency.

2. Site - The EGCR plant, including the area within the fence and the immediate environs, ancillary buildings, road, parking lots, etc., which are integral parts of the physical plant and its operation.

3. Off-Area - Any location beyond the controlled area.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Provides assistance in planning for handling and storage of radioactive materials produced or received on the site and for transfer of radioactive materials to off-area locations.

   b. Directs radiation and contamination surveys on all outgoing and incoming shipments of radioactive materials, including wastes.

   c. Routinely surveys radioactive sources for leaks and source storage areas for radiation and contamination hazards.

   d. Completes a Radiation Work Permit or Material Transfer Tag when transfer, storage, or handling conditions warrant specific health physics precautions. (See Section III-7.)

2. Chemical Engineering Section

   a. Stores and maintains custody of all sources and SS material. Small calibration sources issued on a semipermanent basis to other sections or individuals in the EGCR organization are regularly inspected by this section.

   b. Periodically checks condition of sources normally installed as part of in-plant systems, e.g., BSD system.

   c. Establishes procedures for safe handling of radioactive material, including design of containers for transfer and storage.

   d. Supervises general integrity of containers and specifies maintenance operations.

3. Supervisors

   a. Indoctrinate all persons involved with handling operations in proper safety precautions and ensure that such precautions are observed.

   b. Initiate requests for Radiation Work Permit or Material Transfer Tag.

REGULATIONS

1. All shipping containers, casks, and other devices used in the transfer of radioactive materials are inspected routinely to ascertain integrity, adequacy of gaskets, fastenings, and tie-downs.

2. Off-area shipments comply with regulations of the Interstate Commerce Commission and with such additional federal, state, and local regulations as may exist. (See Appendix A-IV-2 for applicable ICC regulations.)

3. All transfers of radioactive materials to off-area locations are adequately shielded and contained. Temporary shielding or containment may be employed for radioactive materials while in transit on site.

REGULATIONS (Continued)

4. All transfers--regardless of destination--are identified by appropriate labels, tags, and markings. Transfers of radioactive materials to other sites for storage, processing, or disposal are tagged (see Figure III-3.2) with the following general information.

   a. Type of radiation and intensity at the surface of the container.

   b. Radiation intensity of the unshielded source (if applicable).

   c. Transferable surface contamination on the outside of the container (if applicable).

   d. Handling instructions and precautions to be observed by the receiver.

   e. Type of material being transferred.

5. Applicable zoning and radiation control procedures are observed during all EGCR handling operations.

6. The interplant mail (area mail) is not used for the transfer of radioactive materials, radioactive sources or samples, contaminated objects, or other hazardous items.

# MEDICAL SERVICES

## POLICY

Routine health services are provided, as for other TVA employees in the area, by the Knoxville Area Health Office. First-aid equipment is provided, and employees trained in first aid will be available at all times. Emergency medical service and ambulance service are available by prearrangement with Oak Ridge National Laboratory.

## DISCUSSION

Industrial hygiene, occupational health, and industrial safety services are provided in the same manner and by the same organizations that provide these services for other TVA generating plants. They are described in the TVA Administrative Release Manual and will not be repeated here. The Radiological Health Section assists, coordinates, and supplements these services.

## RESPONSIBILITIES

1. Management

   a. Provides first-aid room or rooms convenient to work locations and keeps them stocked with supplies recommended by the Knoxville Area Health Office.

   b. In accordance with procedures established for radiation workers, requires that all EGCR employees be given preemployment, re-employment, or transfer examinations and the results cleared with Knoxville Area Health Office prior to assignment to EGCR.

   c. Requires that all EGCR employees be given periodic examinations in accordance with procedures established for radiation workers.

   d. Requires that all radiation workers being terminated or transferred have complete physical examinations.

   e. Requires that all employees in the Operations Group obtain first-aid training.

2. Knoxville Area Health Office

   a. Provides health services, including a resident industrial nurse, as desirable.

   b. Provides periodic visits to EGCR for an industrial nurse supervisor or a physician for health counseling, immunizations, etc.

   c. Through referral, provides emergency medical services as follows:

      (1) Attention by BEC (Bureau of Employees Compensation) designated physicians for nonradiation injuries.

      (2) Emergency ambulance service by ORNL.

      (3) Emergency medical service and medical attention to radiation injuries or contaminated injuries at ORNL or as otherwise directed by AEC.

   c. Provides assistance in preparing BEC claims and forms.

3. Supervisors

   Each supervisor obtains first aid or medical attention for injured persons under his control.

4. Radiological Health Section

   a. Monitors injured employee and the area and advises medical attendant regarding the dangers of exposure and contamination.

   b. Provides first-aid assistance.

REGULATIONS

1. All injuries, regardless of how slight, must be reported. (See TVA Administrative Release Manual, VIII INJURY.)

2. All injuries which are known or suspected to be contaminated must be monitored. (See Section VI-2.)

3. The Knoxville Area Health Office is notified of all injuries in accordance with procedures contained in the TVA Administrative Release Manual, VIII INJURY.

# RADIATION INCIDENTS

## POLICY

All incidents involving the known or suspected exposure of persons to ionizing radiation in excess of permissible limits are promptly investigated.

## DEFINITIONS

1. Radiation Incident - Any situation involving radiation or radioactive material which may result in (a) significant exposure to personnel, (b) appreciable damage to or loss of plant property or equipment, or (c) potentially adverse effects upon public relations.

2. Maximum Permissible Limits - The accidental exposure limits in rems are given in Table II-1.3. Maximum permissible body burden is specified by the Federal Radiation Council or, in the absence of such specification, is the value listed in Handbook 69, National Bureau of Standards.

## DISCUSSION

AEC Manual, Chapter 0502, requires routine annual reports of external and internal exposures of contractor personnel and specifies conditions under which special reports are required.

## RESPONSIBILITIES

1. Supervisors

   a. Bring to the attention of the Radiological Health Section any known or suspected radiation incident.

b. Initiate immediate handling of any injuries (see Section VI-2 for contaminated injuries).

c. Initiate prompt remedial action to prevent or minimize recurrence.

2. Radiological Health Section

a. Initiates investigation immediately upon notification of an actual or suspected radiation incident.

b. Provides management with information needed to prevent or control further exposure of personnel by inadvertent or unregulated entry into or exit from hazardous areas.

c. Documents and evaluates evidence of personnel exposure and reports the findings to management.

d. Maintains a master file of all radiation incidents.

e. Prepares special reports of excessive radiation exposures for transmittal to AEC and other appropriate agencies.

3. Individual Employees

Each EGCR employee has an inherent responsibility to notify his supervisor and a Radiological Health representative of any real or suspected radiation incident involving himself or other persons.

4. Management

a. Provides treatment, protection, and control to minimize the adverse effect of radiation emergencies on the employee, the plant, and the public.

b. Submits reports, as required, to AEC and other agencies.

REGULATIONS

1. Each radiation incident is promptly investigated, evaluated, and reported.

REGULATIONS (Continued)

2. Prompt and effective controls are established to prevent or minimize subsequent exposures and prevent the occurrence of a similar incident.

3. Radiation incidents are documented to the extent necessary to describe them.

4. A record of each radiation incident is placed in the personal exposure history file of employees who receive radiation exposures in excess of permissible limits.

5. The release of information to the public is made only by AEC or upon its direction in accordance with established procedures.

# CONTAMINATED INJURIES

## POLICY

Because of the hazard from internal deposition of radioisotopes, special attention is given to injuries which occur in contamination zones and to the prevention of contamination of existing wounds.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Monitors injuries for contamination and assists medical representatives in establishing emergency decontamination procedures.

   b. Provides first-aid assistance as needed.

2. Supervisors

   a. Ensure that before entry into contamination zones all employees have adequate protective apparel, including bandages when needed for skin breaks, rashes, and infections.

   b. Obtain monitoring by a health physicist for all wounds likely to be contaminated.

3. Management

   a. Provides facilities, supplies, and equipment for protection and treatment of injuries and for decontamination of wounds.

   b. Records and reports injuries promptly to appropriate agencies.

   c. Provides or obtains specialized emergency equipment and services, such as ambulance service and hospitalization.

4. Individual Employees

   a. Obtain adequate protection for skin breaks before entry into contamination zones or work with contaminated materials.

b. Report to supervisor all injuries sustained while in contamination zone or while working with contaminated materials, or skin breaks which may have become contaminated.

REGULATIONS

1. The decontamination and treatment of contaminated injuries is instituted promptly and performed in accordance with approved procedures.

2. In case of severe injuries, lifesaving measures take precedence over decontamination of the patient.

3. In the event an open cut is sustained in a contamination zone or contamination of a wound is known or suspected, the following actions are instituted.

   a. Control severe bleeding and flush off any acidic, caustic, or toxic materials.

   b. Flush wound with domestic tap water for at least 5 minutes and promote bleeding by massaging toward the injury.

   c. Apply a tourniquet to prevent uptake of contamination by the blood stream, if appropriate.

   d. Notify the Radiological Health Section and have the wound and the object causing the injury surveyed.

4. During normal plant operation, no employee having an open cut, puncture wound, rash, or infection on the hands or forearms is permitted to enter a contamination zone or work with contaminated materials. In an emergency when no employee is available for such work except one with such an injury, the skin area must first be treated and dressed and adequately protected to obviate radioactive contamination of the injury. The employee is instructed as to his own precautions. Radiological Health surveillance is provided and the injury is monitored for radioactive contamination before beginning and after completing the work.

# PERSONNEL DECONTAMINATION

## POLICY

Prompt removal of radioactive contamination from employees is necessary to avoid the possibility of inhalation, ingestion, or injection of radioactive materials and to prevent direct radiation exposures.

## RESPONSIBILITIES

1. Radiological Health Section

   a. Provides decontamination kits and instructions for their use in change rooms and at other designated locations.

   b. Monitors the progress of decontamination efforts and recommends additional reagents or medical treatment.

   c. Requests body fluids analyses of persons significantly contaminated or where internal contamination is known or suspected.

2. Management

   a. Provides adequate facilities for personnel decontamination, including sinks, showers, and provisions for control of radioactive liquid wastes.

   b. Provides or obtains adequate medical treatment for persons inhaling or ingesting radioactive contaminants or sustaining contaminated injuries.

3. Individual Employees

   Each employee cooperates fully with the Radiological Health Section to obtain adequate decontamination and treatment.

## REGULATIONS

1. Contamination of employees is reported promptly to the Radiological Health Section.

2. The decontamination of employees is performed only in accordance with standard procedures posted at each decontamination station.

3. Medical treatment takes precedence over decontamination efforts in cases of severe bodily injury.

4. Records are maintained for all cases of significant personnel contamination. Where internal contamination is involved, the resultant internal exposure is determined and included in the individual's personal radiation exposure history file.

# FIRE FIGHTING IN PRESENCE OF RADIATION

## POLICY

Fire-fighting operations are conducted as safely as possible. Exposure of emergency personnel to radioactive materials while combating fires is minimized.

## DISCUSSION

While there is no specialized fire department at EGCR, adequate fire-fighting equipment is provided. Automatic sprinkler systems, $CO_2$ blanket systems, and a well-organized Fire Brigade are continuously available at the site. The Fire Brigade is capable of combating and controlling minor fires. In more serious situations, the ORNL Fire Department is available to assist emergency fire-fighting personnel and will respond to all emergency calls.

## DEFINITIONS

1. Yellow Area - An area in which there exists the possibility of significant radioactive contamination, either surface or airborne.

2. Magenta Area - An area identified by a conspicuous sign (see Section III-3) in which there is the likelihood that total body exposure $\geq$ 10 rems may be acquired in 1 hour.

3. White Area - All other plant areas.

4. Emergency Fire-Fighting Personnel - Employees trained in combating fires in the presence of radiation. This includes health physicists, electricians, and other mechanics who have specific duties in support of fire fighting.

5. Fire Marshal - The electrical maintenance supervisor who keeps fire-fighting equipment in a state of readiness, assists in training the Fire Brigade, and prepares fire reports.

6. Fire Brigade Director - The Shift Engineer who directs Fire Brigade activities.

7. Emergency Director - That individual designated in the Emergency Instruction Manual to direct emergency activities (Operations Supervisor until relieved by higher authority).

8. Emergency Activities - All activities which involve outside assistance (ORNL, AEC, etc.) for fire-fighting and other emergency assistance and all activities involving releases to the environment of excessive quantities of radioactive contaminants.

RESPONSIBILITIES

1. Radiological Health Section

   a. Maintains a current status board of yellow and magenta areas.

   b. Has available suitable emergency equipment, including high-range radiation survey meters and direct-reading dosimeters.

   c. Dispatches a representative to the scene of a fire immediately upon notification.

   d. Surveys fire-fighting personnel and equipment for radioactive contamination after combating fires in yellow or magenta areas.

   e. Assists the Fire Marshal in preparing a written report after all fires involving radioactivity.

2. Fire Brigade Director

   a. Ensures that members of the Fire Brigade are thoroughly familiar with the various areas.

   b. Initiates and conducts fire-fighting tactics in accordance with established procedures.

   c. Through the Installation Emergency Director, requests outside assistance when needed.

3. Fire Brigade

   Upon notification, the Fire Brigade reports immediately to the scene of the fire and conducts fire-fighting operations as directed.

RESPONSIBILITIES (Continued)

4. Emergency Director

The Emergency Director assumes direction of emergency activities.

REGULATIONS AND PROCEDURES

When a fire is detected:

1. The appropriate alarm is sounded throughout the entire plant.

2. The senior Radiological Health representative present at the site reports immediately to the Emergency Director or Fire Brigade Director and acts as follows:

   a. Yellow Area - Determines the extent of contamination hazards and advises the Emergency Director or Fire Brigade Director concerning the use of special protective equipment.

   b. Magenta Area - Advises the Emergency Director or Fire Brigade Director of the radiation hazards known to exist and recommends protective equipment, time limitations, and other special precautions.

   c. White Area - Stands by to provide assistance and consultation, as required.

3. The members of the Fire Brigade report immediately to the scene of the fire and act as follows:

   a. Yellow Area - Wear respiratory equipment as advised by the Radiological Health representative.

   b. Magenta Area - Enter and combat fire only after the degree of the radiation hazard has been determined and with the approval of the Emergency Director or the Fire Brigade Director.

   c. White Area - Combat fire in accordance with standard fire-fighting procedures for nonradioactive areas.

4. Personnel and equipment, including emergency assistance groups, are surveyed for radioactive contamination before release.

5. Individuals requiring emergency medical treatment or observation are sent immediately to the ORNL infirmary.

6. Dosimeters and film badges of emergency fire-fighting personnel are collected and processed immediately if, in the opinion of the Radiological Health representative, such action is necessary.

7. A written report of all fires is made by the Fire Marshal with assistance as needed from the Radiological Health representative, who answers the alarm.

# APPENDIXES

Sections of the appendixes are numbered with reference to the section in the text of the Manual to which they are most closely related.

# DEFINITIONS, SYMBOLS, ABBREVIATIONS, UNITS, AND EQUIVALENTS

## DEFINITIONS

Alpha Particle - A particle consisting of two protons and two neutrons originating in the nucleus of a heavy radioactive atom.

Atom - The smallest part of an element which exhibits the chemical behavior characteristic of the element.

Attenuation - The process by which a beam of radiation is reduced in intensity when passing through matter. It is the combination of absorption and scattering processes and results in a decrease in flux density of the radiation when projected through matter.

Autoradiograph - Measurement of radiation from radioactive material in or on an object, made by placing the object in close proximity to a photographic film.

Backscattering - The deflection of radiation by scattering processes through angles greater than 90 degrees with respect to the original direction of motion.

Beta Particle - A charged particle emitted from the nucleus of an atom and having a mass and charge equal in magnitude to those of the electron.

Body Burden - The amount of radioactive material in the body at the time of interest.

Bone Seeker - Any compound or ion which migrates in the body, preferentially into bone.

Bremsstrahlung - Secondary photon radiation produced by deceleration of charged particles passing through matter.

Buildup Factor - The ratio of the actual intensity of X- or gamma radiation (both primary and scattered) at a point in an absorbing medium to the intensity of only the attenuated primary radiation.

Calibration - Determination of accuracy and setting or resetting of a measuring device.

Chamber, Ionization - An instrument designed to measure quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume.

Chamber, Pocket - A small pocket-sized ionization chamber used for monitoring radiation exposure of personnel.

Confidential - As it applies to personal exposure records, confidential means that such records for individual employees are not kept in general files where they are available to fellow workers.

Contamination, Radioactive - Radioactive material in any place where it is not desired and, particularly, in any place where its presence may be harmful. The harm may be in vitiating an experiment or in actually being a source of danger to personnel.

Controlled Area - The area immediately surrounding the site in which people enter occasionally or work. Waterways, highways, etc., may pass through the controlled area without changing the classification, provided there are adequate means of evacuation in case of an emergency.

Off-Area - Any location beyond the controlled area.

Corpuscular Emission, Associated - The full complement of secondary charged particles (usually limited to electrons) associated with an X-ray or gamma-ray beam in its passage through air.

