UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

July 16, 1982

FCUF:WAN
Docket No. 40-2061
License No. STA-583

DISTRIBUTION LIST - KERR-MCGEE, WEST CHICAGO

Attached is a copy of a Health Physics Manual which Kerr-McGee proposes to use in place of their existing procedures. This manual was submitted to NRC Region III in August 1981 and has been reviewed by both the Regional staff and the NRC Headquarters staff. The staff is considering incorporating the new Health Physics Manual into the Kerr-McGee license by amendment to the license.

DISTRIBUTION LIST

Kerr-McGee -- Docket No. 40-2061

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February 9, 1982

HEALTH PHYSICS MANUAL

for the

DECOMMISSIONING AND STABILIZATION

of the

KERR-McGEE CHEMICAL CORPORATION

WEST CHICAGO RARE EARTHS FACILITY

PREPARED BY

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Prepared by _____
Certified Health Physicist

_____
Health Physicist

Approved by _____
Project Manager--Catalytic

_____
Staff Health Physicist

_____
Vice President-Health and Environmental Division

_____
Project Manager - Kerr-McGee

RECORD OF REVISIONS

Rev. No.	Description	Date
A	Original Issue for Approval	3-9-81
B	Issue for Approval (Incorporating Rev. A Client Comments)	3-30-81
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WEST CHICAGO FACILITY
HEALTH PHYSICS MANUAL
REVISIONS

DATE	SECTION	REVISION	PAGE
Feb '82	CONTENTS	APPENDIX G	11 of 11
"	2	2.2.1	1 of 2
"	2	2.2.2	2 of 2
"	2	2.4	2 of 2
"	2	2.5	2 of 2
"	5	5.1	1 of 23
"	5	5.2	1 of 23
"	6	6.4	2 of 3
"	6	6.6	2 of 3
"	7	7.1	1 of 6
"	8	8.5	3 of 7
"	8	8.6.8	7 of 7
"	8	8.6.9	7 of 7
"	9	9.1	1 of 2
"	9	9.2	1 of 2
"	10	10.6	3 of 9
"	10	10.7	3 of 9
"	12	12.3	5 of 49
"	12	12.3.3	8 of 49
"	12	12.8	42 of 49
"	12	12.8.4	44 of 49
"	APPENDIX	APPENDIX G	

TABLE OF CONTENTS

REFERENCES

APPENDIX A. Outline of Basic Radiation Protection Training

APPENDIX B. Outline of Management Principles of Radiation Exposure and Contamination Control

APPENDIX C.
a) USNRC Regulatory Guide 8.15. Acceptable Programs for Respiratory Protection.
b) USNRC NUREG-0041. Manual of Respiratory Protection Against Airborne Radioactive Materials.

APPENDIX D. Radiation Detection Instrumentation Information

APPENDIX E. Thorium-232 and Uranium-238 Decay Chains

APPENDIX F. Kerr-McGee Corporation Radiation Health and Safety Standard No. 9. 9-16-80, Exposure to Gamma Radiation During Pregnancy

APPENDIX G. USNRC, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, November 1976.

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF TABLES

1. INTRODUCTION AND PURPOSE

1.1. INTRODUCTION

This document is the manual of radiation protection procedures to be used by personnel during the decommissioning and dismantling of the Kerr-McGee West Chicago Rare Earths Facility. This procedure gives specific guidance on all aspects of the Health Physics control program. It is the primary document used by the Health Physics group in controlling work practices and procedures to ensure compliance with 10CFR20, Standards for Protection Against Radiation, and specific requirements of Kerr-McGee Chemical Corporation, as well as in setting forth the rules under which the radiological safety aspects of the decommissioning will be performed.

This document will be used primarily by the Health Physics group. It is written for use by technicians with prior training and experience in applied health physics. It will also be used by construction supervisory personnel to assist them in managing the entire work project.

This procedure contains the specific guidelines and rules for operation that are to be implemented in the dismantling and decommissioning of the West Chicago Facility.

This procedure shall be read and understood by all Health Physics (HP) technicians and by all construction supervisors assigned to decontamination and decommissioning work. The rules must be followed to avoid possible adverse consequences and added costs in performing the work.

Readers are advised to use the Table of Contents to locate specific information as necessary.

1.2. PURPOSE

The Health Physics Manual for the decommissioning of the West Chicago Facility has been written to assure that work by the construction personnel is done in accordance with the applicable rules and regulations applying to safe handling of radioactive materials and sources of radiation.

1.2 PURPOSE (Cont'd)

Much of the specific work to be done is spelled out in the control work packages for the various jobs. Some of these work packages call for a Special Work Permit (SWP). The SWP will spell out in detail the specific Health Physics requirements for performing the work. These requirements are in addition to the general requirements discussed in this manual.

2. ADMINISTRATION

2.1. POLICY

Kerr-McGee Chemical Corporation is committed to a policy which will accomplish the decommissioning of its West Chicago Facility with a minimum radiation exposure to the workers, public, and environment. This manual is constructed on an ALARA foundation.

2.2. RESPONSIBILITIES AND AUTHORITY

2.2.1. Health Physicist

The person designated by Kerr-McGee Chemical Corporation as Site Health Physicist for the West Chicago Rare Earths Facility has the responsibility and authority for managing a safe and effective radiation safety program. He reports directly to the on-site project manager of the Kerr-McGee West Chicago Facility and functionally to the corporate Staff Health Physicist.

The minimum qualifications and training for the position of Site Health Physicist include a college degree in engineering or related science, four weeks of formal health physics training and one year of applied health physics experience or equivalent.

The Site Health Physicist or his designee is responsible for training all personnel in basic and site-specific radiation safety principles and practices. In addition, he is responsible for evaluating radiological hazards to workers and the environment, and for implementing methods to determine compliance with regulatory and license requirements. He will report to management any departure from safe work practice, any item of noncompliance with accepted practices or procedures, and any need for improvement in the radiation safety program. The Site Health Physicist has the authority to terminate work when unsound radiological practices exist.

2.2.2. Health Physics Personnel

Health Physics personnel are responsible for following procedures and other written or verbal instructions from the Site Health Physicist in order to provide radiologically safe work conditions and to minimize adverse environmental impacts. Health Physics personnel will report any unsatisfactory radiological work conditions to the Site Health Physicist, who will determine further course of action.

2.3. QUALITY ASSURANCE

Regular auditing of the Health Physics program will be carried out in accordance with Kerr-McGee Corporation procedures. Auditing will be performed by staff compliance specialists, and/or the Staff Health Physicist of the Environment and Health Management Division, Kerr-McGee Corporation. These audits are conducted at least quarterly. Audit reports are sent to responsible management for corrective action as appropriate.

2.4 PROCEDURE APPROVAL AND REVIEW

All Health Physics procedures developed and written for implementation at the West Chicago Facility will be reviewed and approved by the Site Health Physicist, the corporate staff Health Physicist, the Project Manager and any specialists designated by the Project Manager. All existing Health Physics manuals and procedures will be reviewed annually by the Corporate Staff Health Physicist.

2.5 HEALTH PHYSICS MANUAL REVISIONS

Revisions to this Health Physics Manual will be reviewed and approved by the Site Health Physicist, the corporate staff Health Physicist, the Project Manager and any specialists designated by the Project Manager. Dated replacement pages will be submitted to the NRC 30 days prior to incorporation in the manual.

3. TRAINING

3.1. BASIC RADIATION PROTECTION TRAINING

All assigned personnel who will work with radiation or radioactive materials or in radiation controlled areas shall receive a minimum of four hours of training in the principles of basic radiation protection.

This training will be given by a member of the Health Physics group. The training class will cover the material in Appendix A, "Outline of Basic Radiation Protection Training".

Each person attending the Basic Radiation Protection Class must sign an attendance list to indicate that he has attended the class. Oral, written or practical testing covering this material will indicate satisfactory completion of the class. Documentation of testing shall be retained.

3.2. TRAINING OF SUPERVISORS

All construction supervisory personnel shall receive an additional two hour training course in the management principles of radiation exposure and contamination control.

This training will be given by a member of the HP supervisory staff. This training class will cover additional material beyond the material covered in the Basic Radiation Protection Training Course. This training course will cover the material in Appendix B "Outline of Management Principles of Radiation Exposure and Contamination Control".

Each person attending this course shall sign an attendance list to indicate that he has attended the class. Satisfactory completion of this course material is documented, and this documentation is retained.

3.3. HEALTH PHYSICS TECHNICIAN TRAINING

All Health Physics Technicians working at the West Chicago Facility will be trained in the contents of this manual and in the specific instrumentation they are to use. The Table of Contents serves as an outline for this course. The HP supervisory staff will normally train new HP technicians.

Depending on the level of qualification of the technicians, additional training beyond this manual will be given. The Argonne National Laboratory Health Physics Technician Manual (ANL 7291) is a good reference as well as the Rockwell NRRPT class curriculum for technicians with little previous Health Physics experience. Written assignments and tests show technician proficiency.

3.4. RESPIRATORY PROTECTIVE EQUIPMENT TRAINING

Each worker who is required to use respiratory protective equipment shall receive training in the use of the specific equipment he is to use. No person will use respiratory equipment until he is specifically trained in the use of the equipment.

The training will include appropriate material given in Section 8. and in Appendix C, USNRC Regulatory Guide 8.15 and NUREG-0041. In addition the class will include specific training and practice in the fitting and use as well as limitations of the equipment.

Written procedures for respiratory training at the West Chicago Facility are contained in the document: Health Physics Training Manual, Kerr-McGee Corporation Respiratory Protection, March 14, 1977, which is modeled after USNRC Regulatory Guide 8.15 and NUREG-0041 (see Appendix C).

4. ACCESS CONTROL

4.1. INITIAL SITE ACCESS

New employees will be instructed where to enter the site. They will be instructed to report to the Project Superintendent or his designee.

4.1.1. Project Supervisors

Project supervisors will report to the Project Superintendent; then to the Health Physics Supervisor. The HP Supervisor will notify the new supervisor of his HP training schedule and initiate personnel monitoring records. The new supervisor will be given specific instructions on limited access to the plant prior to completion of the required training program.

4.1.2. Employees

Employees will be instructed to report to their Foreman and then to the Health Physics Supervisor. The HP Supervisor will notify the new employee and his supervisor of his schedule for Basic Radiation Protection Training and coordinate with the supervisor for additional training as necessary, for example, Respiratory Equipment Training. The HP Supervisor will immediately initiate personnel monitoring records for the new employee. He will also give specific instructions on limited access to the plant or escort requirements before completion of the required training and personnel monitoring processing.