Counter, Geiger-Mueller - Highly-sensitive, gas-filled, radiation-measuring device which operates at voltages sufficiently high to produce avalanche ionization.

Counter, Scintillation - The combination of phosphor, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphor.

Curie - The unit of activity disintegrating at the rate of $3.700 \times 10^{10}$ atoms per second. Abbreviated c. One or more particles may be emitted per disintegration. Several fractions of the curie are in common usage.

Microcurie - One-millionth of a curie ($3.7 \times 10^4$ dps). Abbreviated μc.

Millicurie - One-thousandth of a curie ($3.7 \times 10^7$ dps). Abbreviated mc.

Picocurie - One-millionth of a microcurie ($3.7 \times 10^{-2}$ dps or 2.22 dpm). Abbreviated pc or μμc. Sometimes called a micro-microcurie.

DEFINITIONS (Continued)

Decay, Radioactive - Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles or photons.

Decay Constant - The fraction of the number of atoms of a radioactive nuclide which decays in unit time.

Densitometer - Instrument utilizing a photocell to determine the degree of darkening of developed photographic film.

Disposal Ground - A place for burying unwanted radioactive objects to prevent escape of their radiations, the earth acting as a shield.

Dose (Dosage) - According to current usage, the radiation delivered to a specified area or volume or to the whole body.

Absorbed Dose - The quantity of energy imparted to a mass of material exposed to radiation. (See Rad.) This is the preferred usage for the term "dose."

Air Dose - X-ray or gamma-ray dose expressed in roentgens delivered at a point in free air. In radiologic practice it consists of the radiation of the primary beam and that scattered from surrounding air.

Cumulative Dose (Radiation) - The total dose resulting from repeated exposure to radiation of the same region or of the whole body.

Maximum Limiting Dose - That limit of radiation dose which may be received by persons working with ionizing radiation and which, in the light of present knowledge, does not constitute undue risk.

Dose Distribution Factor (DF) - A factor expressing the modification of biological effect due to nonuniform distribution of internally deposited isotopes.

Dose Equivalent (DE) - The product of absorbed dose (D), quality factor (QF), dose distribution factor (DF), and other necessary modifying factors. The unit of dose equivalent is the "rem."

Dose Rate (Dosage Rate) - Radiation dose delivered per unit time.

Dose Rate Meter - Any instrument which measures radiation dose rate.

Dosimeter - Instrument used to detect and measure an accumulated dosage of radiation.

Electron - Negatively-charged particle which is a constituent of every neutral atom.

Secondary Electron - An electron ejected from an atom, molecule, or surface as a result of a collision with a charged particle or photon.

Electron Volt - A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt.

Employee - A person attached to the Project by virtue of payroll, assignment, loan, or training status.

Emulsion, Nuclear - A photographic emulsion specially designed to permit observation of the individual tracks of ionizing particles.

Epilation (Depilation) - The temporary or permanent removal of hair.

Erythema - An abnormal redness of the skin due to distention of the capillaries with blood. It can be caused by many different agents, e.g., heat, certain drugs, ultraviolet rays, and ionizing radiation.

Exposure - The product of radiant flux density multiplied by exposure time.

Film Badge - A badge for personnel monitoring purposes. The badge may contain two or three photographic films of differing sensitivity, filters which shield parts of the film from certain types of radiation, and additional insert components to aid in determining the energy spectrum of the incident radiation.

Film Ring - A film badge in the form of a finger ring.

Fission Products - Elements or compounds resulting from fission.

Flux - For electromagnetic radiation, the quantity of radiant energy flowing per unit time. For particles and photons, the number of particles or photons flowing per unit time.

DEFINITIONS (Continued)

Gamma Ray - Short wavelength electromagnetic radiation of nuclear origin with a range of wavelengths from about $10^{-8}$ to $10^{-11}$ cm.

Geiger-Mueller (G-M) - See Counter.

Gene - The fundamental unit of inheritance which determines and controls hereditarily transmissible characteristics.

Geometry Factor - The fraction of the total solid angle about the source of radiation that is subtended by the face of the sensitive area of a detector.

Germ Cells - The cells of an organism whose function it is to reproduce its kind.

Gonad - A gamete-producing organ in animals--testis or ovary.

Half-Life, Biological - The time required for the body to eliminate one-half of an administered dose of any substance by regular processes of elimination. This time is approximately the same for both stable and radioactive isotopes of a particular element.

Half-Life, Effective - The time required for a radioactive element fixed in the tissue of plant or animal to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

Half-Life, Radioactive - The time required for a radioactive substance to lose 50 percent of its activity by decay.

Half-Value Layer (Half Thickness) - The thickness of any particular material necessary to reduce the intensity of an X-ray or gamma-ray beam to one-half its original value.

Health, Radiological - The art and science of protecting human beings from injury by radiation, as well as promoting better health through beneficial applications of radiation. In this Manual, it is frequently used with or without the word "Section" to refer to the Radiological Health Section.

Health Physicist - A professionally-trained practitioner of health physics. TVA job classification.

Health Physics Technician - TVA job classification in the sub-professional series. Sometimes called surveyor or inspector.

Interlock - A device to prevent hazardous operations, or to prevent activation of a control, until a preliminary condition has been met.

Ion - An atomic particle, atom, molecule, or chemical radical bearing an electrical charge, either negative or positive.

Ion Pair - Two particles of opposite charge, usually referring to the electron and the positive atomic or molecular residue resulting after the interaction of ionizing radiation with the orbital electrons of atoms.

Isotope - One of several nuclides having the same number of protons in their nuclei and, hence, having the same atomic number and chemical properties, but differing in the number of neutrons and, therefore, in the mass number. The use of this term as a synonym for nuclide is to be discouraged.

Latent Period - The period or state of seeming inactivity between the time of exposure of tissue to an injurious agent and the beginning of the response.

Micro - Prefix designating one-millionth.

Micron - Unit of length equal to one-millionth ($10^{-6}$) meter.

Monitoring - Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present.

Area Monitoring - Routine monitoring of the level of radiation or of radioactive contamination of any particular area, building, room, or equipment. May be used to distinguish between routine monitoring and survey activities.

Environmental Monitoring - Monitoring of the environs which may include air, water, soil, biological organisms, etc., to measure the dispersion and distribution of radioactive contaminants into the environment.

DEFINITIONS (Continued)

Personnel Monitoring - A program devised to measure the amount of radiation or contamination to which individuals are exposed. The program may include dosimetry, body fluid analysis, contamination survey, etc.

Neutron - Elementary nuclear particles with a mass approximately the same as that of a hydrogen atom and electrically neutral; its mass is 1.008982 mass units.

Nucleus (Nuclear) - That part of an atom in which all the positive electric charge and most of the mass are concentrated.

Occupational Worker (Radiation Worker) - Employees, trainees, and assignees employed on work causing or resulting in exposure to ionizing radiation.

Physics, Health - A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

Positron - A particle equal in mass to the electron and having an equal but opposite charge.

Proton - An elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a mass of 1.007594 mass units.

Quality Factor (QF) - The linear-energy-transfer-dependent factor by which absorbed doses are to be multiplied to obtain, for purposes of radiation protection, a quantity which expresses on a common scale for all ionizing radiation the irradiation incurred by exposed persons. This factor was formerly called "Relative Biological Effectiveness (RBE)," a term which the International Commission on Radiological Units and Measurements (ICRU), Report 10a, recommended in 1962 be used in radiobiology only.

Rad - The unit of absorbed dose which is 100 ergs/gm in any medium. The rad is a measure of the energy imparted to matter (i.e., retained by matter) by ionizing radiation per unit mass of irradiated material at the place of interest.

Radiation - The emission and propagation of energy through space or through a material medium in the form of waves or particles.

Background Radiation - Radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in parts of a building, in the building material itself, etc.

External Radiation - Ionizing radiation arising from sources outside the body.

Internal Radiation - Ionizing radiation arising from sources within the body as a result of deposition of radioelements in the body tissues by inhalation, ingestion, or injection.

Radiobiology - That branch of biology which deals with the effects of radiation on biological systems.

Relative Biological Effectiveness - (See Quality Factor.) The RBE is a factor which expresses the ratio of an absorbed dose of X- or gamma rays to the absorbed dose of a particular radiation required to produce an identical biological effect in a given organ or tissue.

Roentgen - A unit of exposure. That quantity of X- or gamma radiation such that the associated corpuscular emission per 0.001293 grams of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign. Abbreviated R.

Microroentgen (μR) - One-millionth roentgen.

Milliroentgen (mR) - One-thousandth roentgen.

Roentgen Equivalent Man (rem) - The rem is the unit of dose equivalent used to express human biological doses as a result of exposure to one or many types of ionizing radiation. The dose in rems is equal to the sum of dose equivalents for each type of radiation being absorbed.

Site - The EGCR plant, including the area within the fence and the immediate environs, ancillary buildings, roads, parking lots, etc., which are integral parts of the physical plant and its operation.

DEFINITIONS (Continued)

Source, Radioactive - A quantity of radioactive material confined in a capsule or otherwise to permit the beneficial use of the radiations from the material (e.g., calibration source, gamma ray, and logging source).

Source Material - Material containing uranium or thorium in excess of 1/20 percent.

Special Nuclear Material - Plutonium, uranium enriched in the isotope $U^{233}$ or in the isotope $U^{235}$, and any other material which the AEC determines to be special nuclear material, but does not include source material.

Specific Ionization - The number of ion pairs per unit length of path of ionizing radiation in a medium, e.g., per cm of air or per micron of water or tissue.

SS Material - A collective term which includes source material, special nuclear material, and those other materials to which, by direction of the AEC General Manager, the provisions of Part 7400 apply.

Standard, Calibration - A sample of radioactive material, usually with a long half-life, in which the number and type of radioactive atoms at a definite reference time are known.

Survey, Radiological (Radiation, Contamination) - A critical evaluation of the radiation hazards incident to the production, usage, storage, or disposal of radioactive materials or other sources of radiation under a specific circumstance.

X-Rays - Penetrating electromagnetic radiations having wavelengths shorter than those of visible light, sometimes called "Roentgen Rays" after their discoverer, W. C. Roentgen.

## SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| A | activity (radio); atomic mass number |
| $A_o$ | activity, original |
| ~ | approximately |
| b | buildup factor |
| c | curie |
| e | base of natural logarithms |
| e, $e^-$ | charge of the electron |
| $_{-1}e^o$ | electron; beta particle |
| $_{+1}e^o$ | positron |
| $e^+$ | charge of the positron |
| $_1H^1$ | proton |
| h | Planck's constant |
| $h\nu$ | photon energy; quantum |
| I | intensity of radiation |
| $I_o$ | initial intensity |
| m | mass |
| mc | millicurie |
| $_on^1$ | neutron |
| Q | electric charge; reaction energy in Mev |
| $T_{1/2}$ | half-life, physical |
| $T_b$ | half-life, biological |
| $T_{eff}$ | half-life, effective |
| Z | atomic number |
| $\alpha$ | alpha particle |
| $\beta, \beta^-, _{-1}\beta^o$ | beta ray (particle) |
| $\beta^+, _{+1}\beta^o$ | positron |
| $\gamma$ | gamma ray |
| $\theta$ | angle between incident & scattered radiation |
| $\lambda$ | decay constant |
| $\lambda_b$ | biological elimination constant |
| $\mu c$ | microcurie |
| $\mu\mu c$ | micro-microcurie, picocurie |
| amu | atomic mass unit |
| at. no. | atomic number |
| at. wt | atomic weight |
| Bev | billion electron volts |
| Btu | British thermal unit |
| C | centigrade |
| cal | calorie (gram) |
| cc | cubic centimeter |

SYMBOLS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| cfm | cubic feet per minute |
| cfs | cubic feet per second |
| cgs | centimeter-gram-second |
| cm | centimeter |
| cpm | counts per minute |
| cps | counts per second |
| cu | cubic |
| cu ft | cubic foot |
| cu in. | cubic inch |
| cu m | cubic meter |
| cu yd | cubic yard |
| dpm | disintegrations per minute |
| dps | disintegrations per second |
| esu | electrostatic unit |
| ev | electron volt |
| exp | exponential function |
| fps | feet per second |
| ft | foot |
| g | acceleration of gravity |
| gal | gallon |
| gm | gram |
| hr | hour |
| in. | inch |
| insol. | insoluble |
| K | electron capture from K shell |
| Kev | thousand electron volts |
| kg | kilogram |
| kilo- | prefix meaning 1000 |
| l | liter |
| lb | pound |
| ln | natural logarithm |
| m | meter, milli- |
| Mev | million electron volts |
| mg | milligram |
| mil | 0.001 inch |
| ml | milliliter |
| mm | millimeter |
| MPC | maximum permissible concentration |
| mμ | millimicron; millimicro- |
| pc | picocurie |

| | |
|---|---|
| psi | pounds per square inch |
| q | maximum permissible radionuclide body burden (μc) |
| R | roentgen |
| rad | radiation absorbed dose |
| RBE | relative biological effectiveness |
| RCG | radioactivity concentration guide |
| rem | roentgen equivalent man |
| RPG | radiation protection guide |
| rpm | revolutions per minute |
| sec | second |
| SpA | specific activity |
| sq cm | square centimeter |
| sq ft | square foot |
| sq in. | square inch |
| sq m | square meter |
| sq yd | square yard |
| vol. | volume |
| wt | weight |
| μ | micron; micro- |

## UNITS AND EQUIVALENTS

Units of radioactive materials are usually expressed in curies, exposure in roentgens, and absorbed dose of radiation in rads or rems. Surface contamination with beta or gamma emitters is usually expressed in dose units at a given distance. Although these units have previously been defined, their importance warrants a brief discussion on proper usage and application.

Curie - The unit of activity disintegrating at the rate of $3.700 \times 10^{10}$ atoms per second. One or more particles may be emitted per disintegration. Since this unit indicates only the rate of disintegration and nothing about the energy, number, or type of radiations emitted, it can be used as a measure of hazard only when the radioactive material is specified.

Dose Equivalent (DE) - The product of absorbed dose (D), quality factor (QF), dose distribution factor (DF), and other necessary modifying factors. The unit is the rem for expressing on a common scale for all ionizing radiation the irradiation incurred by exposed persons.

Roentgen - The exposure unit for X- or gamma radiation. The corpuscular emission associated with 1 roentgen produces, in 1 cubic centimeter of air at standard conditions of temperature and pressure, ions carrying 1 electrostatic unit of quantity of electricity of either sign.

Rad - The unit of absorbed dose--the amount of energy imparted to matter by ionizing particles per unit mass of irradiated material at the point of interest (100 ergs/gm). The rad may be applied to all ionizing radiation. Since the absorbed dose results from the interaction of radiation with matter, it depends upon the properties of the irradiated material, as well as upon the radiation field. For example, an exposure dose of 1 R of X- or gamma radiation will result in an absorbed dose of 0.887 rads/gm of air. In soft tissue, however, the same exposure dose of X- or gamma radiation will produce an absorbed dose of 1 rad at a depth of about 5 cm. In bone, the same exposure dose may result in an absorbed dose of as much as 3 rads.

Rem - Roentgen equivalent man--the unit used to express all types of radiation dose equivalent in one convenient term. For example, a dose of 30 mrads of gamma and 1 mrad of neutrons will result in a total dose of 40 mrems if a dose equivalent factor of 10 is used for neutrons.

## Practical Factors* For Dose Equivalent

| Type of Radiation | Factor | Dose Equivalents |
|---|---|---|
| X- and gamma rays | 1 | 1 R = 1 rad = 1 rem |
| Beta particles | 1 | 1 rad = 1 rem |
| Thermal neutrons | 2.5 | 1 rad = 2.5 rems |
| Fast neutrons | 10 | 1 rad = 10 rems |
| Alpha particles | 10 | 1 rad = 10 rems |
| Protons | 10 | 1 rad = 10 rems |
| Heavy ions | 20 | 1 rad = 20 rems |

*Formerly called Relative Biological Effectiveness (RBE).

# EGCR RADIATION DETECTION INSTRUMENTS

## PORTABLE

| Instrument | Type | Model Number |
|---|---|---|
| **Alpha** | | |
| Alpha Survey Meter (PSA) | Scintillation | ORNL, Q-1975A |
| **Beta-Gamma** | | |
| G-M Survey Meter | Geiger-Mueller | ORNL, Q-2092A |
| Cutie Pie | Air Ionization | ORNL, Q-2299 |
| Survey Meter (High Range) | Air Ionization | ORNL, Q-2299 (Modified) |
| **Neutron** | | |
| Thermal Neutron Survey Meter | $BF_3$ Proportional | ORNL, Q-2004 |
| Fast Neutron Survey Meter | Proportional Counter | ORNL, Q-2047A |

STATIONARY

| Instrument | Type | Model Number |
|---|---|---|
| Alpha | | |
| Alpha Scintillation Poppy | Scintillation | ORNL, Q-2091 (w/alpha probe) |
| Beta-Gamma | | |
| Continuous Air Monitor | Moving Filter G-M Tube | ORNL, Q-2240 |
| Local Ratemeter | Geiger-Mueller | Tracerlab, Type SU-3D |
| Hand and Foot Monitor | Geiger-Mueller | ORNL, Q-1939B |
| Building Area Monitor | Geiger-Mueller | Tracerlab, Type TA-6-10R |
| Liquid Waste Monitor | Scintillation | Tracerlab, Type MW-2P |
| Coolant Loop Monitor | Geiger-Mueller | Tracerlab, Type TA-6-100R |
| Spent Fuel Storage Basin Monitor | | Tracerlab, Type MW-1A |
| Stack Gas Monitor | Particulate, Total Gas, Iodine | Tracerlab, Model MAP-1A/MGP-1A |

# ALPHA SURVEY METER (PSA)

## PORTABLE

### DESIGN

| | |
|---|---|
| Type of radiation detected | Alpha |
| Range | 5 (± 3) cpm to ~ 500 (± 22) cpm |
| Response time | 1 minute |
| Warmup time | 30 seconds |
| Detector face area | 100 sq cm |
| Detector geometry | 10-15 percent |
| Calibration standard | $Pu^{239}$ plated on stainless steel |

### APPLICATION

This instrument is intended for use as a low-count-rate, contamination monitoring instrument. For maximum accuracy, the probe face must be placed very near (~ 1/4 inch) the contaminated surface and moved slowly.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Detects alpha particles independently of beta and gamma radiation intensities up to about 1 rad/hr.