4.1.3. Visitors

Visitors must contact the Site Project Manager. He will notify the HP Supervisor. Training and personnel monitoring requirements for each visitor will be determined on an individual basis. However, all persons entering the controlled

4.1.3. Visitors (Cont'd)

areas shall be provided with adequate personnel monitoring devices. A brief indoctination concerning radiation hazards and warning signs will be given to all visitors entering radiation controlled areas. See Figure 4-1. The visitor will be instructed by the HP Supervisor on his limitations to access to areas within the work site.

4.2. ACCESS TO WORK AREAS

4.2.1. Clean Areas

Clean areas are not used for storage or use of radioactive or contaminated materials. Radioactive or contaminated materials may only be transported through a clean area if they are properly packaged or bagged to limit radiation and prevent the spread of contamination. Radiation levels and contamination levels will be maintained below the limits specified in Table 4-1.

4.2.2. Controlled Areas

Entry to radiologically controlled areas is limited. Entry for work to be performed in controlled areas is regulated by written operating procedures for routine work or a Special Work Permit, (SWP) for non-routine work. (See Section 13.) Visitors or personnel engaged in inspection type work will be required to be informed of hazards in the controlled area and to have an escort into controlled areas, or to receive training regarding controlled area hazards and requirements.

Controlled areas include Radiation Areas, Contamination Control Areas and Airborne Radioactivity Areas.

Entry to controlled areas is to be limited to personnel required to accomplish the task. Radiation and airborne radioactivity exposure control must be adhered to, and casual or unnecessary entry eliminated.

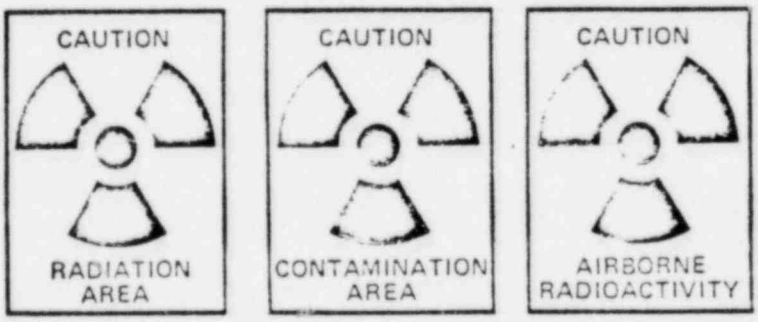
KERR-McGEE CHEMICAL CORPORATION
WEST CHICAGO FACILITY

KM-4792

VISITOR INFORMATION

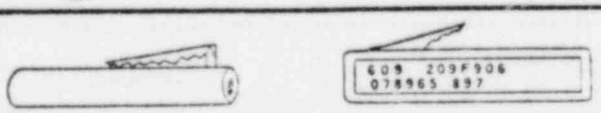
NOTICE TO VISITOR: ALL VISITORS MUST BE ESCORTED AT ALL TIMES WHILE ON THIS SITE.

CAUTON. Radioactive materials are present on this site. Radioactive materials may be found throughout the site. Grounds, buildings and equipment have low levels of contamination.



CONTROLLED AREAS: Do not enter areas with these signs unless you have an escort or health physics has given specific approval and you understand access limitations.

You must wear protective clothing in controlled areas. Health physics will provide you with instructions.



You must wear a personal radiation dosimeter if you enter an area which is controlled.

No smoking, eating, drinking or chewing in controlled areas.
NO EXCEPTIONS.

You may request to see radioactive materials license for this facility as granted by the USNRC.
Notify Health Physics if you do not understand these instructions.

NAME _____ DATE _____

Figure 4-1

TABLE 4-1

CLEAN AREA RADIATION AND CONTAMINATION LIMITS

Clean areas must be maintained below the radiation and contamination limits as listed below.

1. Radiation exposure limit: 2 mR/hr

2. Removable alpha contamination limit: 200 dpm/100 cm^2

4.2.3. Radiation Areas

Access to Radiation Areas is controlled by use of written procedures or Special Work Permits (SWP). Radiation Areas will be posted with Radiation Area signs. These signs indicate the radiation level, exceeding 2 mR/hr. A timekeeper is not required for normal entry into a radiation area unless specified on the SWP. Personnel dosimeters are required for work in Radiation Areas.

4.2.4. Contamination Control Areas

A Contamination Control Area is an area which may be contaminated to a level greater than the limits defining a clean area. Contamination control areas are marked with Radioactive Materials signs and signs designating the contamination levels and boundaries. In addition, step-off-pad procedures are used to control contamination at the access point.

Entry to Contamination Control Areas is controlled by use of written procedures or Special Work Permits (SWP). Protective clothing specified must be worn before entering the Contamination Control Area. Smoking, eating, drinking, or chewing are not permitted in Contamination Control Areas.

Each person shall use the step-off-pad procedure when leaving the Contamination Control Area. All exposed body surfaces and clothing shall be monitored at the control line or the step-off-pad. If body surface contamination is detected, personnel must notify Health Physics and wait at the step-off-pad for Health Physics assistance.

Contaminated clothing is placed in the receptacles provided at each step-off-pad.

4.2.5. Airborne Radioactivity Areas

Access to Airborne Radioactivity Areas is controlled by the use of the Special Work Permit (SWP). Airborne Radioactivity Areas are posted with Airborne Radioactivity Area signs. Airborne Radioactivity Areas will always be within Contamination Control Areas, and protective clothing will always be required.

4.2.5. Airborne Radioactivity Areas (Cont'd)

Respiratory equipment may be required in the Airborne Radioactivity Area depending on the concentration of specific nuclides present, the work to be done, and the stay time in the area. Individuals who are to use respiratory equipment must first successfully complete the Respiratory Equipment Training Course.

Before entering an Airborne Radioactivity Area requiring the use of respiratory equipment, the equipment must be inspected, fitted and tested operationally according to the specific procedure for the respirator used. Leaking respirators shall not be used. If supplied air is used, the individual must determine the adequacy of the air supply before he enters the work area.

Records are maintained of the following information for each person working in an Airborne Radioactivity Area:

a. Individual exposed (SWP)
b. Type of respiratory equipment used (SWP)
c. Stay time in work area (SWP or work location cards)
d. Nasal smear results, if necessary (Survey Data Sheet)
e. Airborne radioactivity concentration (Air Sample Data Sheet, SWP, and Survey Data Sheet)

5. PERSONNEL MONITORING

5.1. DOSIMETRY

The Site Health Physicist maintains records of all radiation exposures incurred by personnel including all crafts, contractors, and inspectors working at the site. These records are maintained in an up-to-date manner to comply with the requirements of 10CFR20. Records are maintained in accordance with Section 5.5. The following records are kept for each worker exposed to radioactivity or radiation.

a. Form NRC-4 or equivalent listing his previous radiation exposure history.
b. Records of previous radiation exposure as received from employers.
c. Form NRC-5 or equivalent listing current occupational exposure for whole body, skin and extremities.
d. Bioassay documents evaluating results of whole body counts or excreta analysis in the event of potential internal exposure(s) exceeding 520 MPC-hours per year.
e. Evaluations of lost or erroneous dosimeter, TLD, or film badge readings.
f. Copies of all correspondence relating to the individual's radiation exposure records.

5.2. REQUIREMENT FOR DOSIMETRY

Personnel dosimetry is required for anyone who enters a radiologically controlled area in which he may receive in one calendar quarter a dose to a major portion of his body in excess of 312 millirem. Any person who enters or works in a radiation area will be required to have a personal dosimeter. As a matter of policy, all personnel on the Kerr-McGee property shall be required to use a dosimeter except in offices and other locations designated as clean areas.

5.3. TYPES OF DOSIMETRY

5.3.1. Film Badge

The film badge is a device used to measure the total dose received by a person exposed to beta, x- or gamma radiation.

Ionizing radiation striking silver atoms in the film emulsion causes excitation of the electrons in small clusters of silver atoms. Later processing chemically develops these clusters into silver grains in the emulsion. The optical density of the emulsion is read to determine the film dose. Correction must be made for energy, exposure level, emulsion number, development time and temperature to evaluate the dose received by the person. Filters are used in various areas of the film to determine energy and quality of the ionizing radiation.

The film badge, if issued, must always be worn when in specified controlled areas. Normally the film badge is worn in the vicinity of the left breast pocket. It must not be shielded by other devices such as ID badges, pens or pencils, coins or keys. Film badges are worn upright with the label away from the body. Film badges are not taken offsite without HP approval.

Care must be taken that the film badge is not lost, damaged, or exposed to radiation except while being worn. The film badge is used to provide the permanent radiation exposure history for the wearer.

5.3.2. Thermoluminescent Dosimeters (TLD)

The Thermoluminescent Dosimeter (TLD) is a device used for measuring the total dose received by a person exposed to both beta and x- or gamma radiation.

Ionizing radiation striking electrons within the crystal lattice of lithium fluoride crystal chips raises electrons to higher energy levels where they become trapped. Later development by heating allows the electrons to return to their ground state. This process emits light photons. The quantity of light is directly proportional to the dose (in rad) received by the TLD. This solid state device is stable and capable of measuring doses over the practical ranges of HP dosimetry.

5.3.2. Thermoluminescent Dosimeters (TLD) (Cont'd)

The TLD, if used, must always be worn when in controlled areas. Normally the TLD will be worn in the vicinity of the left breast pocket. It must not be shielded by other devices such as ID badges, pens or pencils, coins or keys.

Care shall be taken that the TLD is not lost, damaged, or exposed to radiation except while being worn. The TLD provides the basis for the permanent radiation exposure history of the wearer. TLD badges are worn upright with the label away from the body. TLDs are not taken offsite without HP approval.

5.3.3. Self-Reading Dosimeters

Self-reading dosimeters operate on the principle of the gold-leaf electroscope. A quartz fiber is displaced electrostatically by charging it. An image of the fiber is focused on a scale and can be seen by looking through the dosimeter lens. Exposure of the dosimeter to x- or gamma radiation discharges the fiber and the fiber will return to its original position. The amount of discharge and therefore the amount of change in fiber position is proportional to the radiation exposure.

Self-reading dosimeters must be handled with care. Dropping the dosimeter may discharge it, making its reading go off scale. In this case, an evaluation of the exposure is made, and the dosimeter is recharged.

5.3.4. Extermity Dosimetry (RESERVED)

5.4. ISSUING DOSIMETRY

Personnel dosimetry will be issued for new employees and for visitors as required. An employee provided with personnel dosimetry must supply information as required on forms NRC-4 and NRC-5 or equivalents. This information will include name of the individual, social security number, date of birth and previous occupational radiation exposure history.