### LIMITATIONS

The extremely thin (.1 mil), light-tight covering over the detector surface is easily punctured. The probe face must not be allowed to contact sharp objects. When not in use, the instrument should be kept on "Charge" to prevent damage to the "permanent" battery.

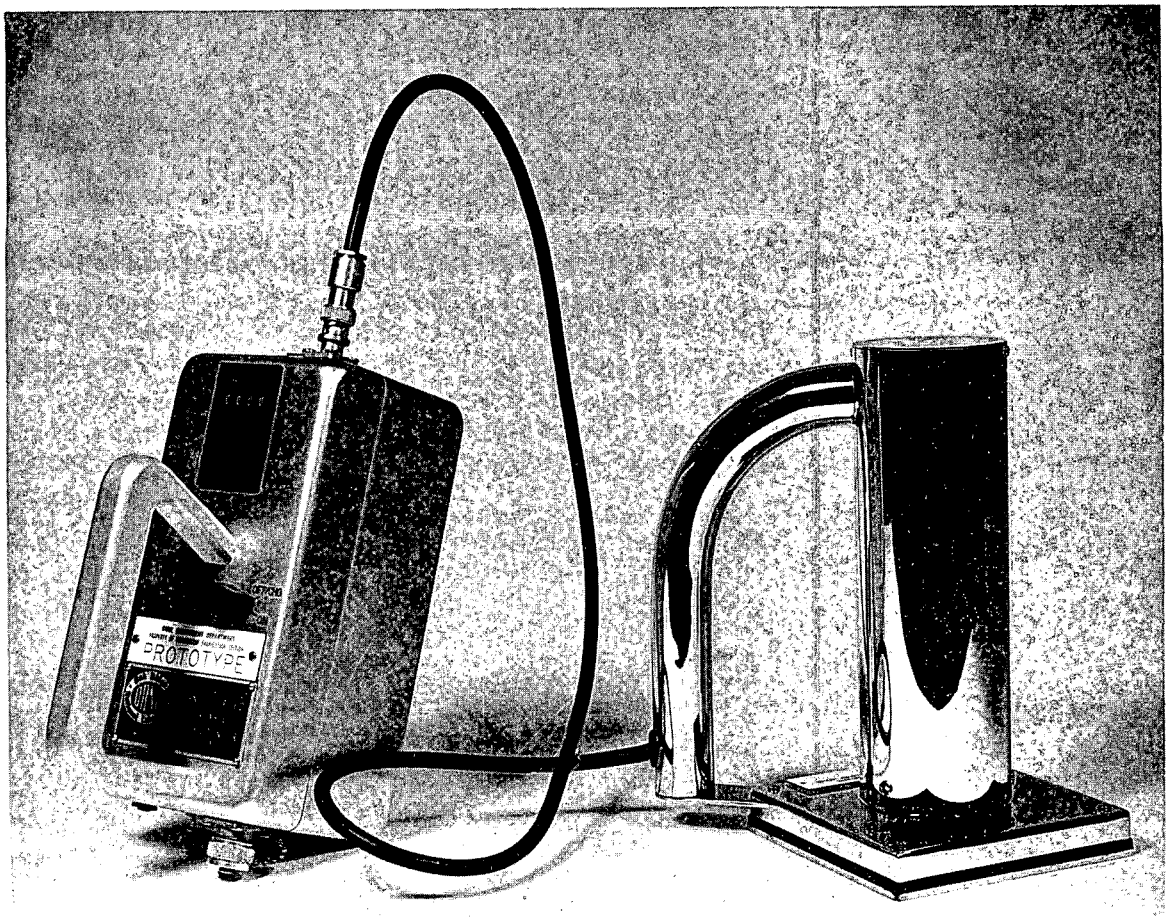


Figure A-III-1.1

Alpha Survey Meter (PSA)

# GAS-FLOW ALPHA COUNTER (PGA)

## PORTABLE

## DESIGN

| | |
|---|---|
| Type of radiation detected | Alpha |
| Range | 5 (± 3) cpm to 100,000 (± 300) cpm |
| Response time | 1 minute |
| Warmup time | 3 minutes (flushing time) |
| Detector face area | 61 sq cm |
| Detector geometry | 10-15 percent |
| Calibration standard | $Pu^{239}$ plated on stainless steel |

## APPLICATION

This instrument is particularly adaptable to rapid surveys and can be used in inclement weather without appreciable loss in efficiency. For maximum accuracy, the probe face must be very near (~ 1/4 inch) the contaminated surface and moved slowly.

## SENSITIVITY TO OTHER TYPES OF RADIATION

When high voltage and discriminator are properly adjusted, detects alpha particles independently of beta and gamma radiation intensities up to about 1 rad/hr; slight response to fast neutrons.

## LIMITATIONS

The gas chamber is covered by an extremely thin, aluminized Mylar screen which is easily punctured. Normal operation time per bottle of propane gas is 16 hours.

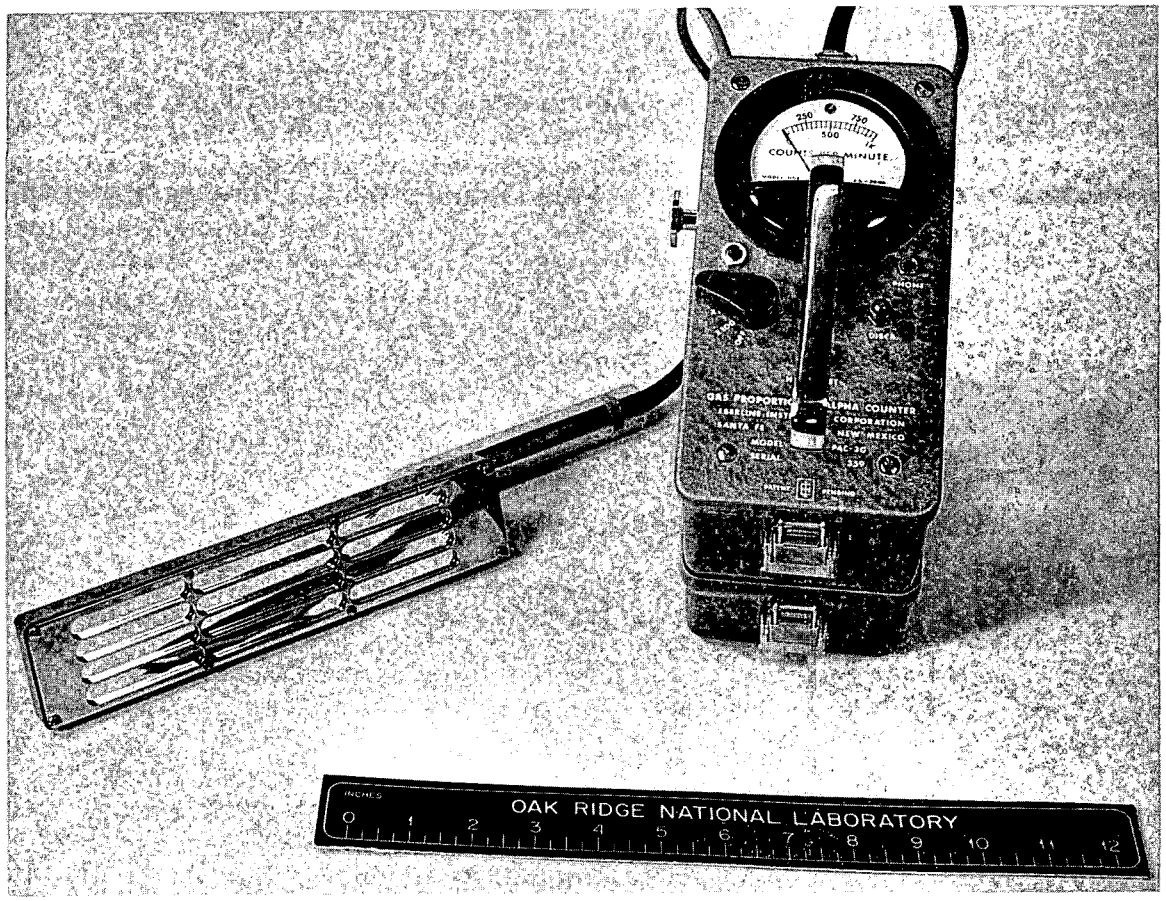


Figure A-III-1.2

Gas-Flow Alpha Counter (PGA)

# G-M SURVEY METER

## PORTABLE

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | .05 (± .02) mrad/hr to 20 (± 2) mrads/hr |
| Response time | < 3 seconds |
| Warmup time | None |
| Detector face area | G-M tube--Normal sensitive area is 3 inches in length and 3/4 inch in width. |
| Detector geometry | Not applicable |
| Calibration standard | Ra gamma |

### APPLICATION

This instrument is intended primarily as a detection device and not as a dose-rate or dose-measuring instrument. With the shield open, it will detect beta radiation with energies above 0.2 Mev.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Slightly sensitive to fast and slow neutrons.

### LIMITATIONS

G-M type instruments have an inherent disadvantage of "blocking" or indicating zero in high-radiation fields. Consequently, such instruments must never be used as dose-rate devices where there is the possibility of intense radiation beams or "leaks" in biological shields. Earphones should be used when monitoring low-contamination levels.

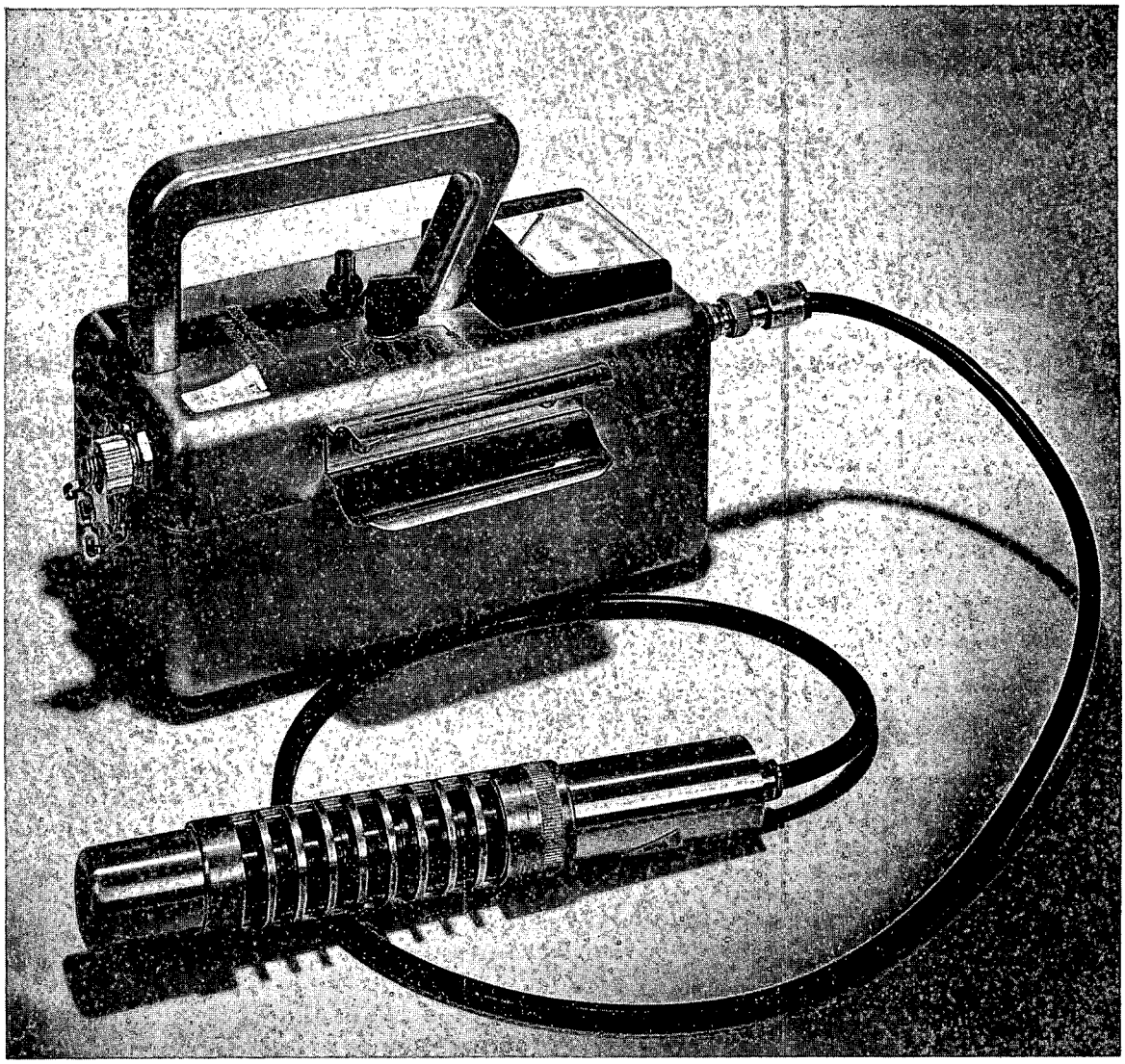

Figure A-III-1.3

G-M Survey Meter

# CUTIE PIE

## PORTABLE

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | 5 (± 2) mR/hr to 10 (± .1) R/hr |
| Response time | < 3 seconds |
| Warmup time | 10 seconds |
| Detector area | Cylinder--6 inches in length by 3 inches in diameter |
| Detector geometry | Not applicable |
| Calibration standard | Ra gamma |

### APPLICATION

The cutie pie is one of the best dose-rate measuring instruments available. It may be zeroed in radiation fields up to about 20 R/hr. There is a slight directional dependence on the chamber; and, for this reason, readings should always be taken with the chamber axis perpendicular to a line from the source.

### SENSITIVITY TO OTHER TYPES OF RADIATION

There is a slight (< 10 percent) response to neutron radiation.

### LIMITATIONS

Most models of the cutie pie are moisture sensitive and cannot be used effectively in humid atmospheres. There is also a response to radio frequency and magnetic fields, and spurious readings may be obtained.