5.4.1. Film Badges or TLD

Permanent employees assigned to the West Chicago Facility shall be issued personnel dosimeters. For this application film badges are the preferred dosimeters. TLD badges may be substituted for film badges if desired. A log of film badges will be kept. This will include a record of film badges used for personnel monitoring and area monitoring and control badges. This log will also show return of exposed film badges to the processor for development when the exposure period is ended.

Control badges are used by the processor to measure and subtract the background exposure that the badges receive while in storage. It is important that control badges are stored with the other unused badges and that they are received from and returned to the processor with the other badges. In case a control badge is damaged or additional control badges are needed, any badge may be designated as a control badge as long as it has been stored in the same manner as the other badges. Film or TLD dosimeters will be processed on a monthly basis.

Film badge results received from the processor shall be retained. The reports constitute the permanent record of personnel occupational radiation exposure at the West Chicago Facility. A timely review of the results determines completeness and compliance with all exposure limits.

5.4.2. Self-Reading Dosimeter

Temporary employees, visitors or inspectors may be issued self-reading dosimeters for personnel monitoring if dosimetry is required. A log of all personnel issued a self-reading dosimeter shall be maintained.

Dosimeters are charged every day at the beginning of the shift if necessary. A dosimeter is charged if the fiber is more than halfway across the scale or if it is less than 100 mR from tne end of the scale.

The dosimeter is charged by pressing the dosimeter firmly onto the charging pedestal of the dosimeter charger. At the same time look into the dosimeter and adjust the control knob until the fiber image is at the zero mark on the scale. Remove the dosimeter and touch the charging pin lightly with a pencil point or small wire to eliminate the remaining electric charge on the charging pin. Read the dosimeter. This is the initial reading. Record the initial reading on the visitor dosimeter record.

5.4.2. Self-Reading Dosimeter (Cont'd)

Read the dosimeter periodically if working in a radiation area. Otherwise read the dosimeter at the end of the work day or when leaving the site and record the final reading. Subtract the initial reading from the final reading and record the dose received for that wearing period.

5.5. FORMS AND RECORDS

Personnel monitoring records are important for several reasons. First, it is essential that no employee receive more exposure than is permitted by law. Second, records of radiation exposure may be used as the legal basis for the settlement of claims under workmen's compensation laws or other legal proceedings. Third, the records are necessary for planning work and keeping radiation exposures as low as reasonably achievable (ALARA). Therefore, the records of issue and return of dosimetry must be done in a careful and businesslike manner, and all records concerning dosimetry must be maintained as permanent operating records. All records must be kept current.

The purpose of this procedure is to clearly explain how these forms are to be prepared. Use ink to fill out the forms. Avoid pencil, broad tip markers and water-soluble inks.

5.5.1. Occupational External Radiation Exposure History Form, NRC-4 or Equivalent

The Occupational External Radiation Exposure History form is completed for each person who will perform work involving exposure to radiation. This form is filled out, signed and dated and the calculation of Unused Part of Permissible Accumulated Dose must be completed before his exposure may exceed 1.25 rem per quarter. A sample form NRC-4 is shown in Figure 5-1.

The employee completing the form completes the Identification section at the top of the form. The full name should be given including the full middle name. If the employee has no middle name, then this should be indicated by (NONE).

Form NRC 4
(6 77)
10 CFR 20

U. S. NUCLEAR REGULATORY COMMISSION

Approved by GAO
B-180225 (R0081)
Expires 4-30-80

OCCUPATIONAL EXTERNAL RADIATION EXPOSURE HISTORY

See Instructions on the Back

IDENTIFICATION

1. NAME (PRINT – LAST, FIRST, AND MIDDLE)	2. SOCIAL SECURITY NO.
3. DATE OF BIRTH (MONTH, DAY, YEAR)	4. AGE IN FULL YEARS (N)

OCCUPATIONAL EXPOSURE – PREVIOUS HISTORY

5. PREVIOUS EMPLOYMENTS INVOLVING RADIATION EXPOSURE – LIST NAME AND ADDRESS OF EMPLOYER	6. DATES OF EMPLOYMENT (FROM – TO)	7. PERIODS OF EXPOSURE	8. WHOLE BODY (REM)	9. RECORD OR CALCULATED (INSERT ONE)

10. REMARKS	11. ACCUMULATED OCCUPATIONAL DOSE – TOTAL	

13. CALCULATIONS – PERMISSIBLE DOSE WHOLE BODY	12. CERTIFICATION I CERTIFY THAT THE EXPOSURE HISTORY LISTED IN COLUMNS 5, 6, AND 7 IS CORRECT AND COMPLETE TO THE BEST OF MY KNOWLEDGE AND BELIEF.
(A) PERMISSIBLE ACCUMULATED DOSE = 5(N – 18) = _____ REM	EMPLOYEE'S SIGNATURE _____ DATE
(B) TOTAL EXPOSURE TO DATE (FROM ITEM 11) = _____ REM	14. NAME OF LICENSEE
(C) UNUSED PART OF PERMISSIBLE ACCUMULATED DOSE (A – B) = _____ REM	

Figure 5-1

INSTRUCTIONS FOR PREPARATION OF NRC FORM 4

This form or a clear and legible record containing all the information required on this form must be prepared by each licensee of the Nuclear Regulatory Commission who, pursuant to Section 20.101, proposes to expose an individual to a radiation dose in excess of the amounts specified in Paragraph 20.101(a) of the regulations in Part 20, "Standards for Protection Against Radiation," 10 CFR. The requirement for completion of this form is contained in Section 20.102 of that regulation. The information contained in this form is used for estimating the external accumulated occupational dose of the individual for whom the form is completed. A separate Form NRC-4 shall be completed for each individual to be exposed to a radiation dose in excess of the limits specified in Paragraph 20.101(a) of Part 20 of the Commission's regulations.* Listed below by item are instructions and additional information directly pertinent to completing this form:

Identification

Item 1. Self-explanatory.
Item 2. Self-explanatory except that, if individual has no social security number, the word "none" shall be inserted.
Item 3. Self-explanatory.
Item 4. Enter the age in full years. This is called "N" when used in calculating the Permissible Dose. N is equal to the number of years of age of the individual on his last birthday.

Occupational Exposure

Item 5. List the name and address of each previous employer and the address of employment. Start with the most recent employer and work back.

Include only those periods of employment since the eighteenth birthday involving occupational exposure to radiation. For periods of self-employment, insert the word "self-employed."

Item 6. Give the dates of each employment listed in Item 5.
Item 7. List periods during which occupational exposure to radiation occurred.
Item 8. List the dose recorded for each period of exposure from the records of previous occupational exposure of the individual as calculated under Section 20.102. Dose is to be given in rem.

"Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

Item 9. After each entry in Item 8 indicate in Item 9 whether dose is obtained from records or calculated in accordance with Section 20.102.
Item 10. Self-explanatory.

Total Accumulated Occupational Dose (Whole Body)

Item 11. The total for the whole body is obtained by summation of all values in Item 8.

Certification

Item 12. Upon completion of the report, the employee must certify that the information in Columns 5, 6, and 7 is accurate and complete to the best of his knowledge. The date is the date of his signature.

Calculations

Item 13. The lifetime accumulated occupational dose for each individual and the permissible dose under Paragraph 20.101(b) are obtained by carrying out the following steps. The value for N should be taken from Item 4. Subtract 18 from N and multiply the difference by 5 rem. (For example, John Smith, age 32, N = 32, PAD = 5(32-18) = 70 rem.) Enter total exposure to date from Item 11. Subtract (b) from (a) and enter the difference under (c). The value in (c) represents the unused part of the permissible accumulated dose. This value for permissible dose is to be carried forward to Form NRC-5, "Current Occupational External Radiation Exposure (Whole Body)."

Item 14. Self-explanatory.

*This form requires the signature of the employee concerned.

PRIVACY ACT STATEMENT

Pursuant to 5 U.S.C. 552a(e) (3), enacted into law by section 3 of the Privacy Act of 1974 (Public Law 93-579), the following statement is furnished to individuals who supply information to the Nuclear Regulatory Commission on Form NRC-4. This information is maintained in a system of records designated as NRC 27 and described at 40 Federal Register 45344 (October 1, 1975).

1. AUTHORITY Sections 53, 63, 65, 81, 103, 104, 161(b), and 161(o) of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201(b), and 2201(o)). The authority for soliciting the social security number is 10 CFR Part 20.

2. PRINCIPAL PURPOSE(S) The information is used by the NRC in its evaluation of the risk of radiation exposure associated with the licensed activity and in exercising its statutory responsibility to monitor and regulate the safety and health practices of its licensees. The data permits a meaningful comparison of both current and long-term exposure experience among types of licensees and among licensees within each type. Data on your exposure to radiation is available to you upon request.

3. ROUTINE USES The information may be used to provide data to other Federal and State agencies involved in monitoring and/or evaluating radiation exposure received by individuals employed as radiation workers on a permanent or temporary basis and exposure received by monitored visitors. The information may also be disclosed to an appropriate Federal, State, or local agency in the event the information indicates a violation or potential violation of law and in the course of an administrative or judicial proceeding.

4. WHETHER DISCLOSURE IS MANDATORY OR VOLUNTARY AND EFFECT ON INDIVIDUAL OF NOT PROVIDING INFORMATION It is voluntary that you furnish the requested information, including social security number; however, the licensee must have a completed Form NRC-4 on each individual whom the licensee proposes to expose to a radiation dose in excess of the amounts specified in 10 CFR 20.101(a). Failure to obtain the requested information before permitting such exposure may subject the licensee to enforcement action in accordance with 10 CFR 20.601. The social security number is used to assure that NRC has an accurate identifier not subject to the coincidence of similar names or birthdates among the large number of persons on whom data is maintained.

5. SYSTEM MANAGER(S) AND ADDRESS Director, Office of Management Information and Program Control
U.S. Nuclear Regulatory Commission, Washington, D.C. 20555

Figure 5-1 (Reverse side)

5.5.1. Occupational External Radiation Exposure History Form, NRC-4 or Equivalent (Cont'd)

In the section of the form marked Previous History of Occupational Exposure the employee must list all of his previous employment where he was occupationally exposed to ionizing radiation. Employment during the current quarter should be listed separately at the top, and all earlier periods of exposure listed in order under the current quarter information. Period of employment and period of exposure should be listed to the nearest month and year and should be the inclusive period. It is only necessary to list those places of employment where occupational radiation exposure occurred. The form is signed and dated. This signature is a certification of the accuracy of the information listed.

To obtain records of exposure history from former employers in accordance with the Privacy Act of 1974, the individual must sign a release statement. A copy of a typical release statement is given in Figure 5-2. Copies of the signed form are made and sent to the previous employers as authorization for the release of the employee's dose history. The dose history is determined by Health Physics according to the instruction given in 10CFR20.102.

The total accumulated dose is determined from the history information based on available records of exposure or calculated exposure data for periods (in quarters) of exposure for which records are unavailable. Calculations for dose when records are not available are explained in 10CFR20.102. Copies of the records used are attached to the form.

The Total Accumulated Dose is subtracted from the Permissible Accumulated Dose (PAD) to obtain the Unused Part of Permissible Accumulated Dose. This number is the limiting value for exposure. This computation must be performed before any person may receive an exposure greater than 1.25 rem in any quarter.

In most cases the unused part of the dose will be well over 3 rem but for some workers, particularly young workers, it may not be. If the unused part of the PAD is not over 3 rem, then the permissible exposure should not exceed 1.25 rem per quarter or the unused part of the PAD, whichever is smaller.

Kerr-McGee Chemical Corporation
798 Factory Street
West Chicago, IL 60185

Subject: Radiation Exposure Request for:

Name
S.S.#:
Date of Birth:
Facility:
From: To:

Gentlemen:

Our records indicate that the above named individual was engaged in licensed activities controlled by the license while engaged in work at your facility during the period indicated above.

In accordance with the requirements of 10CFR19.13(c), please furnish a copy of the report of the individual's exposure to radiation or radioactive materials to Kerr-McGee Chemical Corp. at the address given above and to the attention of , Supervisor, Health Physics, for inclusion in the individual's radiation exposure history file. The report should cover each calendar quarter and should include the dates and locations of licensed activities in which the worker participated during the indicated period.

Sincerely,

Supervisor, Health Physics

cc: Employee
HP File

I hereby authorize the release of the above information to Kerr-McGee Chemical Corp. for inclusion in my radiation exposure history file.

Signed_____ Date_____

Figure 5-2

5.5.2. Current Occupational External Radiation Exposure Record, NRC-5 or Equivalent

A file of exposure received is maintained on each person who is issued a film badge. This Current Occupational External Radiation Exposure Record is used to record the personnel monitoring information for each person, and it becomes the permanent file record of his exposure. Film badge processor reports fulfill this requirement if all necessary information is reported by the processor.

Required information includes a complete evaluation of the individual's dose received at the West Chicago Facility. Whole body, skin and extremity doses are recorded. A running total for the calendar quarter and a lifetime accumulated dose evaluation are also required.

5.5.3. Dose Evaluation Report

If a dosimeter or film badge is lost or damaged, the exposure received by that individual must be estimated and documented for the permanent record. The Dose Evaluation Report form (shown in Figure 5-3) is used for this purpose.

This form should be filled out promptly while people can still remember what they did and before the employee leaves the job so that he can sign the completed form to indicate that he agrees with the estimate. The completed form is filed with the radiation exposure records.

5.5.4. Visitor Dosimeter Record

Visitors, inspectors or other individuals using a self-reading dosimeter will fill out the appropriate portions of the Visitor Dosimeter Record, Figure 5-4. Initial and final dosimeter readings are recorded on this form as well as the dose received. These forms must be retained as the permanent record of radiation exposure for these individuals.

5.6. AIRBORNE RADIOACTITY EXPOSURE

Monitoring for airborne radioactivity exposure is as important as monitoring for external radiation exposure. Monitoring for airborne radioactivity exposure requires the following elements:

KERR-McGEE CHEMICAL CORPORATION
WEST CHICAGO FACILITY

KM-4793

DOSE EVALUATION REPORT

Name _____ Social Security No. _____

Date of Birth _____ Company or Craft _____

Lost TLD ☐ No.: _____ Time period of badge or dosimeter

Lost Film Badge ☐ No.: _____ From _____ To _____

Other ☐ (Describe) _____

Description of Occurence:

(Use additional sheets if necessary and check here if used ☐)

Summary of Available Records of Exposure: (Give survey numbers, SWP numbers, Dosimeter Readings, etc.)

(Use additional sheets if necessary and check here if used ☐)

Estimated Exposure (Evaluate above data and estimate occupational external radiation exposure. Describe evaluation below and attach additional sheets if necessary. Check here ☐ if used.)

_____ rem
WHOLE BODY

_____ rem
SKIN

_____ EMPLOYEE

_____ SUPERVISOR

_____ INVESTIGATOR

Action:

Personnel Monitoring Records Adjusted

Date _____

By _____

File This Report with Applicable Dosimetry Records For Period.

Figure 5-3

KERR-McGEE CHEMICAL CORPORATION
WEST CHICAGO FACILITY

VISITOR DOSIMETER RECORD KM-4737

VISITOR

NAME | SOCIAL SECURITY NO | AGE YRS

COMPANY AFFILIATION | PHONE

COMPANY ADDRESS

CITY, STATE, AND ZIP CODE

"My known or estimated occupational radiation dose is _____ mrem for the current calendar quarter and _____ mrem for the calendar year.

I know of no medical disqualification that should prevent my receiving a radiation dose within the prescribed federal standards."

SIGNATURE | DATE

SECURITY

POCKET CHAMBER NO. | EXPOSURE PERIOD From To

	INITIAL	FINAL	NET
mR			
mrem		BY — HEALTH PHYSICIST	

FILE COPY

Figure 5-4

5.6. AIRBORNE RADIOACTIVITY EXPOSURE (Cont'd)

a. Air sampling for airborne radioactivity
b. Record keeping regarding personnel work locations and time in location
c. Respiratory protective equipment records regarding devices used by workers in airborne radioactivity areas.

By closely monitoring these three elements, a continuous record of personnel exposure to airborne radioactivity is maintained.

5.6.1. Air Sampling for Airborne Radioactivity

Air sampling is performed in work areas where airborne radioactivity may exceed 25% of the maximum permissible concentration for nuclides present. Air sampling procedures are discussed in Section 12. The fraction of the MPC present in a work area is determined from air sample results, so that the need for respiratory protective equipment can be determined.

5.6.2. Work Location Records

To continuously monitor a worker's exposure to airborne radioactivity, Daily Work Location Cards may be used. These cards, shown as Figure 5-5, are filled out by workers each day. These cards indicate how long workers were in specific areas. Information from the daily card along with air sample and respiratory protection information are transferred to an Airborne Radioactivity MPC-Hour Exposure Record shown in Figure 5-6. The estimated MPC-hours exposure is maintained continuously for each worker.

5.6.3. Respiratory Protective Equipment Record

Airborne radioactivity exposure must include information regarding respiratory protective equipment used. The Airborne Radioactivity MPC-Hour Exposure Record summarizes for each worker his airborne exposure and respiratory protection used.

NAME	BADGE NO.	DATE	TIME WORK BEGAN ☐ A.M. ☐ P.M.	TIME WORK ENDED ☐ A.M. ☐ P.M.

	WORK LOCATION (BE SPECIFIC)	ACTUAL HOURS WORKED	RESPIRATORY PROTECTION USED*
1			
2			
3			
4			
5			

DAILY WORK LOCATION KM-2532-C

* N - NONE
H - HALF MASK
F - FULL MASK
S - SUPPLIED AIR

HEALTH PHYSICS
USE ONLY

IMPORTANT

ALL HOURS OF WORK WEARING RESPIRATORY PROTECTION MUST BE LISTED.

Figure 5-5

AIRBORNE RADIOACTIVITY MPC-HOUR EXPOSURE RECORD - WEST CHICAGO FACILITY

NAME

BADGE NUMBER

DATE	ACTIVITY $\mu Ci/ml$	% MPC	EXPOSURE HOURS	HOURS RESP WORN	* RESP TYPE	** MODE	PROTECT. FACTOR	MPC HOURS

*
H - Half Face
F - Full Face
S - Supplied Air
N - None

**
NP - Negative Pressure
PP - Positive Pressure
CF - Continuous Flow
D - Demand
PD - Pressure Demand
R - Recirculating

CALCULATED BY (SIGNATURE)

FIGURE 5-6

5.6.3. Respiratory Protective Equipment Record (Cont'd)

Protection factors of the respiratory device used enter the calculation of the total MPC-hours by reducing the MPC-hours by whatever factor is associated with the respiratory device. In this way an up-to-date record of airborne radioactivity exposure is maintained for each worker.

5.7. BIOASSAY

Bioassay is the determination of the types and amounts of radioactive materials which are inside the body. Internal exposures from these materials can then be determined by analyzing these materials and determining their rate of excretion, their deposition and any other information regarding their placement in the body.

5.8. REQUIREMENTS FOR BIOASSAY

5.8.1. Preliminary Bioassay

Bioassay performed before a person starts work in controlled areas is not necessary on a routine basis at the West Chicago Facility. Workers who have had previous significant exposure to uranium or thorium or their daughters may require preliminary bioassay. Requirements for preliminary bioassay are determined on a case-by-case basis by the Health Physics Supervisor. Evaluation of occupational exposure history as recorded on form NRC-4 will be made to determine the need for preliminary bioassay.

5.8.2. Routine Bioassay

Routine bioassay for workers at the West Chicago Facility will be required infrequently, if at all. The principal nuclides for bioassay purposes are Ra-228 and Th-232. Radium-228 will not be a common contaminant. Thorium-232 is found throughout the site but in low concentrations.

Airborne materials are the most likely to be taken into the body, and routine bioassay will be determined on a case-by-case basis from the amount of airborne exposure an individual has had. Airborne radioactivity levels will be determined by air samples.

Routine bioassay will be required if an individual works in airborne radioactivity areas so that he is exposed to 520 MPC-hours or more in a calendar year as a result of chronic inhalation exposure and/or a series of small acute exposures to airborne thorium. The preferred bioassay method in this case is in vivo (lung) counting using procedures with a minimum sensitivity of 6-8 mg of Th (nat.) for persons with a typical chest wall thickness.

5.8.2. Routine Bioassay (Cont'd)

MPC hours are calculated using the appropriate Maximum Permissible Concentrations listed in Table I, Column I, Appendix B, 10CFR20. Exposure to the MPC in air for one hour is equal to one MPC-hour. Exposure to two times the MPC for one half hour is also one MPC-hour. These figures assume that no respiratory protective equipment is worn by the individual.