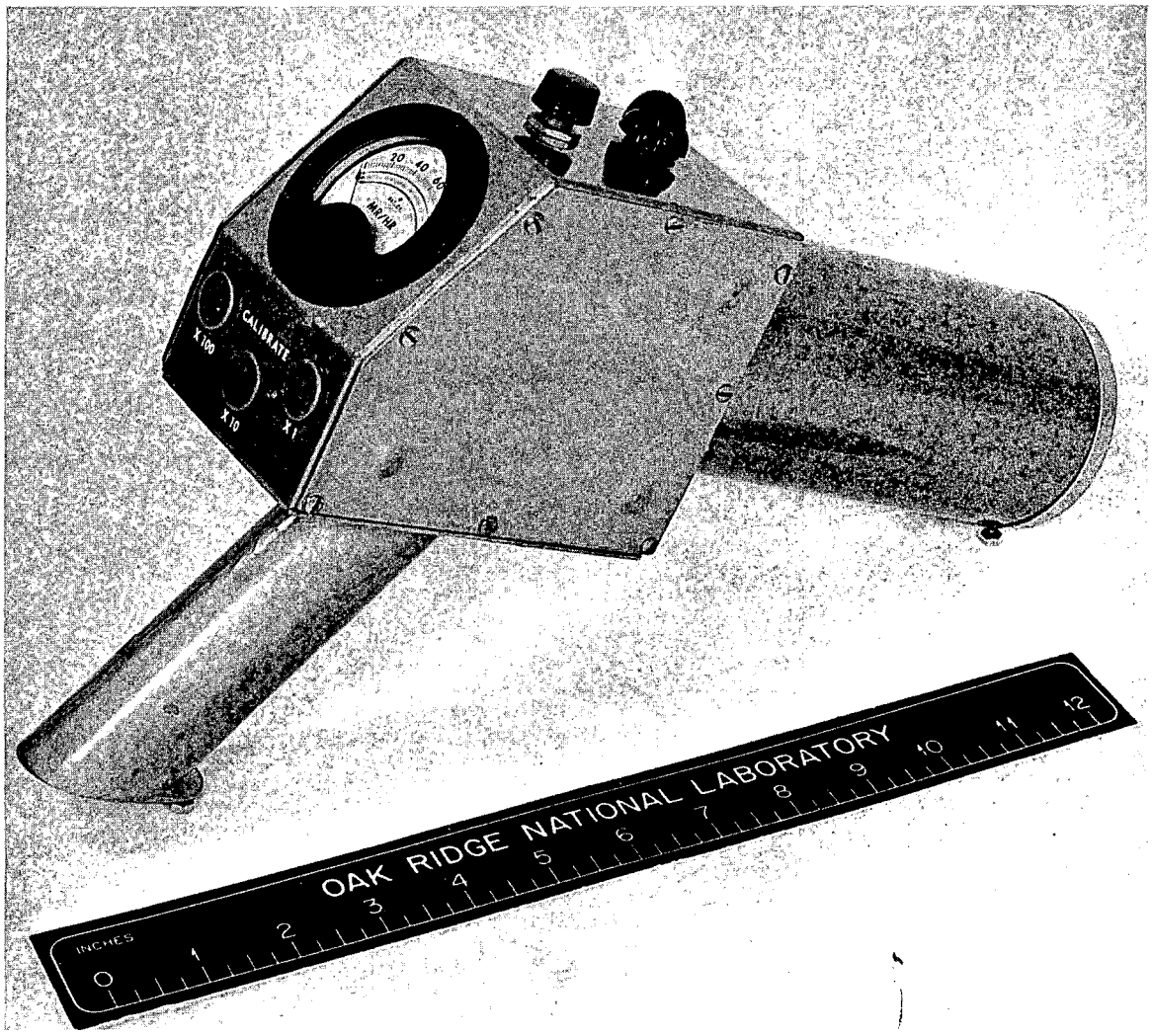


Figure A-III-1.4

Cutie Pie

# SURVEY METER (HIGH RANGE)

## PORTABLE

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | 1.0 (± .1) R/hr to 1000 (± 100) R/hr |
| Response time | Not applicable |
| Warmup time | Not applicable |
| Detector area | Not applicable |
| Detector geometry | Not applicable |
| Calibration standard | Ra gamma |

### APPLICATION

The high-range survey meter is used as an emergency survey instrument when high-radiation dose rates (> 100 R/hr) are encountered. It can be used to discriminate between high-energy beta and gamma radiation.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Slightly sensitive to neutron radiation.

### LIMITATIONS

May be influenced by the presence of high radio frequency and magnetic fields and is affected by moisture and temperature fluctuations.

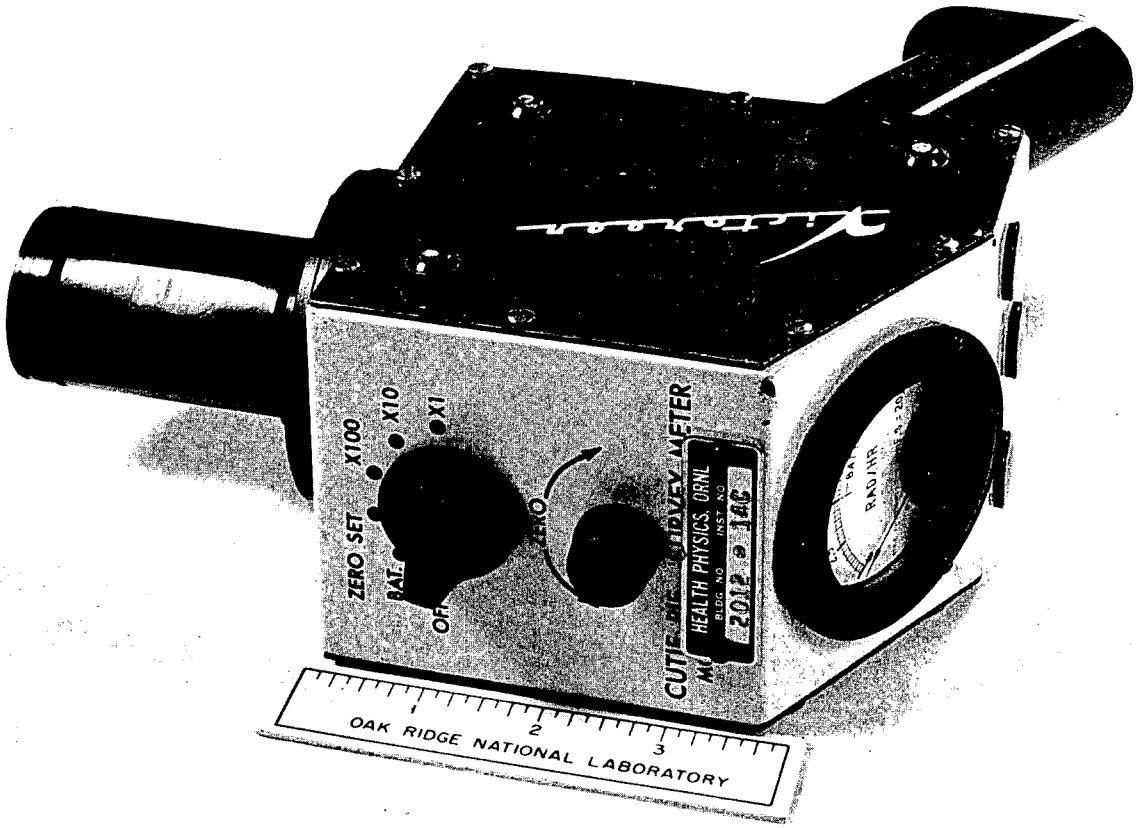


Figure A-III-1.5

Survey Meter (High Range)

# THERMAL NEUTRON SURVEY METER

## PORTABLE

### DESIGN

| | |
|---|---|
| Type of radiation detected | Thermal neutrons |
| Range | 50 (± 10) neutrons per sq cm per second to 20,000 (± 2,000) neutrons per sq cm per second |
| Response time | 30 seconds |
| Warmup time | 30 seconds |
| Detector area | Cylinder--6 inches in length by 1/2 inch in diameter |
| Detector geometry | Not applicable |
| Calibration standard | Po-Be neutron source |

### APPLICATION

With discriminator the thermal neutron survey meter is a transistorized, lightweight instrument designed to measure thermal neutron fluxes in the presence of other radiation.

### SENSITIVITY TO OTHER TYPES OF RADIATION

The instrument is relatively insensitive to other types of radiation.

### LIMITATIONS

The discriminator must be adjusted to prevent sensitivity to gamma radiation. A frequent check with a gamma source is made to assure correct discriminator setting.

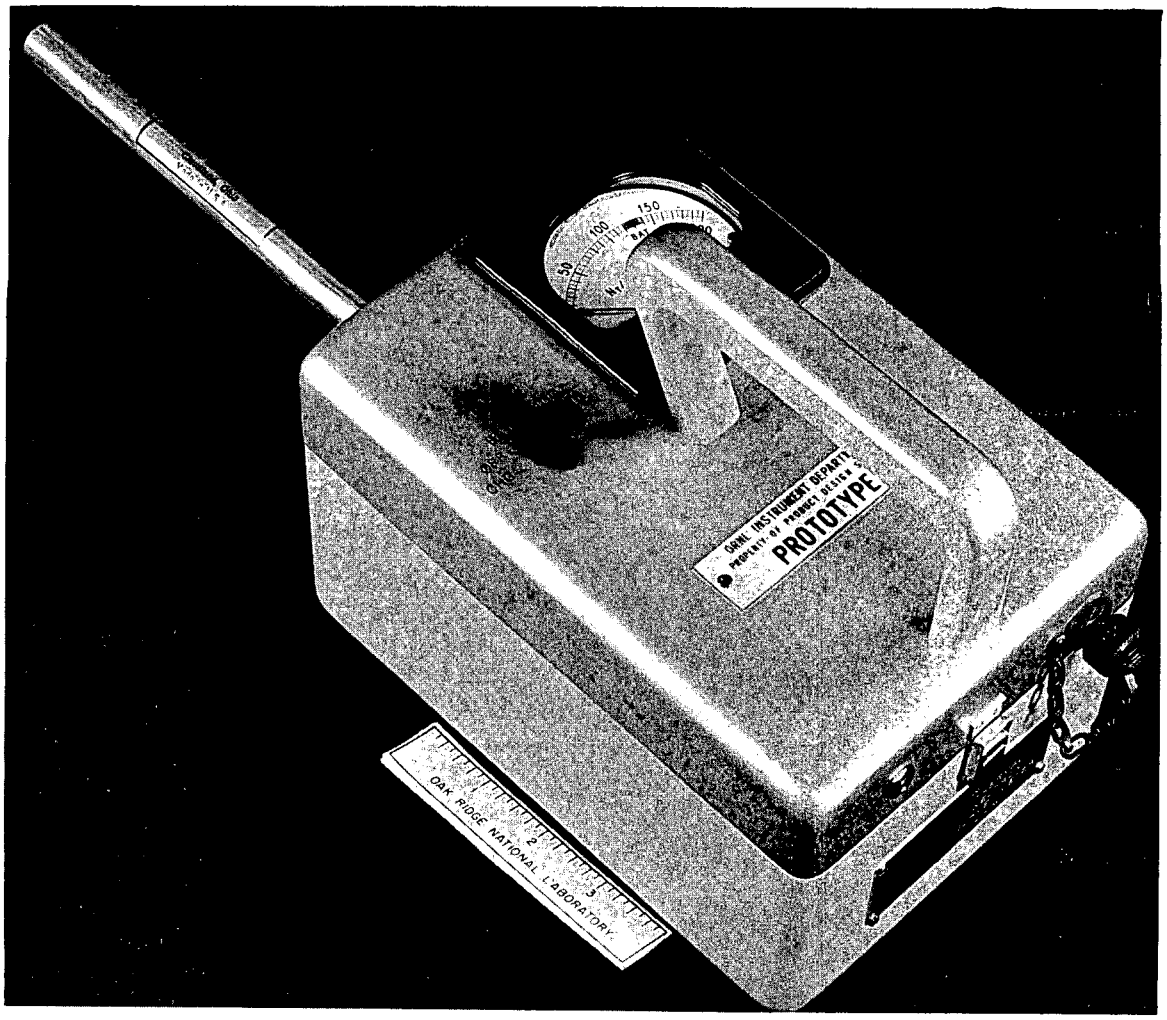


Figure A-III-1.6

Thermal Neutron Survey Meter

# FAST NEUTRON SURVEY METER

## PORTABLE

### DESIGN

| | |
|---|---|
| Type of radiation detected | Fast neutrons |
| Range | 0 to 2500 mrad/hr |
| Response time | 30 seconds |
| Warmup time | 30 seconds |
| Detector area | Not applicable |
| Detector geometry | Not applicable |
| Calibration standard | Po-Be neutron source |

### APPLICATION

The fast neutron survey meter is used to measure fast neutron dose rates in the presence of other radiation.

### SENSITIVITY TO OTHER TYPES OF RADIATION

When properly adjusted, is sensitive only to fast neutrons.

### LIMITATIONS

This instrument is a highly-specialized survey meter which requires considerable knowledge in operating techniques for correct usage.

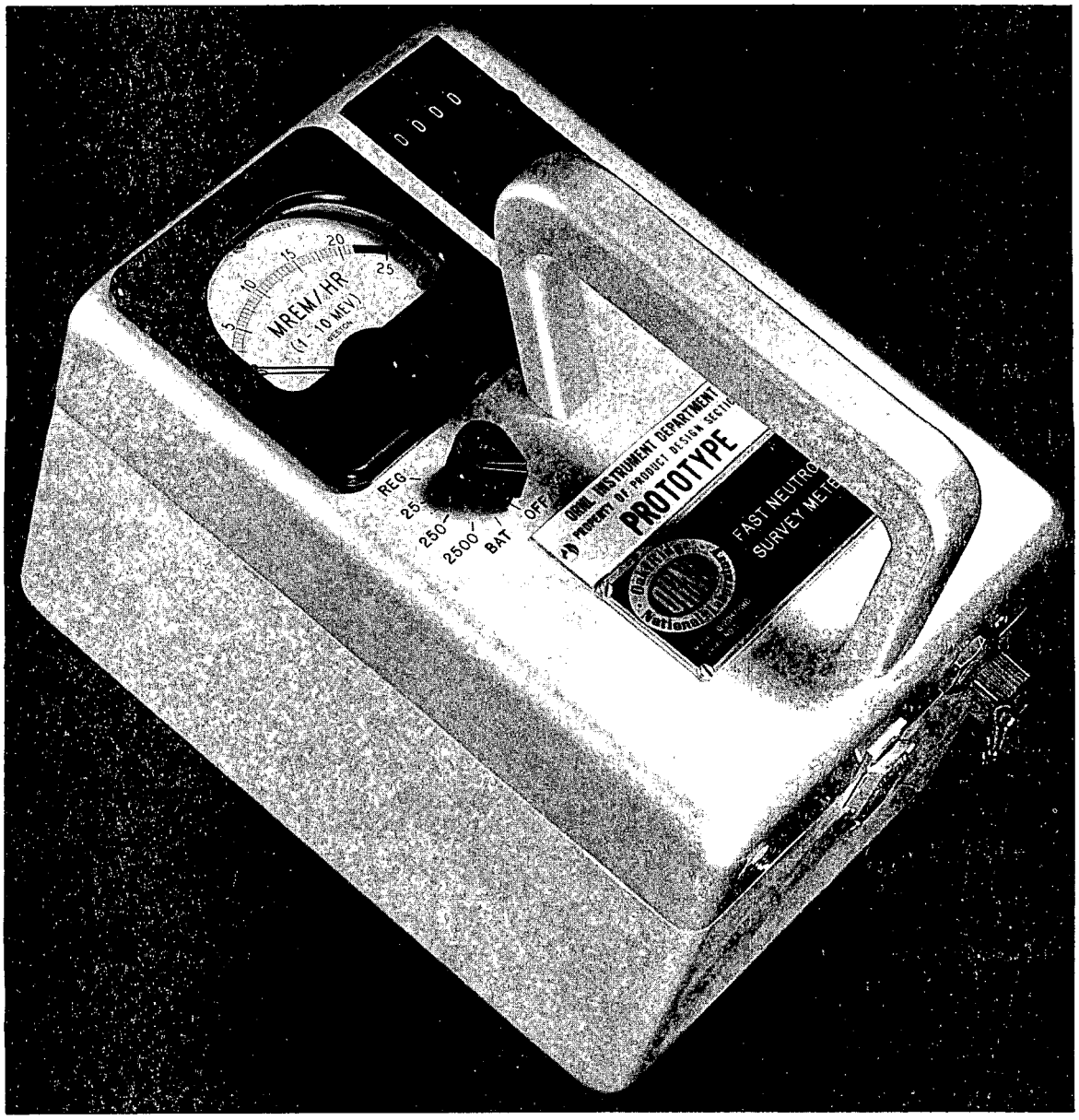


Figure A-III-1.7

Fast Neutron Survey Meter

# NEUTRON AREA MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Gamma, neutron |
| Range | .01 mrem/hr to 100 mrems/hr |
| Response time | 2 seconds |
| Warmup time | Not applicable |
| Detector area | Not applicable |
| Detector geometry | Not applicable |
| Calibration standard | Po-Be, $Co^{60}$ |

### APPLICATION

The neutron area monitor is mounted on the traveling bridge over the spent fuel storage basin to alarm when significant neutron and gamma fluxes are encountered. It is used primarily as a warning device and does not fulfill the requirements for an accurate determination of gamma and neutron hazards.

### SENSITIVITY TO OTHER TYPES OF RADIATION

When properly adjusted, sensitive to neutron and gamma radiation only.

### LIMITATIONS

May be affected by fluctuations in line voltage and by excessive temperature and moisture conditions.