5.8.3. Nonroutine and Emergency Bioassay

Bioassay may be required in unusual or accidental circumstances including accidental ingestion of a quantity of materials, possible injection from being wounded by a highly contaminated object, accidental inhalation of concentrated materials released by opening a tank or other closed system. Nasal swabs, sputum samples and direct monitoring will help show the need for bioassay. Nonroutine bioassay is conducted for unusual acute inhalation exposures exceeding 520 MPC-hours in any calendar quarter. Fecal analysis is used to verify the exposure severity. Such verification will require follow-up in vivo examination.

5.9. METHODS OF BIOASSAY

In general bioassay is accomplished by one or a combination of the methods listed below:

a. direct measurement in a whole body counter or direct measurement of a specific organ
b. excreta analysis, commonly including urine and feces
c. sputum, sweat and vomitus sampling
d. blood sampling
e. hair and nail analysis

Bioassay for thorium is difficult because it is insoluble in body fluids. It is not excreted in the urine. Small fractions of the maximum permitted lung burden (30 mg Th) are difficult to detect in whole body counting systems. Lung burdens resulting from exposures to airborne thorium less than 520 MPC-hours are not likely to be detected by in vivo counting.

5.9. METHODS OF BIOASSAY (Cont'd)

Because of its insolubility the principal excretion mode of thorium is in the feces. Fecal analysis for accidental inhalation must continue over a period of time to monitor short and longer clearance fractions from the respiratory tract. A schedule for fecal analysis for acute exposure is based on the lung model developed by the International Commission on Radiological Protection (ICRP) Task Group on Lung Dynamics. (See ICRP Publications 19, 30.) The deposition of inhaled particles throughout the respiratory tract is estimated. Clearance from different parts of the respiratory tract has a characteristic biological half-life as well as a total fractional amount cleared. These factors are different for different classes of radioactive materials. Considering these biological half lives, fecal analysis for thorium should continue for six days, starting with the day of a large acute exposure. Because of clearance fractions, the total amount of thorium collected in the feces in the six day interval will represent approximately 50% of the total amount inhaled. Daily fecal samples should be analyzed separately to indicate clearance rates.

5.10. PROCEDURES FOR BIOASSAY

5.10.1. Notification of Workers

Individuals who must submit specimens or receive a whole body count are notified in writing. The notice gives the kind of sample required and the date it is to be submitted. An example of a notice is shown in Figure 5-7.

5.10.2. Sample Collection, Preservation and Shipping

Preservation and shipping are dependent somewhat on the analysis to be performed. If an outside vendor provides analytical services he will normally provide sample containers, preservatives and shipping instructions. Follow these instructions, where applicable.

BIOASSAY NOTICE

To:

Name: _____ Date: _____

Number: _____

Analysis: _____

Pick up a bioassay kit from Health Physics on _____
Date

Read the instruction provided with the kit immediately. It is important that you follow the instructions provided with the kit. If you do not understand the instruction please notify Health Physics.

Sign this notice and give it to Health Physics when you get your kit.

Kit Received: _____

Date: _____

Figure 5-7

5.10.2. Sample Collection, Preservation and Shipping (Cont'd)

Personnel who require bioassay shall be notified in advance and shall be provided with a sample kit and instruction sheet. A sample instruction sheet is shown in Figure 5-8. The individual should be given only the instructions pertinent to the type of bioassay required.

Log the samples in when the individual submits the specimen. Preserve and ship the specimens according to the bioassay contractor's instructions.

5.10.3. Analytical Procedures

The analytical procedures used shall be suitable for the analysis required and shall be kept on file. Vendor procedures shall be identified specifically and may be referenced.

5.10.4. Data Analysis and Evaluation

If bioassay results indicate significant internal exposure to radioactive materials, worker restrictions may be imposed until the internal dose evaluation is complete. Check results of the initial bioassay by recounting the sample or analyzing another portion of the specimen or obtaining another specimen. Resampling at appropriate intervals should be scheduled to determine elimination rate.

All information regarding the intake shall be kept to aid in the evaluation of internal dose. Data such as work location conditions and air sampling results should be part of that record.

All records pertaining to the intake, analysis and dose evaluation must be retained. Records of body burdens shall be filed with form NRC-5 equivalent forms.

BIOASSAY INSTRUCTIONS

Please read the instructions for the bioassay requested (checked box). If you do not understand the instructions notify health physics.

☐ Urine

Do not contaminate the specimen. Wash your hands and clean your nails. Shower if possible. Void in the container all urine: last voiding at night, voiding during the night and first morning urine. Write the date and times of the voidings on the container label. Put your name on the container. Turn the sample in to Health Physics as soon as possible.

☐ Feces

Do not contaminate the specimen. Wash your hands and clean your nails. Shower if possible. Line the toilet bowl with plastic bag provided. Defecate directly into the plastic bag. Close the bag and tape it shut with tape. Dry the exterior of the bag. Place the bag in the container provided. Label the container with the date, time and your name. Turn the specimen in to Health Physics promptly. You may freeze the speciment for temporary storage to prevent smells. All feces for the day must be collected and turned in daily to Health Physics. Feces will normally be collected for six consecutive days. Use each container only once.

☐ Whole Body Count

Do not wear contaminated clothing during the whole body count. Wash your hands and clean your nails. Shower if possible and wash your hair. Wear clean clothing to the whole body count.

Figure 5-8

5.10.5. Special Procedures

If special procedures are required for the evaluation or determination of significant body burdens of radioactive materials, the procedure shall be documented and shall be added to this manual and referenced in the records of the individual's exposure.

6. RADIATION EXPOSURE CONTROL

6.1. ALARA

The radiation protection standards set forth in Section 6.2 are used to control radiation exposure to workers. It is the established policy that worker exposure to ionizing radiation at the West Chicago Facility will be kept as low as reasonably achievable at all times.

6.2. BASIC RADIATION PROTECTION STANDARDS

Basic radiation protection standards are set forth in 10CFR20 "Standards for Protection Against Radiation". For the purpose of controlling occupational radiation exposure at the West Chicago Facility, the following standards are used.

No individual in any calender quarter shall receive a total occupational dose in excess of:

a.	Whole-body, including head and trunk, active blood forming organs, lens of eyes, and gonads	1.25 rem
b.	Hands and forearms, feet and ankles	18.75 rem
c.	Skin of the whole body	7.5 rem

6.3. RADIATION EXPOSURE LEVELS FOR FERTILE WOMEN

The need to minimize exposure of the embryo and fetus is paramount. It is the policy at the West Chicago Facility that particular efforts will be made to keep the radiation exposure of the embryo or fetus to the very lowest practicable level during the entire gestation period. Exposure limits for fertile women are the same as for men. Once a pregnancy is diagnosed exposure may be evaluated and efforts made to keep the total dose to the embryo or fetus to 0.5 rem for the total gestation period. This shall be done in accordance with Kerr-McGee Radiation Health and Safety Standard Procedure No. 9, dated 9-16-80. See Appendix F.

6.4 FACILITY GUIDE FOR RADIATION EXPOSURE LIMITS

An external radiation dose equivalent limit of 100 mrem per week is established for control purposes. No worker's exposure may exceed this value without permission from the Site Health Physicist. In no event may an individual's exposure for any quarter exceed the limits set forth in Section 6.2.

This facility limit will aid in efforts to keep radiation exposure to an embryo or fetus as low as practicable, particularly in limiting embryo exposure before pregnancy is diagnosed. (See Appendix F for further guidance on radiation exposure during pregnancy).

6.5. EXTENDED RADIATION EXPOSURE LIMITS (RESERVED)

6.6. OVEREXPOSURES

In case an individual exceeds the facility guide limit, the Site Health Physicist shall be notified.

If an individual exceeds any USNRC radiation exposure limit as stated in 10CFR20 a written report must be made to the NRC within 30 days.

USNRC
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137
phone: (312) 932-2500 (day or night)

If an individual's exposure exceeds 5 rem a report must be made within 24 hours by telephone to the NRC as listed above.

All reports provided to the NRC shall also be transmitted to the Project Manager at the same time the report is made to the NRC.

The report will be made by the Site Health Physicist with input from the individual(s), foremen, supervisors and superintendents as necessary. Each report will cover as a minimum the following information:

6.6. OVEREXPOSURES (Cont'd)

a. Identification of individual exposed, including name, social security number, and date of birth.

b. The extent of the overexposure, including exposure rates.

c. The cause of the overexposure.

d. Corrective action taken or planned to assure against a recurrence.

In any case in which an overexposure is suspected, any individual involved will be immediately removed from duties involving occupational exposure to radiation until full evaluation of the exposure can be made.

7. CONTAMINATION CONTROL

7.1. SURFACE CONTAMINATION

Surface contamination must be controlled and contained to minimize the spread of radioactive materials.

All surfaces outside radiologically controlled areas established by the Site Health Physicist shall be kept to levels of contamination less than those shown in Table 7-1.

Clean surfaces must be protected from contamination by sisal kraft paper or polyethylene sheeting before contaminated work is begun. If radioactive liquids may spill, a catch basin must be provided that can contain the entire volume that may spill. Vents of enclosures for contaminated components that are or may become pressurized shall have absolute filtered exhausts to prevent blowing radioactivity out of the enclosure. Contaminated liquid spills must be cleaned up promptly and not allowed to dry on the floor or surface since dry materials can easily become airborne. All burning, welding, cutting, and grinding operations on contaminated systems may require preparation for contamination control. Requirements for these jobs should be reviewed before they are started.

7.1.1. Boundaries and Signs for Contamination Control Areas

Each Contamination Control Area must be clearly marked by the use of tape, rope, or other temporary boundaries to prevent accidental entry. All boundaries must be marked with signs bearing a magenta symbol on a yellow background and the words "Radioactive Materials".

Each Contamination Control Area shall have an access point with a sign giving the contamination level and the protective clothing requirements for entry. Entry to and exit from a Contamination Control Area must be through the access point to prevent spread of contamination. Proper step-off-pad procedures must be used by all personnel entering or leaving the Contamination Control Area.

TABLE 7-1

ACCEPTABLE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[b,c,f]	MAXIMUM[b,d,f]	REMOVABLE[b,e,f]
U-natural, U-236, U-238 and associated decay products	5,000 dpm α/100cm^2	15,000 dpm α/100cm^2	1,000 dpm α/100cm^2
Th-nat, Th-232, Ra-223, Ra-224[g], U-232	1,000 dpm/100cm^2	3,000 dpm/100cm^2	200 dpm/100cm^2
Ra-226, Ra-228	100 dpm/100cm^2	300 dpm/100cm^2	20 dpm/100cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$/100cm^2	15,000 dpm $\beta\gamma$/100cm^2	1,000 dpm $\beta\gamma$/100cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate director for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived from each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

[g] Ra-224 not supported by Th-228 or Ra-228 precursors.

(Ref: USNRC Regulatory Guide 1.86)

7.1.2. Use of the Step-Off-Pad

Step-off-pads are used at the access points to contamination control areas. A step-off-pad may be as simple as a line across the floor, or as complex as a change area for a full crew of men to change out of an area.

At the West Chicago Facility a change room is provided at the control access point (step-off-pad).

Protective clothing, gloves, safety shoes and booties are removed at the control point. Issued clothing which will be removed at the end of the work shift may be used for craft employees. A frisking station will be set up at the control point. Each person must frisk (monitor) himself for radioactive contamination before he enters clean areas. Instructions for frisking will be posted at the frisking areas and will be followed by all personnel leaving the controlled area. Workers will sign the Daily Monitor record (Figure 7-1) each time they leave the controlled area. This prevents subsequent contamination and transfer of contamination from the controlled area. Section 8. lists procedures for removal of protective clothing.

7.1.3. Protecting Surfaces from Contamination

All surfaces within Contamination Control Areas should be protected from gross contamination. It is easier to provide temporary coverings and later to remove the covering than to decontaminate the original surfaces. Concrete and wood are especially difficult to clean since they are porous materials.

In some cases strippable coatings can be used to protect surfaces. Masking tape can be used for this purpose to protect piping, small equipment and openings from contamination.

DAILY MONITOR - RADIOACTIVE CONTAMINATION - WEST CHICAGO FACILITY

BY MY SIGNATURE BELOW I ACKNOWLEDGE THAT I HAVE MONITORED MYSELF FOR RADIOACTIVE CONTAMINATION IN ACCORDANCE WITH POSTED INSTRUCTIONS. NO CONTAMINATION ABOVE RELEASE CRITERIA FOR THIS FACILITY WAS DETECTED.

SIGNATURE	BADGE NO	DATE	TIME	SIGNATURE	BADGE NO	DATE	TIME

Figure 7-1

7.2. AIRBORNE RADIOACTIVITY CONTROL

Rooms or areas where the average concentration of airborne radioactivity exceeds 25% of the maximum permissible concentration during the time the area is occupied shall be posted with signs saying "Caution Airborne Radioactivity Area" and having a magenta radiation symbol on a yellow background. When applicable, stay times based on current air sampling data shall be posted at the portal to the area.

Boundaries may be established, using existing walls and ventilation systems or temporary tents or other enclosures, to prevent the uncontrolled release of airborne radioactivity to the general area.

Work in Airborne Radioactivity Areas must be controlled to prevent over-exposure to airborne radioactive materials and consequent internal radiation exposure from radioactivity within the body.

The control measures that must be taken are as follows:

- Control the source
- Control local ventilation
- Provide respiratory protection
- Sample airborne radioactivity

7.2.1. Source Control

Source control involves choosing techniques that minimize the generation of airborne radioactivity. For example, work wet rather than dry; work cold rather than hot; cut large chips rather than small. Use plastic bags and wrapping to prevent contamination from becoming airborne. Engineering controls for dust abatement and radon concentration reduction will be used whenever practical and benefical.

7.2.2. Local Ventilation Control

Local ventilation control can be used to remove radioactive materials as they are generated. A sweep velocity of at least 400 ft/min is required over the work area to control fines. This is a high velocity and it will require a large air mover with an absolute filter to accomplish this.

Adequate natural ventilation in work areas will prevent increased concentrations of airborne radioactivity.

7.2.3. Respiratory Protection

Respiratory protection may be provided to workers exposed to airborne radioactivity provided that an acceptable respiratory equipment program is instituted that meets the requirements of USNRC Regulatory Guide 8.15 and NUREG 0041 (see Appendix C). Respiratory equipment should not be used as a substitute for control of the sources. Respiratory equipment shall be selected, used and maintained as reported in Section 8. and Appendix C.

7.2.4. Sampling Airborne Radioactivity

Sampling of airborne radioactivity is required when an individual is present in an airborne concentration that may exceed 25% of the maximum permissible concentration. Sampling of airborne radioactivity is explained in Section 12.

8. PROTECTIVE CLOTHING AND EQUIPMENT

8.1. PROTECTIVE CLOTHING

The purpose of protective clothing is to provide a barrier between the contamination on surfaces and the people who must work in the contaminated area. Clothing that is unfit for use either because of design or damage should not be used. The degree of protection required will be evaluated and will be specified on the SWP by Health Physics.

8.2. GENERAL REQUIREMENTS FOR PROTECTIVE CLOTHING

Nondisposable protective clothing is laundered to remove loose contamination. Some fixed contamination may be present on the clothing, however. Therefore, all protective clothing is considered contaminated. Such clothing is not worn in lunch rooms, offices or in any other uncontrolled area. Required safety equipment must be worn with protective clothing.

Protective clothing requirements will depend on areas of work, and the type of work to be accomplished.

For inspection type work outside of clean area, the requirements are hard hats, gloves and shoe covers. Lab coats may also be worn when the possibility of contamination is low.

Work which involves a greater possibility for contamination will require additional protective clothing. Written procedures or an SWP will state the clothing requirements. These in general will include: coveralls, hard hats, gloves and shoe covers.

Where the potential for contamination is high the SWP may also require plastic booties, plastic gloves and taping of cuffs and sleeves.

After use protective clothing is considered to have removable contamination on it and is handled carefully to prevent the spread of radioactivity.

8.3. GUIDELINES FOR SELECTION OF PROTECTIVE CLOTHING AND RESPIRATORY EQUIPMENT

The following criteria apply to the selection of protective clothing and respiratory equipment. The SWP will state all clothing requirements.

a. Shoe Covers. Different types of shoe covers are available depending on the type of work to be performed. Rubber boots or plastic booties with canvas shoe covers may be used when contamination is likely. Canvas shoe covers alone or with plastic booties under them may be worn for work.

b. Gloves. Cotton work gloves may be worn for dry work. For wet work plastic or rubber gloves are worn. Glove liners are used under plastic or rubber gloves. They do not provide protection from contamination.

c. Protective Clothing. Protective clothing is required where contamination is high or when the type of work to be accomplished presents a potential for contamination. Lab coats may be worn for inspection type work. Cloth or disposable coveralls are worn for other types of work. Wet work or work involving acids, caustics or other chemicals will require additional protective clothing features.

d. Head Covers. Hard hats are required throughout the site except in office areas.

e. Respiratory Protection. Depending upon air sampling and respiratory equipment protection factors, respiratory protective equipment will be selected as outlined in USNRC Regulatory Guide 8.15 and NUREG-0041. (Appendix C).

8.4. REMOVAL OF PROTECTIVE CLOTHING

The correct sequence is important for removal of protective clothing. The outer surfaces of protective clothing may be contaminated. If these surfaces touch skin, contamination will result. The rule is touch only contaminated to contaminated and clean to clean.

8.4. REMOVAL OF PROTECTIVE CLOTHING

The general sequence for protective clothing is as follows:

a. Remove coveralls and hard hats. These remain outside the change room.

b. Remove shoe covers and step over the control line as each one is removed. If issued safety shoes are worn, these remain in the controlled area at the end of the shift.

c. Remove gloves.

d. Frisk exposed body surfaces and clothing for contamination. Frisk dosimeters for contamination. If additional clothing is worn such as two pairs of coveralls, booties or glooves, in general remove the most contaminated items first.

8.5. AVAILABILITY OF PROTECTIVE CLOTHING

Protective clothing will be picked up from the location specified by the Site Health Physicist. If additional protective clothing supplies are needed, contact Health Physics personnel.

Coveralls may be obtained from any local vendor. Coveralls and other protective clothing should be of the same color and style so they may be readily identified.

Laundry of protective clothing is done on site. Wash water must be sampled before release to the sanitary sewerage system. Disposable protective clothing may be used and disposed of when no longer serviceable.

Experience has shown that very little contamination remains on freshly laundered clothing. Consequently, a "spot check" survey program is used to assure that protective clothing is clean. Freshly laundered clothing exhibits no removable (smearable) contamination. Freshly laundered clothing with contamination greater than 1000 dpm/100cm^2 will be disposed of as waste.

8.6. RESPIRATORY PROTECTION

8.6.1. References

A respiratory program for protection from airborne radioactive materials will be established as required. Guidelines for this program are contained in USNRC Regulatory Guide 8.15 and NUREG-0041. These references are reproduced as Appendix C.

8.6.2. Personnel Requirements

Before using respiratory equipment, personnel must be trained, fit tested, and medically cleared for its use. These requirements are given in Sections 3. and 19. of this manual.

8.6.3. Policy Statement

Management of Kerr-McGee and the Health Physics staff remain dedicated to ALARA. All methods available will be used to keep worker exposure to airborne radioactive materials as low as reasonably achievable. Engineering controls for dust and radon emission abatement will be used whenever practical and beneficial throughout the decommissioning of the West Chicago Facility.

Routine use of respiratory protection will be determined by results of air sampling. Routine use of respiratory protection is not anticipated due to the low levels of contamination and low specific activity of the materials. Personnel protection from dusts may be necessary for workers during actual demolition and waste site stablization work when dust hazards may be present.

Nonroutine respiratory protection may be necessary in unusual work conditions. These may include: work in enclosed dusty areas, work in areas of unusually high loose surface contamination, opening tanks, pipes or other enclosed systems which may contain radioactive residues.

8.6.3. Policy Statement (Cont'd)

Respiratory protection of different types will be available and operable for emergency use. Emergency conditions requiring respiratory protection may include: fire involving radioactive materials, accidental spillage of contaminated materials from tanks, pipes and other containers, unexpected high winds in high dust areas.

Workers required to wear respiratory protection will be given adequate rest to prevent fatigue. Workers may be rotated to limit the total time any person wears respiratory protection. Physical and psychological conditions of workers should be considered in assignments requiring respiratory protection.

8.6.4. Selection of Respiratory Equipment

Respiratory protection to fit the degree of hazard present will be available. Devices ranging from type H cartridge half face or full face respirators to supplied air equipment may be used as necessary. The device required for each job will depend on the protection factor of the device and the airborne contamination levels as determined by air sampling.

8.6.5. Issuance

When work is to be done in an area of airborne radioactivity an SWP is required. The SWP shall indicate the type of respiratory protective equipment required. Workers will be informed of the method for obtaining the appropriate equipment. Positive control of respiratory equipment will be maintained through issuance records and procedures. See Figure 8-1. Respiratory equipment for use shall not be stored in an area of airborne radioactivity or in a contaminated area.