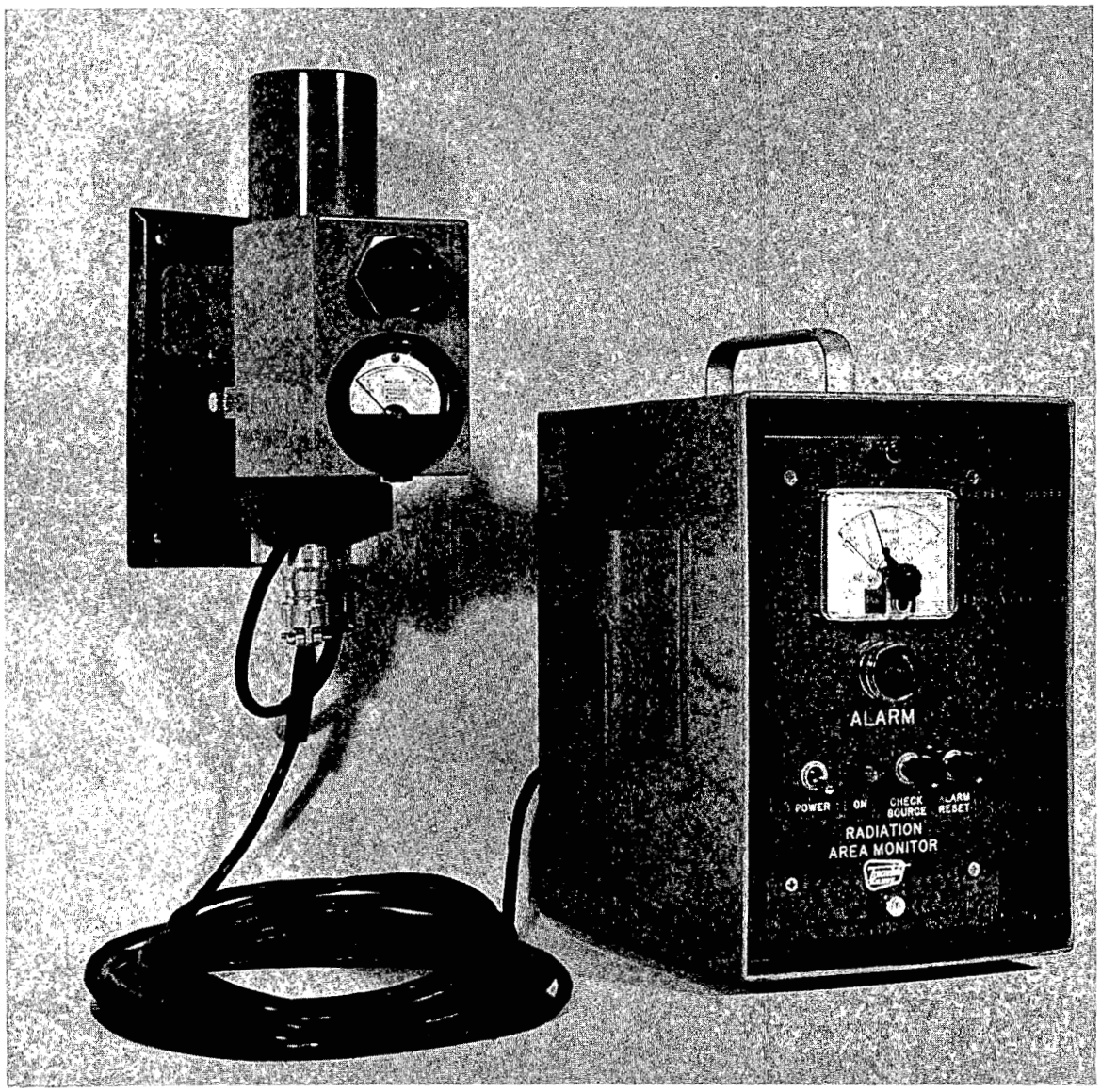


Figure A-III-1.8

Neutron Area Monitor

# ALPHA SCINTILLATION POPPY

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Alpha |
| Range | 5 (± 3) cpm to 500 (± 22) cpm |
| Response time | 1 minute |
| Warmup time | 30 seconds |
| Detector area | 61 sq cm |
| Detector geometry | 10-15 percent |
| Calibration standard | $Pu^{239}$ plated on stainless steel |

### APPLICATION

The AC-powered alpha poppy is intended as a contamination monitoring instrument at contamination zone portals and at other designated locations. When detecting low levels of contamination, the probe face must be very near the object being monitored and moved slowly.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Detects alpha radiation only.

### LIMITATIONS

The detector is covered by a thin (0.1 mil), aluminized Mylar screen which is easily punctured.

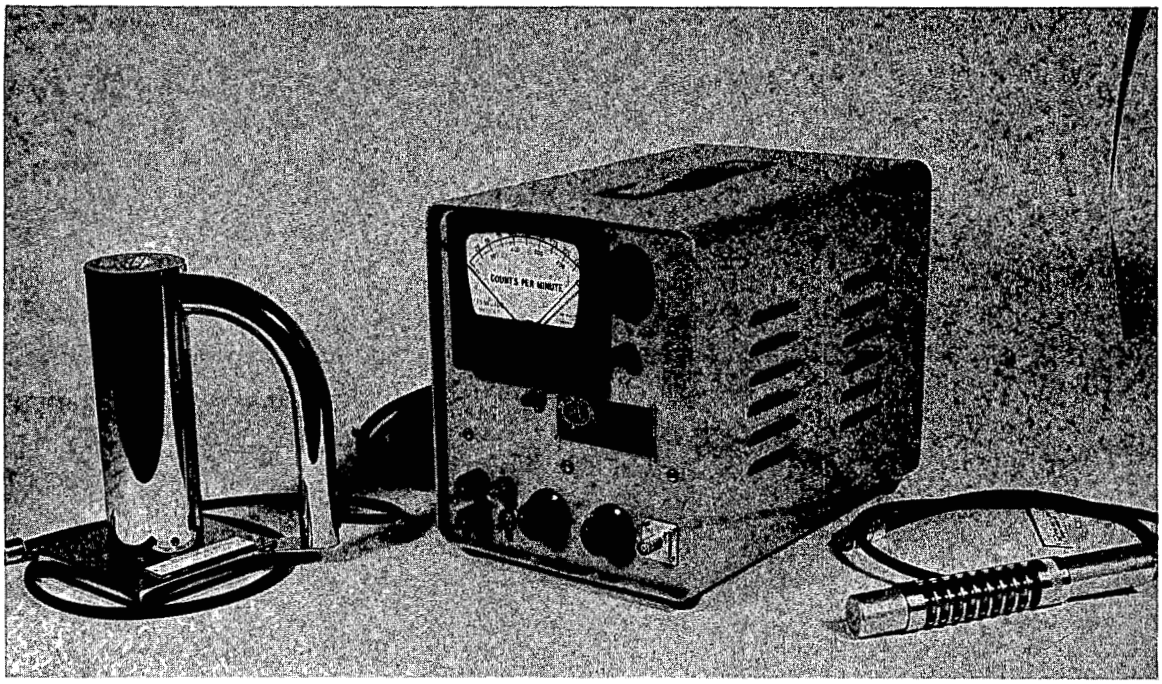


Figure A-III-1.9

Alpha Scintillation Poppy

# CONTINUOUS AIR MONITOR (CAM)

## SEMISTATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | Up to and including maximum permissible concentrations |
| Response time | Not applicable |
| Warmup time | Not applicable |
| Detector area | Varies with type G-M tube |
| Detector geometry | 17-20 percent |
| Calibration standard | Uranium |

### APPLICATION

The CAM is designed to pump a continuous sample of air through a filter adjacent to a sensitive G-M tube. When properly adjusted, the instrument will provide a continuous source of information relative to airborne beta-gamma contamination in the immediate environment. The filter may be removed and analyzed for specific alpha-, beta-, and gamma-emitting radionuclides.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Insensitive to radiation other than beta and gamma. Alpha activity determinations are made by analyses of the filter after a known sampling period.

### LIMITATIONS

The G-M tube will not differentiate between beta and gamma radiation. Heavy dust conditions will cause "dust loading" of the filter paper.

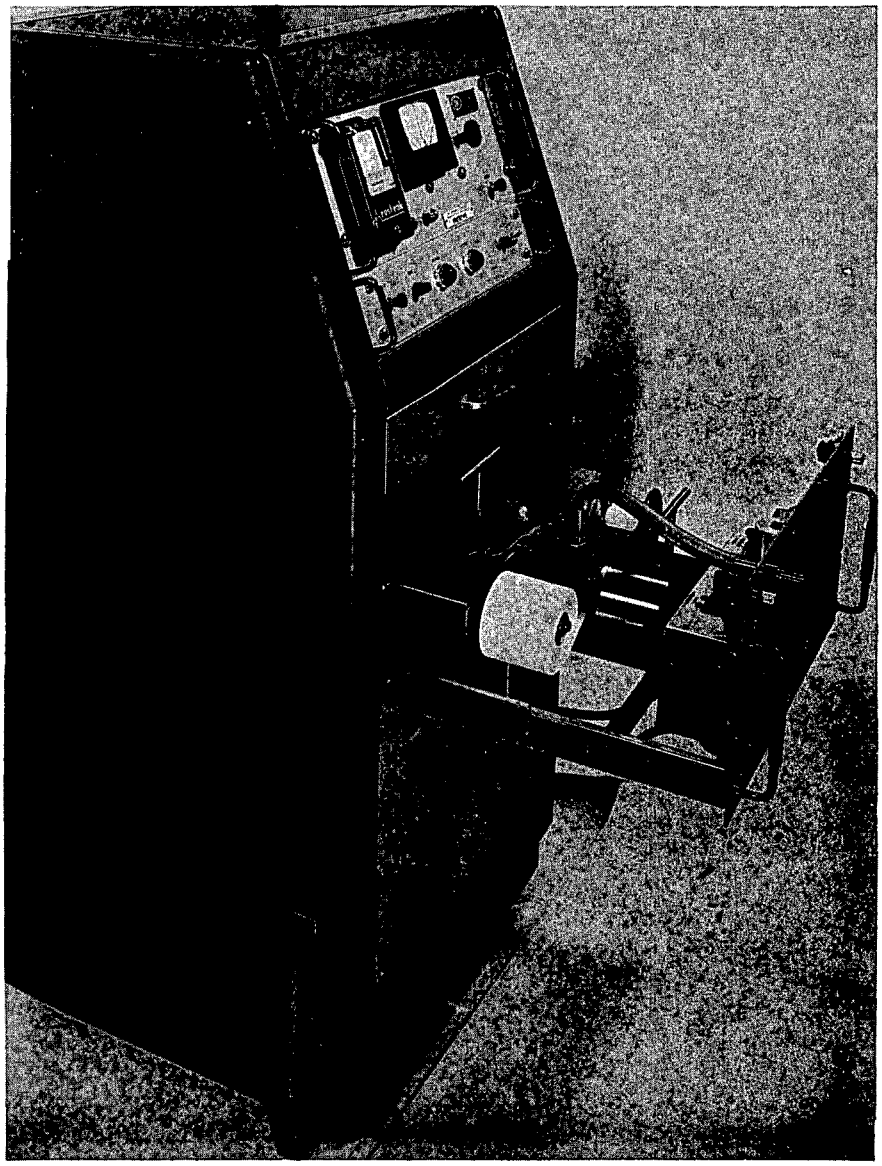

Figure A-III-1.10

Continuous Air Monitor (CAM)

# LOCAL RATEMETER

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | 200 (± 10) cpm to 20,000 (± 1,000) cpm |
| Response time | 1 second for low scale |
| Warmup time | Not applicable |
| Detector area | Varies with type of G-M tube |
| Detector geometry | 10 percent |
| Calibration standard | Ra gamma |

### APPLICATION

Local ratemeters are provided as beta-gamma contamination monitors at each contamination zone portal or change room.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Relatively insensitive to other types of radiation.

### LIMITATIONS

The local ratemeter is a low-count-rate instrument intended only as a contamination monitoring device. High dose rates will "block" the detector tube and may result in damage to it and the instrument. It should not be used to survey highly-contaminated objects.

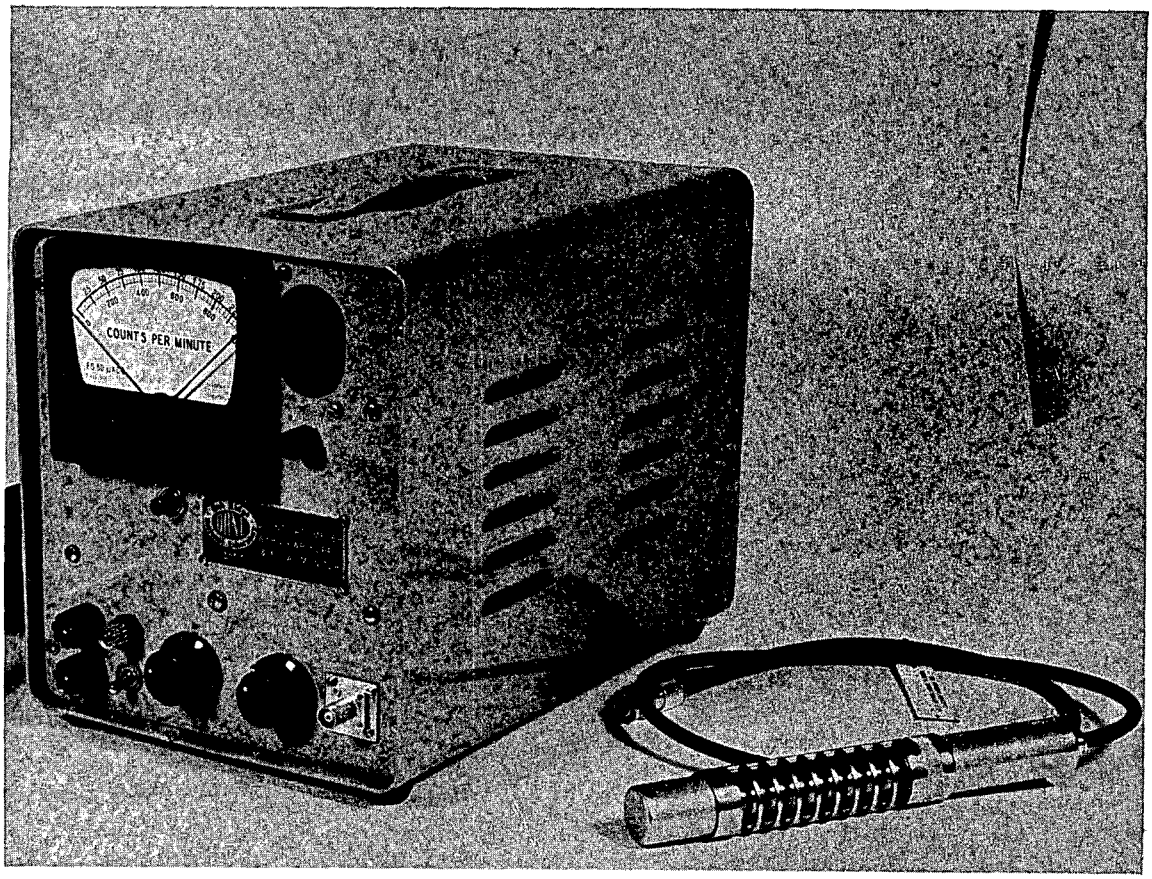


Figure A-III-1.11

Local Ratemeter

# HAND AND FOOT MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | 0.20 to 10 times maximum permissible level |
| Response time | 30-60 seconds |
| Warmup time | Not applicable |
| Detector area | Varies with type of G-M tube |
| Detector geometry | Not applicable |
| Calibration standard | Uranium |

### APPLICATION

The hand and foot monitor is designed as a convenient instrument for checking possible contamination on the hands and feet of personnel. An attached G-M probe is provided for use in monitoring clothing contamination.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Insensitive to all radiation except beta and gamma.

### LIMITATIONS

Background and source range counts should be taken and posted on the instrument daily. To prevent contamination of liners in hand slots, hands should be washed before counting. Counting accuracy may be affected by radiation sources or high background levels nearby.

Figure A-III-1.12

Hand and Foot Monitor

# BUILDING AREA MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | 0.01 mR/hr to 10 R/hr |
| Response time | 3 seconds |
| Warmup time | Not applicable |
| Detector area | Not applicable |
| Detector geometry | Not applicable |
| Calibration standard | $Co^{60}$ and $Cs^{137}$ |

### APPLICATION

Building area monitors are provided at 41 locations throughout the plant to warn, by audible and visual signals, of hazardous radiation conditions. Nine monitors read out in the charge and service machine control room. The remaining monitors read out and record in the Main Control Room.

### SENSITIVITY TO OTHER TYPES OF RADIATION

Sensitive only to beta and gamma radiation.

### LIMITATIONS

May be influenced by surges or fluctuations in line voltage. All of the building radiation monitoring instruments should be energized at all times, and any disruption of power to these instruments should be cleared with the health physicist and the appropriate supervisor.