8.6.6. Use of Respiratory Equipment

Respirators are only effective when used as designed. It is important that workers check the equipment for proper functioning before entering airborne radioactivity area. Defective equipment must not be used and should be reported to Health Physics. Use of protective equipment will be as specified in worker training. Unauthorized use of respiratory protective equipment is not tolerated.

KERR-McGEE CHEMICAL CORPORATION

WEST CHICAGO FACILITY

KM-4796

RESPIRATOR ISSUANCE RECORD

Issue of Respirator

DATE ____________ TIME ____________

NAME ____________

ID NO. ____________

SWP NO. ____________

TYPE OF RESPIRATOR ____________

RESPIRATOR NUMBER ____________

____
SIGNATURE

- -

Return of Respirator

DATE ____________ TIME ____________

NO. OF HOURS RESPIRATOR USED ____________

☐ RESPIRATOR FUNCTIONING PROPERLY

☐ RESPIRATOR DAMAGED OR NOT FUNCTIONING

____
SIGNATURE

Figure 8-1

8.6.7. Return of Equipment

Respiratory equipment must be returned promptly to the designated place to avoid loss or destruction of equipment. Return of equipment is indicated on respiratory protection issuance record.

8.6.8. Maintenance of Respiratory Equipment

All non disposable respiratory protective equipment must be maintained clean, non-contaminated and in good working order. All respiratory protective equipment must be inspected thoroughly before being made available for reissue. After cleaning, a filter paper disc smear is taken on the inside of the facepiece on about 10% of the respirators. Detectable contamination on the smear requires recleaning and a 100% smear inspection of the batch of respirators being cleaned.

8.6.9 Records of Respiratory Program

Records generated in the implementation and operations of the respiratory program shall be retained until disposition is authorized by NRC regulation or otherwise. Records will include:

- Procurement documentation,
- Maintenance and use records,
- Training and fitting program records,
- Documentation of adequacy of the respiratory program (including bioassay if necessary).

9. TOOL AND EQUIPMENT CONTROL

9.1. GENERAL REQUIREMENTS

Only those tools actually required for work shall be taken into a Contamination Control Area. Equipment carried into the contamination control area may become contaminated and will, at the very least, require monitoring for contamination before it can be removed. If it becomes contaminated it must be either decontaminated or disposed of as contaminated waste.

Packing containers or other disposable outer containers should not be taken into contaminated areas.

Personal tools are taken into a contaminated area at the owner's risk.

Complex equipment and hoses or leads should be protected from contamination by wrapping with plastic or putting into plastic sleeves before they are taken into the contaminated area.

Once tools are taken into a contaminated area, they must be left in the area until the work which requires those tools is completed. However, contaminated tools may be transferred through a clean area to another contaminated area if they are bagged to control contamination and if Health Physics personnel approve the transfer.

9.2. MARKING TOOLS AND EQUIPMENT

All tools and equipment that are to be used in a contaminated area are considered to be contaminated until they are monitored by Health Physics personnel and found to be clean. Tools and equipment in contaminated areas should be marked by spraying the tool or equipment with yellow paint if desirable. A Radioactive Materials Label may be used instead of paint. When tools are finally released as clean, the yellow paint (if any) must be covered by green spray paint.

9.3. CONTAMINATION CONTROL AND DECONTAMINATION

Tools and equipment which will be released from the controlled areas should be kept as clean as possible. If contaminated tools or equipment need to be released from the controlled area they may be decontaminated and then monitored again.

Small tools may be cleaned by wiping with a damp paper towel. Dow Bathroom Cleaner (R) is an effective cleaner. Greasy tools can be cleaned using aerosol type degreasers. Gumout (R) is effective. Gumout is volatile and may present a fire hazard.

Perform the cleaning steps as dry as possible. Avoid carrying the contamination into cracks or crevices in the equipment where it is difficult to remove. Complex equipment with inaccessible inside surfaces should be monitored by Health Physics before decontamination is begun.

9.4. REMOVING EQUIPMENT FROM CONTAMINATED AREAS

Tools and equipment that are to be removed from the controlled area must be monitored by Health Physics. A meter survey and a smear survey, if necessary, will be performed and documented on a Radiation Survey Form.

Tools with yellow markings shall have the yellow marking removed or covered with green spray paint following clearance and before the tool is released from the controlled area.

Equipment that has been marked with Radioactive Materials Labels will, following survey and clearance, have the Radioactive Materials Labels removed and clean stickers placed on them until they leave the controlled area. The clean sticker is to be removed following the transfer to the uncontrolled area. (See Section 10.).

10. SIGNS, LABELS, SIGNALS AND BARRIERS

Proper utilization of warning signs and labels is necessary to warn people of the hazards of radioactivity. Placement of certain signs and signals is required by federal regulations (10CFR20). It is important that all workers recognize and understand all radiation warning signs and labels. All workers must respect radiation barriers and must understand procedures for crossing barriers.

10.1. GENERAL REQUIREMENTS FOR MARKING CONTROLLED AREAS

Radioactive materials, Radiation Areas, High Radiation Areas, Airborne Radioactivity Areas, shipping containers, and vehicles must be marked according to the various regulations. It is the responsibility of Health Physics to make radiation measurements as necessary and to provide accurate marking and labeling. All postings must be kept current.

Standard magenta and yellow warning signs are used. Where necessary, the correct and complete wording shall be provided. For example, a magenta and yellow sign stating "Shoe Covers Required" for use in a contaminated area would be insufficient if not accompanied with a standard Radioactive Materials Sign.

In addition to the appropriate signs, all radiation control areas, including Radiation Areas, Contamination Control Areas and Airborne Radioactivity Areas, shall be established by permanent or removable barriers.

Walls, fences, tape or rope barriers shall be used to define the boundaries of the controlled area.

10.2. RADIOACTIVE MATERIALS SIGNS AND LABELS

Devices, equipment or rooms containing radioactive materials must be marked with a standard Radioactive Materials sign or label. This marking must appear if there is more than the following quantities of the specified materials:

10.2. RADIOACTIVE MATERIALS SIGNS AND LABELS

10 mCi natural uranium or
10 mCi natural thorium or
0.1 μCi Ra-226 or Ra-228

Radioactive materials signs must appear if there is more than 10 times the exempt quantity of other nuclides as listed in Appendix C, 10CFR20.

10.3. RADIATION AREA SIGNS

Locations where the Whole Body radiation level is greater than 5 mrem/hr or where a person could receive more than 100 mrem in five consecutive days are Radiation Areas. All Radiation Areas shall be clearly posted with a standard sign with the radiation symbol, the words "Caution Radiation Area", and the dose rate, time and date of measurement.

Radiation Areas signs should not be used indiscriminately. Locations that are clearly not radiation areas, even though low levels of radiation exist, should not be posted.

10.4. HIGH RADIATION AREA SIGNS (RESERVED)

10.5. AIRBORNE RADIOACTIVITY AREA SIGNS

An Airborne Radioactivity Area is an area in which the average concentration of airborne radioactivity exceeds 25% of the applicable Maximum Permissible Concentration (MPC) in air for occupational exposure.

All Airborne Radioactivity Areas shall be clearly posted with a standard sign with the radiation symbol and the words "Caution Airborne Radioactivity Area". In addition if the concentration exceeds the applicable MPC the words "Respiratory Protection Required" shall be added to the sign in large legible letters.

10.6. CONTAMINATION CONTROL AREA BARRIERS

Contamination Control Areas are areas that may be contaminated with radioactive materials and where access is limited for the purpose of controlling the spread of contamination. The boundaries are determined by Health Physics personnel based on survey reports, work to be accomplished and other access factors.

Each Contamination Control Area shall be clearly marked with standard Radioactive Materials signs. The boundaries of the area shall either be walls or fences or shall be marked on the floor with tape or established by tape or rope barricades.

Portals shall be established for access to Contamination Control Areas. The access point shall consist of a step-off-pad and a sign stating the protective clothing requirements within the area.

The sign shall state the general level of contamination in the area and the date and time of the measurement.

10.7. LABELING TOOLS AND EQUIPMENT

Tools and equipment used in contaminated areas are considered to be contaminated. All tools and equipment used in a contaminated area must be monitored by Health Physics personnel before they are taken out of the controlled area. Small tools and equipment used in contaminated areas, which could be easily removed from the contaminated areas, should be painted with yellow primer spray paint. The paint is used to indicate that this tool or equipment may be contaminated. When Health Physics personnel clears the tool, it may be removed from the contaminated area. However, any remaining yellow paint must be removed or covered by green spray primer to indicate that the tool is cleared.

Large tools or equipment or items that are contaminated should be marked with a radioactive materials tag or label. Once the equipment is monitored and released by Health Physics personnel, the radioactive materials label or tag is removed and replaced with a clean sticker.

10.8. MARKING CLEAN AND CONTAMINATED MATERIALS

10.8.1. Clean Label

Stickers or tags will be used by Health Physics to identify tools and equipment which have been surveyed and are found to be free of contamination and radiation. Items which are surveyed and are clean are labelled with one of the tags described below.

A Cleared for Release Tag, Figure 10-1a, is used when an item is cleared by Health Physics for release from the West Chicago Facility. Cleared for Release Tags are removed from the item when it leaves the facility and are then returned to Health Physics. A Clean Tag, Figure 10-1b, is used when an item is cleared by Health Physics for release across a control line but not release from the facility. Documented surveys are maintained supporting the use of all Clean and Cleared for Release Tags.

10.8.2. Clean Tape or Paint

Much of the material and rubble will be uncontaminated. Surveyed materials that are not contaminated and that are to be disposed of may be marked with colored tape or paint, instead of clean stickers. Green tape or paint is suggested. The specific type or paint and color shall be designated by the Health Physics Supervisor in written instruction to the work crew.

When materials are marked as clean, survey data shall be available to document survey results which show that release criteria are met.

10.8.3. Contaminated Tape or Paint

Contaminated rubble is marked with yellow paint. Other materials found to be contaminated are marked with yellow tape or paint. The specific tape or paint and color shall be designated by the Health Physics Supervisor in a written instruction to the work crew. Material that must be removed to a low radiation area to be monitored is marked with blue paint. This may occur where background levels exceed the necessary detection limit for the meter. After the item is removed from the high background area it is re-surveyed and marked accordingly. This same technique may be used for equipment that must be opened for monitoring internal surfaces.