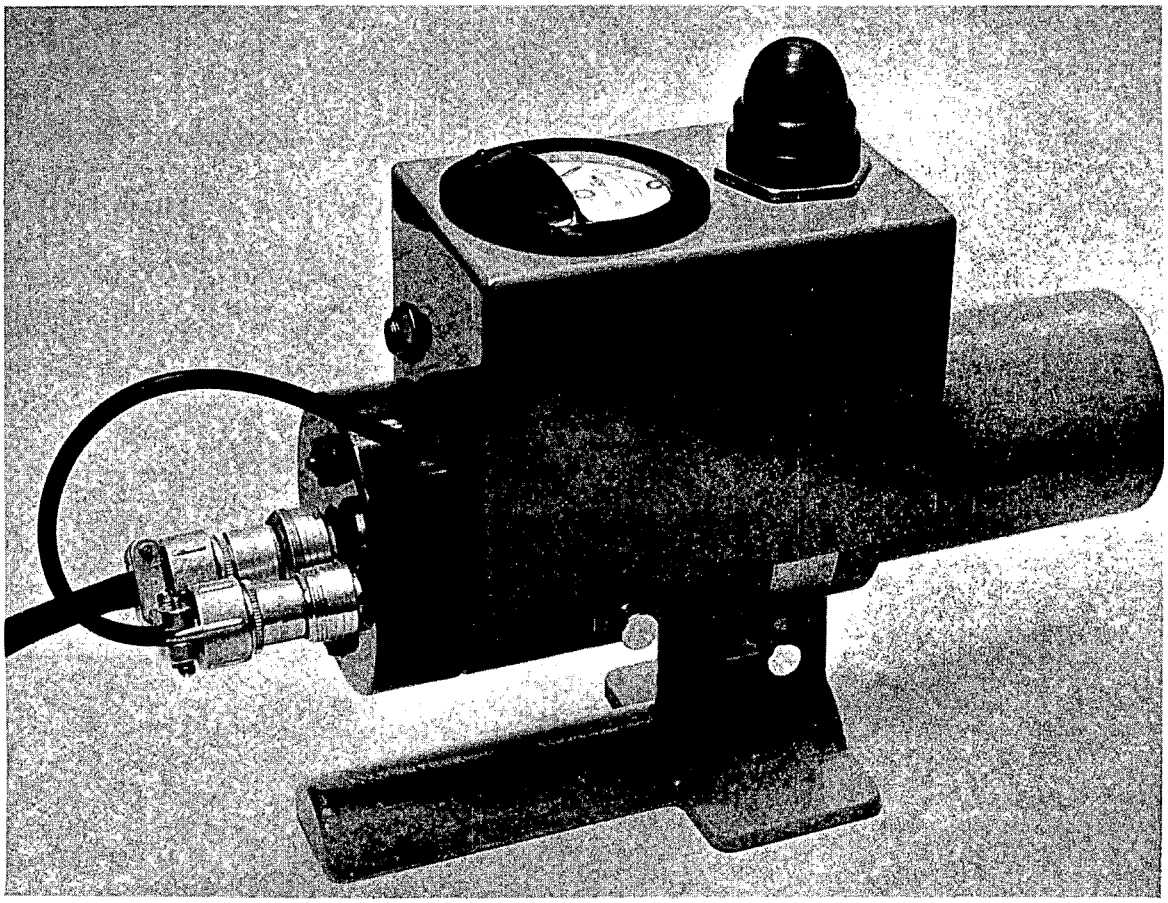

Figure A-III-1.13

Building Area Monitor

# LIQUID WASTE MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Gamma |
| Range | $5 \times 10^{-6}$ to $5 \times 10^{-1}$ μc/ml |
| Response time | 0.5 seconds on low scale |
| Warmup time | Not applicable |
| Detector face area | 1-1/2 inches in diameter by 1 inch thick |
| Detector geometry | 10 percent |
| Calibration standard | $Co^{60}$ or $Cs^{137}$ |

### APPLICATION

The liquid waste monitors are "in-line" detectors in direct contact with the waste effluent. Mounted in a lead-shielded pipe "tie" in the waste line, they are designed to alarm when radiation levels in the liquid waste system being monitored exceed preestablished limits.

### SENSITIVITY TO OTHER TYPES OF RADIATION

When properly adjusted, sensitive only to gamma radiation.

### LIMITATIONS

The detector is sealed in a light - tight enclosure. It should never be removed under any circumstances except by authorized persons. Inadvertent exposure of the detector to light while energized to high voltage may cause extensive damage to the instrument.

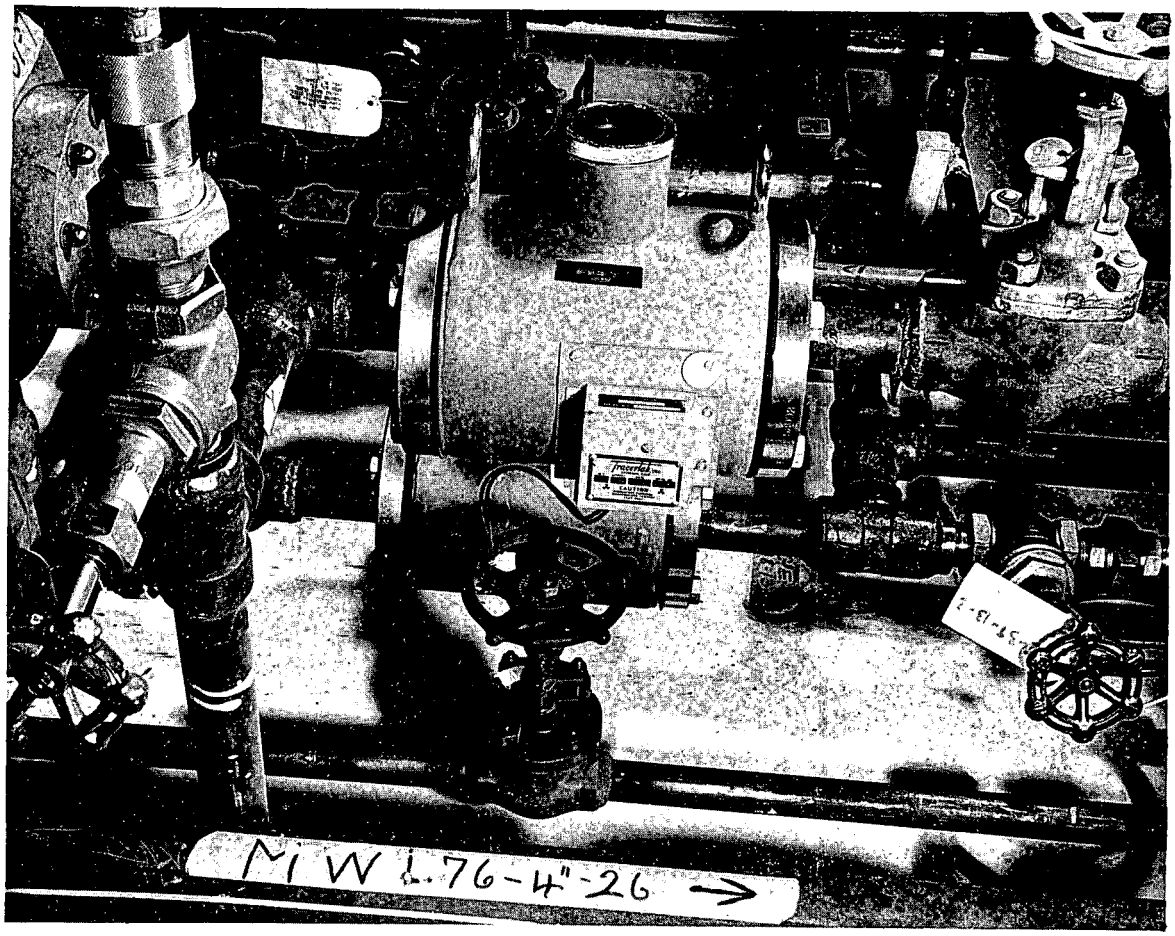


Figure A-III-1.14

Liquid Waste Monitor

# COOLANT LOOP MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | 0.1 mR/hr to 100 R/hr |
| Response time | 2 seconds |
| Warmup time | Not applicable |
| Detector area | Not applicable |
| Detector geometry | Not applicable |
| Calibration standard | $Co^{60}$ or $Cs^{137}$ |

### APPLICATION

The coolant loop monitors are mounted 3 feet from the centerline of the pipe on the discharge side of each steam generator. They can be set to alarm when hazardous radiation levels occur as a result of excessive fission product activity in the primary loop piping.

### SENSITIVITY TO OTHER TYPES OF RADIATION

When properly adjusted, sensitive to only beta and gamma radiation.

### LIMITATIONS

May be affected by fluctuations in line voltage causing spurious readings and alarms. Should be used only as a warning device, not as a dose-rate instrument.

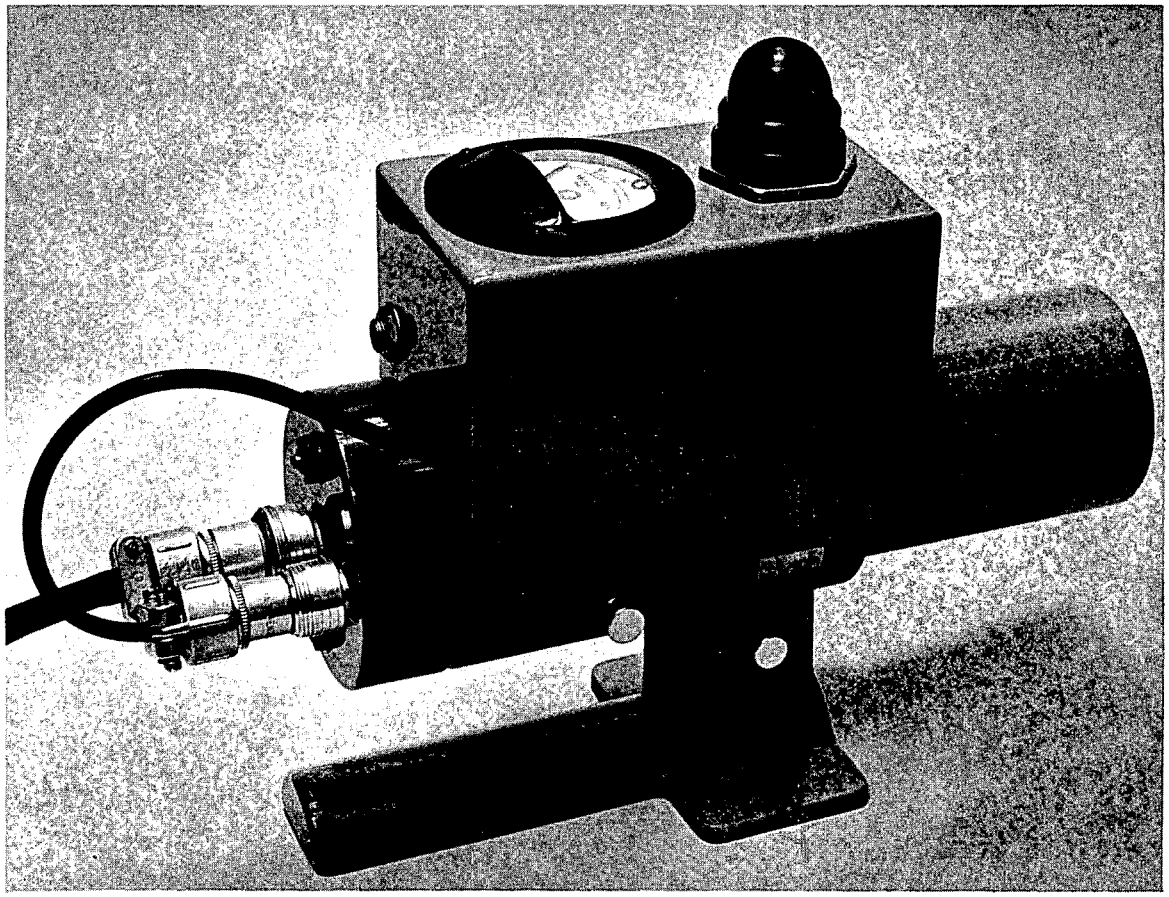

Figure A-III-1.15

Coolant Loop Monitor

# SPENT FUEL STORAGE BASIN MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Gamma |
| Range | $10^{-7}$ to $10^{-2}$ μc/ml |
| Response time | Varies with water flow rate |
| Warmup time | Not applicable |
| Detector face area | 1-1/2 inches in diameter |
| Detector geometry | 10-17 percent |
| Calibration standard | $Co^{60}$ or $Cs^{137}$ |

### APPLICATION

The spent fuel storage basin monitor is used to determine the condition of discharged fuel. This is accomplished by monitoring the water in the discharge chute containing fuel and, if high concentrations are detected, selectively monitoring water in individual sampling tanks containing single fuel assemblies. The instrument is also used to monitor the storage basin water for excessive fission product content, after fuel handling operations.

### SENSITIVITY TO OTHER TYPES OF RADIATION

When properly adjusted, the instrument is sensitive only to gamma radiation.

### LIMITATIONS

The scintillation detector is extremely sensitive to light and, for that reason, must never be removed from its light-tight housing except by authorized persons. Fluctuations in line voltage, excessive shock, and abnormal temperatures will influence the detector output.

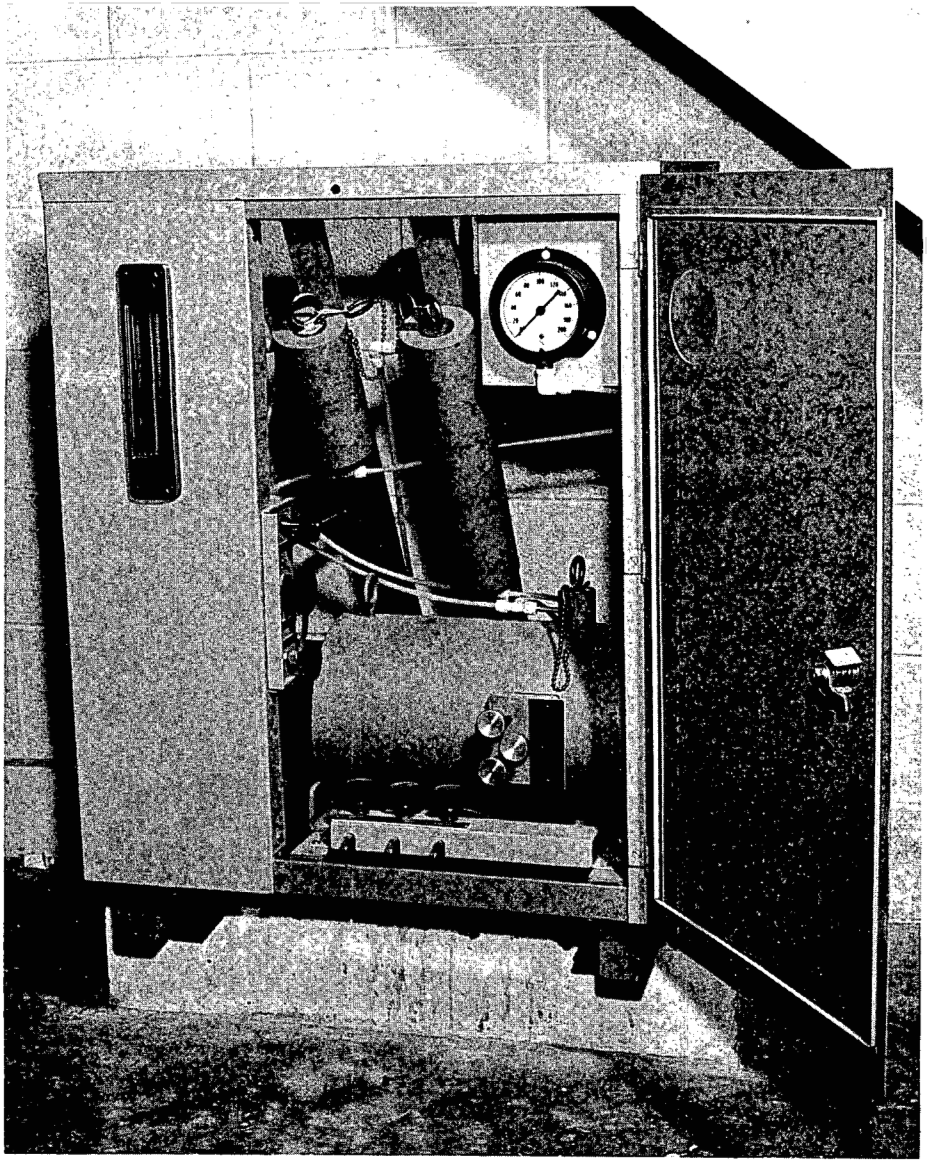

Figure A-III-1.16

Spent Fuel Storage Basin Monitor

# STACK GAS MONITOR

## STATIONARY

### DESIGN

| | |
|---|---|
| Type of radiation detected | Beta, gamma |
| Range | $5 \times 10^{-12}$ to $1.6 \times 10^{-2}$ μc/cc |
| Response time | Not applicable |
| Warmup time | Not applicable |
| Detector area | Not applicable |
| Detector geometry | Not applicable |
| Calibration standard | $Sr^{90}$, $I^{131}$ |

### APPLICATION

The stack gas monitors are mounted on the stack approximately 140 feet above ground. They are designed to monitor continuously all gaseous wastes discharged to the environment and, upon detecting excessive concentrations, alarm automatically in the Main Control Room. If hazardous levels of activity are detected, the stack monitors function to automatically isolate the reactor containment building.

### SENSITIVITY TO OTHER TYPES OF RADIATION

The systems measure beta and gamma radiation independently of other radiation. They are designed to differentiate between particulate, total gas, and iodine activities.

### LIMITATIONS

Filter paper (roll) may break and require splicing. Charcoal trap loses its efficiency when "dust loading" occurs.

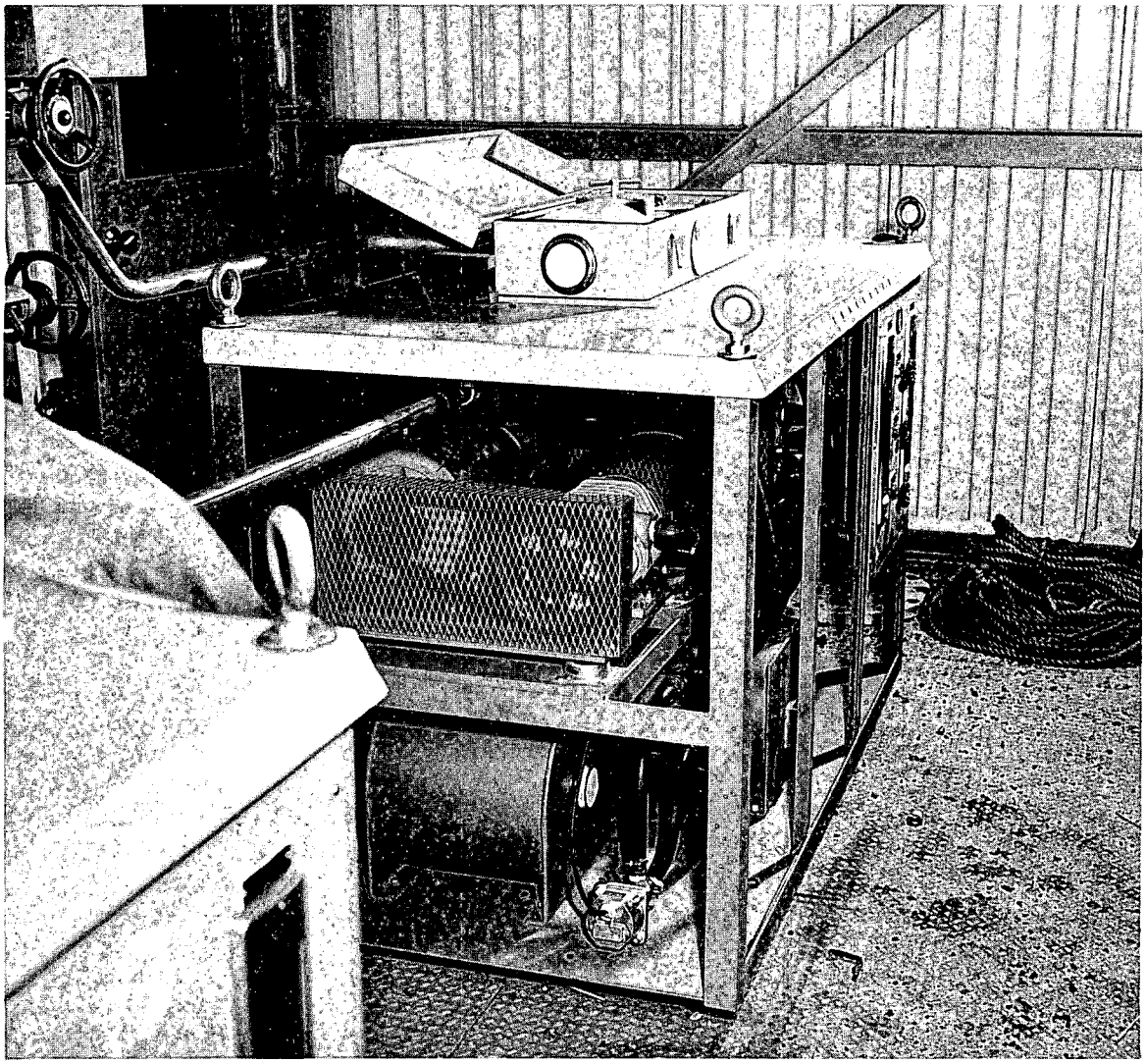

Figure A-III-1.17

Stack Gas Monitor

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Issued March 26, 1964
Supersedes Issue Dated

## ZONED AREAS *for* RADIATION HAZARD *and* EXPOSURE CONTROL

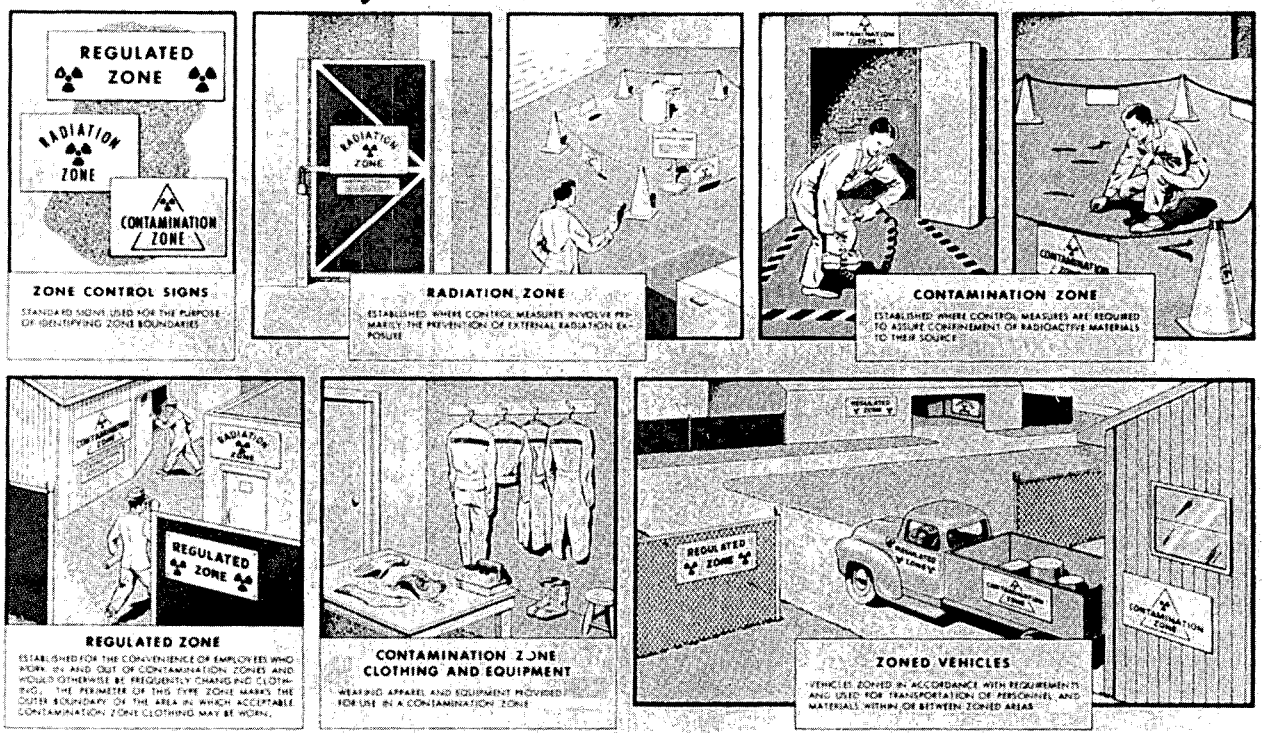


Figure A-III-2.1

# SHIPMENTS OF SPENT FUEL, IRRADIATED SPECIMENS, AND SOURCE AND SPECIAL NUCLEAR MATERIALS TO OFF-AREA LOCATIONS

## DISCUSSION

Shipments of radioactive materials to off-area locations by common carrier must comply with applicable federal, state, and local regulations for the various modes of transportation involved (rail, highway, water, and air). The following abstract has been prepared for guidance in such matters and is taken from pertinent sections of Interstate Commerce Commission, Civil Aeronautics Board, Coast Guard, and Post Office Department regulations. Detailed explanations of specific rules and regulations are contained in Code of Federal Regulations: Parts 71 through 78 of Title 49 (Interstate Commerce Commission), Part 146 of Title 46 (Coast Guard), Part 49 of Title 14 (Civil Aeronautics Board), and the Postal Manual.

## DEFINITIONS

1. Spent Fuel - Intact or segmented fuel elements that have been removed from the reactor due to burnup or failure.

2. Source Material - Any material, except special nuclear material, which contains by weight 1/20 of 1 percent (0.05 percent) or more of (a) uranium, (b) thorium, or (c) any combination thereof.

3. Special Nuclear Material - (a) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the AEC, pursuant to the provisions of Section 51 of the Act (Atomic Energy Act of 1954 as amended), determines to be special nuclear material, but does not include source material; and (b) any material artificially enriched by any of the foregoing, but does not include source material.

4. SS Material - This term is used for accountability purposes. It includes both source and special nuclear materials as defined above and other materials, such as neptunium-237, materials enriched in lithium-6, deuterium, and tritium. The Chemical Engineering Section Supervisor is responsible for SS materials.

5. Radioactive Material - Any material or combination of materials that spontaneously emits ionizing radiation. Such materials are divided into three groups according to the type of rays emitted as follows:

   a. Group I - Radioactive materials that emit gamma rays only or both gamma and electrically-charged corpuscular (particle) rays.

   b. Group II - Radioactive materials that emit neutrons and either or both the types of radiation characteristic of Group I materials.

   c. Group III - Radioactive materials that emit electrically-charged corpuscular (particle) rays only--i.e., alpha or beta--or any other material that is so shielded that the gamma radiation at the surface of the package does not exceed 10 mR per 24 hours at any time during transportation.

6. One Radiation Unit - One mR per hour of gamma radiation at 1 meter from the radioactive source or the amount of radiation which has the same effect on photographic film as 1 mR per hour at 1 meter (mrhm).

7. Radioactive Material Labels - Special labels furnished by the AEC for identifying the contents of packages--red for Groups I and II and blue for Group III Radioactive Materials.

   a. Form 206 and Form 207 are used for shipments by air.

   b. Form 206a and Form 207a are used for shipments by surface transportation.

   c. Placard - Form AEC 212 is a diamond-shaped sign, red letters on yellow background, used for shipments by rail.

   d. Placard - AEC Form "Dangerous - Radioactive Material," sign with letters 3 inches high on a contrasting background, is used for shipments by motor vehicle of packages containing Class D poison, Group I or Group II.

GENERAL SHIPPING CRITERIA

For the most part, off-area shipments of radioactive materials from EGCR will consist of irradiated fuel. Title 10, CFR, Part 72, "Regulations to Protect Against Radiation in the Shipment of Irradiated Fuel Elements," contains explicit instructions in this regard and should be consulted in all cases involving spent fuel. In shipping other radioactive materials, the following guidelines are provided.

GENERAL SHIPPING CRITERIA (Continued)

1. Limits on Quantity in Package

a. Not more than 2,000 mc of radium, polonium, or other members of the radium family of elements, and not more than 2,700 mc--disintegration rate of 100,000 million (or $10^{11}$) atoms per second--of any other radioactive substance may be packed in one outside container for shipment by rail freight, rail express, water, or highway, except by special arrangements and under conditions approved by the Bureau of Explosives (and Coast Guard or CAB, when necessary) or except as specifically provided in subparagraph b of this section. Special instructions for air shipments in excess of 2,000 mc are given in AT 6-C, IV-B-165 (CAB).

b. Not more than 300 c of solid cesium-137, cobalt-60, gold-198, or iridium-192 may be packed in one outside container for shipment by rail freight, rail express, highway, or water, except by special arrangements and under conditions approved by the Bureau of Explosives (and Coast Guard or FAA, when necessary).

c. Postal regulations require, in addition to special care in packaging (see No. 3) and labeling (see No. 4), that a package containing radioactive materials must not emit from its exterior any significant alpha, beta, or neutron radiation; and the gamma radiation at any surface of the package must be less than 10 mR for 24 hours. The package must not contain more than 0.1 mc of radium or polonium, or that amount of strontium-89, strontium-90, or barium-140, which disintegrates at a rate of 5 million atoms per second, or that amount of any other radioactive substance which disintegrates at a rate of more than 50 million atoms per second.

2. Exemptions from Prescribed Packaging, Marking, and Labeling Requirements

a. Radioactive materials are exempt (except in the mails) from prescribed packing, marking (except water shipments which must be marked to show name of contents), and labeling requirements, provided they fulfill all of the following conditions.

(1) The package must be such that there can be no leakage of radioactive material under conditions normally incident to transportation.

(2) The package must contain not more than 0.1 mc of radium or polonium, or that amount of strontium-89, strontium-90, or barium-140, which disintegrates at a rate of 5 million atoms per second, or that amount of any other radioactive substance which disintegrates at a rate of more than 50 million atoms per second.

(3) The package must be such that no significant alpha, beta, or neutron radiation is emitted from the exterior of the package, and the gamma radiation at any surface is less than 10 mR per 24 hours.

b. Empty containers, if authorized for reuse by the Bureau of Explosives, must have all openings--including removable heads, filling, and vent holes--tightly closed before being offered for transportation. Small quantities of the material with which the containers were loaded may remain in empty containers; and, when the vapors remaining therein are unstable, it is permissible to add sufficient inert gas to render the vapors stable.

c. All containers and accessories which have been used for shipments of radioactive materials, when shipped as empty, must be sufficiently free of radioactive contamination so as to conform to subparagraph a above.

d. Any boxcar or motor vehicle which, after use for the transportation of radioactive materials in carload or truckload lots, is contaminated with such materials to the extent that a survey of the interior surface shows that the beta-gamma radiation is greater than 10 mR physical equivalent in 24 hours, or that the average alpha contamination is greater than 500 disintegrations per minute per 100 sq cm, shall be thoroughly cleaned in such a manner that a resurvey of the inside surface shows the contamination to be below these levels. A certificate to that effect must be furnished to the local agent of the carrier or to the driver of the motor vehicle. Cars and motor vehicles which are used solely for the transportation of radioactive materials are exempt from the provisions of this section.

GENERAL SHIPPING CRITERIA (Continued)

3. Packing and Shielding

a. Radioactive materials that present special hazards due to their tendency to remain fixed in the human body for long periods of time (i.e., radium, plutonium, radioactive strontium, etc.) must, in addition to the packing hereinafter prescribed, be packed in inside metal containers, Specification 2R, or other container approved by the Bureau of Explosives and authorized by the Commandant of the Coast Guard for water shipment.

b. All radioactive materials must be so packed and shielded that the degree of fogging of undeveloped film under conditions normally incident to transportation (24 hours at 15 feet from the package) will not exceed that produced by 11.5 mR of penetrating gamma rays of radium filtered by 1/2 inch of lead.

c. The design and preparation of the package must be such that there will be no significant radioactive surface contamination of any part of the container.

d. The smallest dimension of any outside shipping container for radioactive materials must not be less than 4 inches.

e. All outside shipping containers must be of such design that the gamma radiation will not exceed 200 mR per hour or equivalent at any point of readily accessible surface. Containers must be equipped with handles and protective devices when necessary in order to satisfy this requirement.

f. The outside shipping container for any radioactive material, unless specifically exempt by No. 2 above or unless approved by the Bureau of Explosives, shall be as follows:

(1) Wooden Boxes: Specification 15A, 15B, 19A, or 19B - Authorized for not more than 2,700 mc.*

(2) Fiberboard Boxes: Specification 12B - Authorized for not more than 2,700 mc.*

---

*Maximum is 2,000 mc per package for shipments by air (AT 6-C, II).

(3) Fiber Drums: Specification 21A or 21B - Authorized for not more than 2,700 mc.

(4) Metal Barrels or Drums: Specification 6A, 6B, or 6C; 17C or 17H (single trip); or 78.99, 78.115, or 78.118 - Authorized for not more than 2,700 mc.*

(5) Metal-Encased Lead or Uranium Metal-Shielded Containers: Specification 55 - Authorized for not more than 300 c;* containers must be equipped with a seal.

g. Radioactive Materials Group I--liquid, solid, or gaseous--must be packed in suitable inside containers completely surrounded by a shield of lead or other suitable material of such thickness so that at any time during transportation the gamma radiation at 1 meter from any point on the radioactive source will not exceed 10 mR per hour. The shield must be so designed that it will not open or break under conditions incident to transportation. The minimum shielding must be sufficient to prevent the escape of any primary corpuscular radiation to the exterior of the outside shipping container.

h. Radioactive Materials Group II--liquid, solid, or gaseous--must be packed in suitable inside containers completely shielded so that at any time during transportation the radiation measured at right angles to any point on the long axis of the shipping container will not exceed the following limits.

(1) Gamma radiation of 10 mR per hour at 1 meter.

(2) Electrically-charged corpuscular radiation of 10 mrads per hour at 1 meter.

(3) Neutron radiation of 2 mrems per hour at 1 meter.

(4) If more than one of the types of radiation named above is present, the radiation of each type must be reduced by shielding so that the total does not exceed the equivalent of No. (1), (2), or (3).

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*Maximum is 2,000 mc per package for shipments by air (AT 6-C, II).

GENERAL SHIPPING CRITERIA (Continued)

i. Radioactive Materials Group III--liquid or solid--must be packed in suitable inside containers completely wrapped or shielded with such material as will prevent the escape of primary corpuscular radiation to the exterior of the shipping container, and secondary radiation at the surface of the container must not exceed 10 mR per 24 hours at any time during transportation.

4. Labeling

a. Unless exempt by No. 2 above, each outside container of Group I or Group II radioactive material being shipped by carriers other than air carriers must be labeled with the red label and Group III with the blue label, duly executed and applied by the shipper to that part of the package bearing consignee's name and address.

b. Containers shipped as empty must have the old labels prescribed by federal regulations removed, obliterated, destroyed, or completely covered by a square white label measuring not less than 6 inches on each side and bearing thereon the word "EMPTY" in letters not less than 1 inch high. This does not apply to carload or truckload shipments to be unloaded by consignee.

c. Postal regulations require that the identity or nature of contents of any radioactive materials mailed shall be stated plainly on the outside of the package. Any labels required by federal laws or regulations shall be pasted to the outside of the parcel.

5. Violations and Accidents to be Reported

Consignees receiving shipments by rail or highway transport must report promptly to the Bureau of Explosives, 30 Vesey Street, New York 7, New York, all instances of improper staying and broken, leaking, or defective containers. Carriers must report same, plus serious violations of shipping regulations and accidents or fires in connection with transportation or storage in transit of radioactive materials. For water shipments, carrier representative will notify shipper and District Commandant of the nearest U. S. Coast Guard. For air shipments, operator of aircraft will immediately contact shipper for disposal information and notify the nearest representative of the Civil Aeronautics Board or the Federal Aviation Agency.

6. Criticality Considerations

Shipments which follow routine ICC or other federal regulations will not require special consideration of the possibility of a critical mass condition arising during shipment or handling. However, shipments escorted by AEC courier or otherwise exempted from shipment quantity limitations should be reviewed prior to initial assembly to insure that adequate precautions against inadvertent criticality are maintained.

As an example of the quantity of nuclear material requiring criticality consideration, the following is taken from a recent AEC regulation, 10 CFR 71, "Regulations to Protect Against Accidental Conditions of Criticality in the Shipment of Special Nuclear Materials," maximum limits for unsupervised shipment (but still probably requiring additional approvals from the ICC, CAB, Coast Guard, or carrier) not requiring prior AEC approval.

| | |
|---|---|
| Uranium enriched in isotope $U^{235}$ . . | 100 grams contained $U^{235}$ |
| Uranium-233 . . . . . | 60 grams |
| Plutonium . . . . . | 60 grams |

# USE OF RESPIRATORY PROTECTIVE EQUIPMENT

## DISCUSSION

The term "respirator," or "respiratory protective equipment," refers to a large and varied group of devices which are worn on the face or over the head of an individual. Basically, respirators are simple devices which can be divided into two general classes, depending upon the mechanism by which they protect the wearer.

I. One class of respirators functions by filtering out some or all of the contaminants from the inhaled air. They act as barriers between the lung and the surrounding air, filtering out contaminants in a manner similar to the way a home furnace filter traps dust.

II. The other class of respirators separates the respiratory system of the wearer from the contaminated air by supplying him with an artificial atmosphere. Such devices as air-line hoods and oxygen masks are in this category. This class may be further subdivided into three general types.

a. Respirators which contain a canister employing an oxygen-producing chemical such as potassium superoxide.

b. Respirators which use a tank supply of air or oxygen.

c. Respirators which require a remote air supply via pipes or hose from an air pump.

## DESCRIPTION

### 1. Class I - Filter-Type Respirators

#### a. Half Masks

A half mask is the respirator in common use that covers only the nose and mouth (Figure A-IV-5.1). The possibility of leakage around the facepiece is the main limitation of the half mask. Since half masks come in only one standard size, it is evident that certain individuals with extreme facial contours will not be fitted perfectly by the standard half mask. Special attention should be given to such individuals to fit them properly.

Figure A-IV-5.1

MSA Comfo

CAUTION: Class I filter-type respirators of the kind generally used for protection against radioactive materials will prevent penetration of only particulate matter. They do not provide protection against toxic or radioactive gases or atmospheres deficient in oxygen.

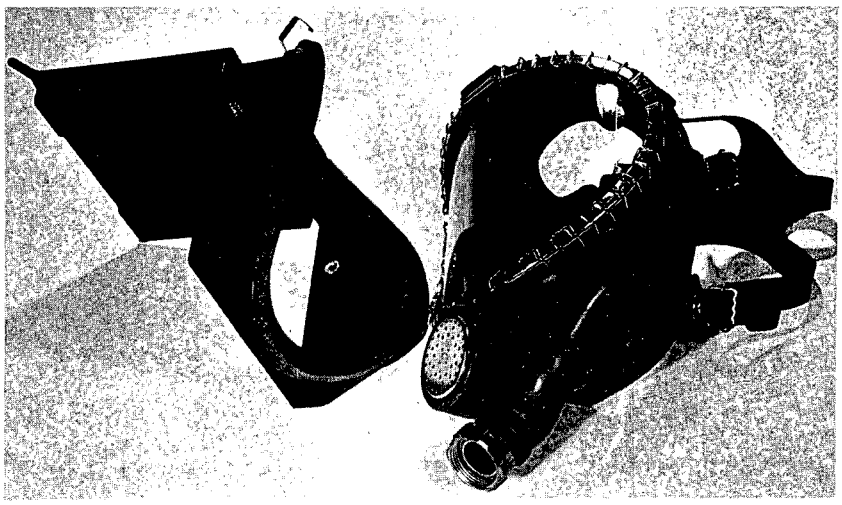

Figure A-IV-5.2

MSA Welder's Mask

DESCRIPTION (Continued)

b. Full-Face Masks

The main limitations of the full-face mask (Figure A-IV-5.3) are the possibility of leakage around the face and malfunctioning of the cartridge. It is possible to obtain less than 1 percent leakage for a properly fitted full-face mask. However, because of the difficulty of fitting all faces with a single size, it is generally assumed that full-face masks are 98-99 percent efficient.

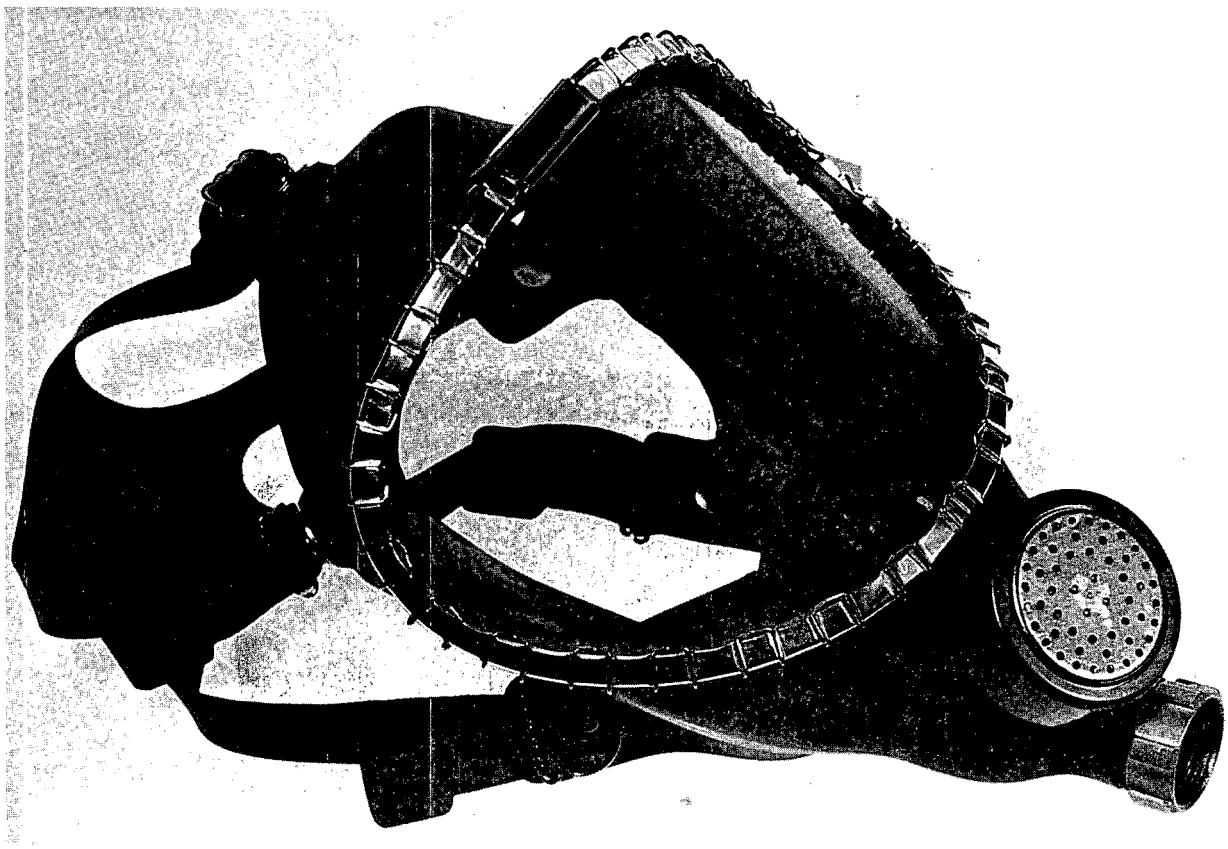

Figure A-IV-5.3

Full-Face Mask

2. Class II - Supplied-Air Masks

a. Oxygen self-generating Chemox MSA (Figure A-IV-5.4). A self-contained mask with an oxygen-generating canister. Allowable working time is approximately 45 minutes.

Figure A-IV-5.4

Oxygen Self-Generating Chemox

DESCRIPTION (Continued)

b. Air-demand type (Figure A-IV-5.5). Bottle contains 40 cubic feet of air at 1,900 pounds per square inch pressure. Allowable breathing time is 30 minutes. Bottle carried in vertical position on back.

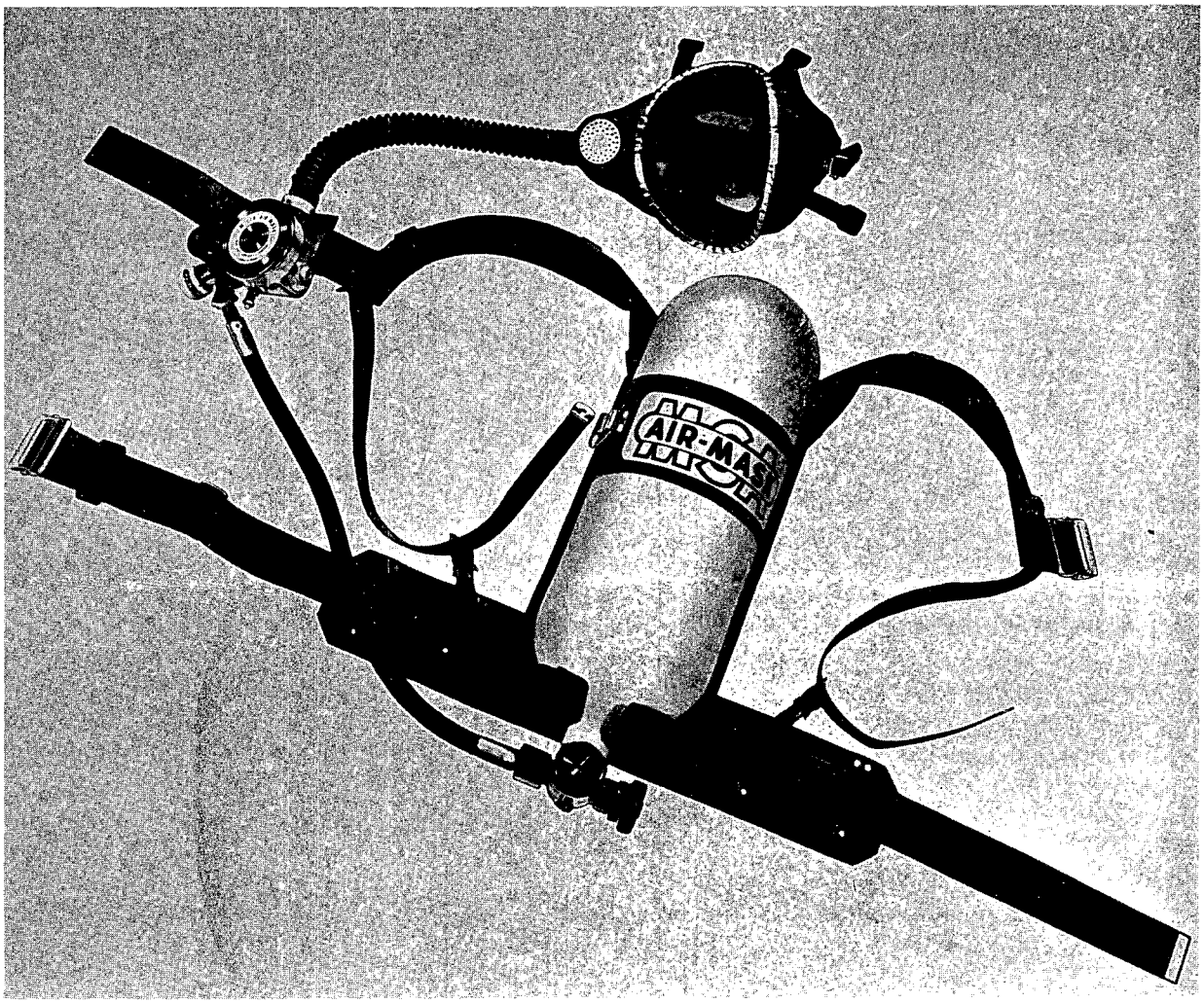


Figure A-IV-5.5

Air-Demand Type

c. Air-Line Equipment

Figure A-IV-5.6

Hose Mask with Demand Regulator

The following table lists the types of supplied-air equipment and gives the correct operating pressures and volumes required. All of this equipment can be used with either 230-cubic foot cylinders of pure breathing air or air compressors specifically designed for supplying respirable air.

TABLE A-IV-5.1

OPERATION OF AIR-LINE EQUIPMENT

| Type | Flow Regulation | Air Pressure at Source (psi) | Cubic Feet per Minute | Hose Type | Operating Time per Man* |
|---|---|---|---|---|---|
| Full face or Half mask | Demand flow | 100-125 | As demanded | Medium pressure | 5 hrs |
| Full face or Half mask | Constant flow Manual valve | 10-15 | 4 | Medium pressure | 55 min |
| Plastic hood | Constant flow Manual valve | 10-15 | 6 | Low pressure (cloth covered) | 50 min |
| Plastic suit | Constant flow | 18-28 | 5 to 7 | Medium pressure | 40 min |

*With 230-cubic foot cylinder and 100-foot maximum hose length.

## LIMITATIONS

It is important to understand that there are many different kinds of respirators, each designed according to the purpose for which it is intended, and high efficiency is obtained for only one type of use. Respirators have their limitations and are not substitutes for effective ventilation or process controls.

For effective operation, a respirator must fit firmly on the wearer to prevent leaks into the facepiece. Some individuals, because of facial contours, find it difficult or impossible to obtain a satisfactory fit.

Full vision on the job is important and any device which protrudes over the lower section of the face may create a serious safety hazard.

Air-line or air-supplied respirators, because of physical size and weight, may be limited for use in confined spaces such as small manholes or hatch entries.

## USE

Issuance of respirators to individuals is controlled to insure maximum efficiency and safety to the wearer. Each worker must be taught how to wear his respirator. He must know how to obtain proper fit and how to check for leaks both in the valves and around the facepiece.

## MAINTENANCE

Periodic cleaning and repair of respirators is essential and should not be delegated to the individual wearer. When used routinely, respirators must be cleaned daily. This affords opportunity to repair worn out or damaged parts and to replace filters and chemical cartridges.

Following cleaning and sanitizing, the respirator is thoroughly inspected. Filters and cartridges are replaced, if necessary.

## REGULATIONS

1. Table A-IV-5.2 lists respiratory requirements for various concentration ranges of radionuclides.

TABLE A-IV-5.2

RESPIRATORY REQUIREMENTS FOR

AIRBORNE CONTAMINANTS

| Concentration Levels ($\mu c/cc$ air) | | |
|---|---|---|
| Alpha | Beta-Gamma | Action |
| $< 5 \times 10^{-10}$ | $< 3 \times 10^{-9}$ | Masks not required unless contamination is identified and is above $(MPC)_{air}$ for 40-hour week. |
| $5 \times 10^{-10}$ to $2 \times 10^{-9}$ | $3 \times 10^{-9}$ to $3 \times 10^{-7}$ | Full-face mask required or complete evacuation of personnel from area. |
| $> 2 \times 10^{-9}$ | $> 3 \times 10^{-7}$* | Positive air supply (hose line, air tanks) or complete evacuation of personnel from area. |

*In this concentration range, the immersion dose rate may be significant.

2. Respirator requirements for each zoned area are posted at the zone portal.

3. The Radiological Health Section conducts periodic training sessions in the care and use of respiratory equipment.

4. All respiratory equipment, including hose lines, oxygen tanks, facepieces, and associated fittings, is inspected periodically by a Radiological Health Section representative and a member of the Plant Maintenance Section.

5. Once used, no respiratory device may be reissued without being cleaned, sanitized, and checked for radioactive contamination by a Radiological Health Section representative.

REGULATIONS (Continued)

6. All bottles of breathing air are color coded and conspicuously labeled "For Breathing Use Only." Fittings and couplings used on breathing air containers and hose are of unique design such that no other container (i.e., nitrogen, acetylene, etc.) can be attached.

7. When using sources of supplied air and hose lines, other than the control room emergency supply manifold, one person is in attendance at the valve manifold at all times. Wherever possible, the source of supplied air is not taken into the contaminated area.

8. Under no circumstances are ordinary sources of compressed air (instrument or plant) used to charge respiratory equipment.