10.9. SHIPPING LABELS

Containers prepared for the shipment of radioactive materials must be labeled in accordance with DOT regulations. The labels to be used are described below.

10.9.1. Radioactive LSA Label

The outside of each package of low specific activity radioactive materials shall be stenciled or marked "RADIOACTIVE - LSA" on two opposite sides. In addition, the vehicle must be marked with a "RADIOACTIVE" placard on both sides and on the front and on the rear of the vehicle (see 49CFR173.392 and 177.823). The "RADIOACTIVE" placard is shown in Figure 10-2.

10.9.2. Radioactive White I Label

Each package of radioactive materials which exceeds the quantities for exempt material but whose surface dose rate does not exceed 0.5 mrem/hr shall be labeled with Radioactive White I Labels as shown in Figure 10-3. Each package must be labeled with labels on two opposite sides of the package.

10.9.3. Radioactive Yellow II Labels

Each package of radioactive material exceeding 0.5 mrem/hr but not exceeding 50 mrem/hr on the surface and also not exceeding 1.0 mrem/hr at 3 feet from the surface shall be labeled with two Radioactive Yellow II Labels as shown in Figure 10-4. Two labels must be placed on opposite sides of the package.

10.9.4. Radioactive Yellow III Label

Each package of radioactive materials exceeding 50 mrem/hr on the surface or 1.0 mrem/hr at three feet from the surface must bear the Yellow III Label, Figure 10-5. Two labels must be affixed to opposite sides of the package. In addition, shipments containing Radioactive Yellow III packages must also be placarded with "RADIOACTIVE" placards on both sides and on the front and rear of the vehicle.

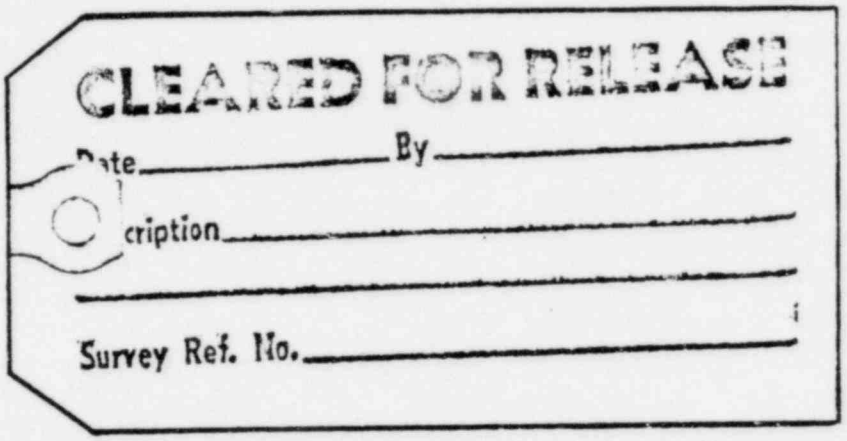


Figure 10-1a. Cleared for Release Tag

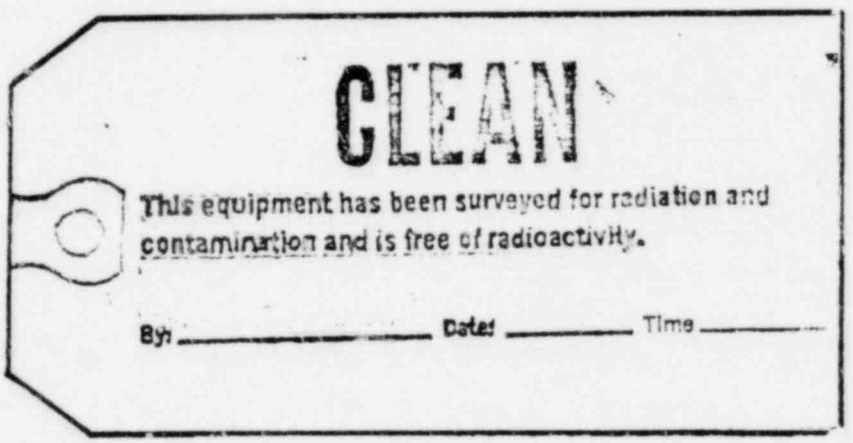
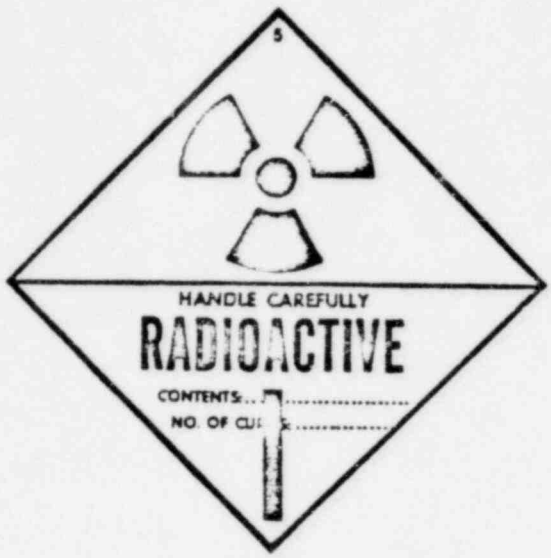


Figure 10-1b. Clean Tag

Figure 10-2. Radioactive Placard



1. Radioactive White-I Label

FIGURE 10-3

2. Radioactive Yellow-II Label

FIGURE 10-4

3. Radioactive Yellow-III Label

FIGURE 10-5

4. Empty Container Label

FIGURE 10-6

10.9.5. Empty Label

Previously used packages or accessories for radioactive materials and which contain residual radioactive contamination are identified by an "empty" label. An empty label as shown in Figure 10-6 must be affixed to the package. All other labels must be obliterated or removed or completely covered. Previously used packages must be monitored for internal and external radioactivity. External surface radiation must not exceed 0.5 mrem/hr.

Internal radioactivity is allowed up to ten times the exempt quantities in Appendix C, 10 CFR 20 or up to 100 times this amount in the cases of natural uranium or thorium.

External removable contamination is allowed up to the following limits:

Contaminant	Limit, dpm/100 cm^2	dpm/swipe*
Natural or depleted uranium and natural thorium:		
Beta-gamma	220,000	22,000
Alpha	22,000	2,200
All other beta-gamma emitting radionuclides	22,000	2,200
All other alpha emitting radionuclides.	2,200	220

*This amount is the limit per swipe (100 cm^2). It assumes a 10% collection efficiency.

10.10. SEALS

Except for LSA (low specific activity) materials in exclusive use shipments, the outside of each package must incorporate a seal, which is not readily breakable and which is evidence that the package has not been opened. Metal packages must be sealed with a tamper proof paint or a polyethylene car seal.

10.11. AVAILABILITY OF SIGNS, LABELS, ETC.

Signs and other special markings will be provided by Health Physics.
Signs and placards may be ordered from local vendors.

11. INSTRUMENTS FOR RADIATION MONITORING

Man cannot sense the presence of radiation, he must use instrumentation for this purpose. The design of each type of instrument depends on the properties of the radiation that it must detect. This section provides background information on the choice and use of instruments. Data about specific instruments are included in Appendix D of this manual.

11.1. SELECTION OF INSTRUMENTS

A variety of factors influence the choice of instruments for particular applications. They must be able to detect the radiation. They should provide the information in the desired way. They may be required to withstand severe environmental conditions. This section describes the various radiation measurement instrument types.

11.1.1. Geiger Counters

These instruments use G-M detectors to detect and measure radiation. They are generally pulse counters. Calibration is empirical, the meter response is set to correspond to a known radiation field. Geiger counters are used principally as detectors of beta and gamma radiation. They should not be used to measure beta radiation dose. Their response is not linear with dose for a mixture of nuclides. G-M instruments are used to measure very low to moderate count rates.

Examples of geiger counters useful for contamination detection are the Eberline PRM-6/HP-230 and PRM-6/HP-210. Both are described in Appendix D.

11.1.2. Ion Chamber Instruments

Instruments of this kind detect the small current generated in an ion chamber when radiation passes through the chamber. This kind of instrument has been designed to measure the dose (exposure) produced by radiation in a given time.

11.1.2. Ion Chamber Instruments (Cont'd)

Because the currents generated at low dose rates are very small, the commonly used ion chamber instruments have limited sensitivity to low levels of radiation. These instruments must be used for the measurement of beta dose rates and are preferred for the measurement of gamma dose rates. Although they may respond to alpha radiation, they do not indicate alpha dose rate. Ion chambers are used for measuring radiation especially when mixed beta and gamma radiation fields are present.

Ion chambers are sensitive devices and should be handled with care to prevent damage and to ensure that they remain operable. They are particularly sensitive to moisture or humidity and should be kept dry at all times.

Typical ion chamber instruments are the Eberline RO-2 and the Victoreen 470A. Descriptions of these instruments are found in Appendix D.

11.1.3. Proportional Counters

Proportional detectors use gas amplification in the proportional region of the detector operating curve to generate detectable pulses and to discriminate between radiations with differing specific ionization. Proportional counters are frequently used for alpha and beta counting.

Special counting gases are used and rather high voltages are required for proportional counters. Stable linear amplifiers with high sensitivity are necessary if discrimination is to be used.

The PAC-4G uses pure propane as the counting gas and is a stable and sensitive alpha survey meter. With the beta probe and with the -3 model it may be used as a beta-gamma survey meter as well as an alpha detector. The AC-21 probe has a thin window to permit alpha radiation to be detected. In the beta model this window permits the detection of low energy beta radiation (but not as low as tritium) and low energy X or gamma rays. This instrument is described in Appendix D.

11.1.4. Scintillation Counters

Scintillation counters use light emitted by some crystalline materials or organic molecules to detect various kinds of radiation. Zinc sulfide (silver activated), or ZnS(Ag), is commonly used for detecting alpha radiation. Various organic phosphors are used for beta or neutron detection and sodium iodide activated with thallium, or NaI(Tl), is the most common gamma scintillator. Scintillators are frequently used to permit particle or energy discrimination.

Scintillators use photomultiplier tubes to amplify the light pulses. PM tubes are sensitive to mechanical shock, temperature, and magnetic fields. They may be permanently damaged if the photocathode is exposed to light while high voltage is applied. Alpha scintillator survey meters are simple, sturdy instruments. Most other types, however, require care in the interpretation of the reading and understanding of detection principles and discriminator settings for proper evaluation of the readings.

The PAC-4S is a scintillation alpha counter with a thin window over a ZnS(Ag) phosphor. The probe may be used on some other count rate instruments. It is common practice to calibrate these instruments to read the 2π count rate from a thin plated alpha source so that direct measurements may be easily estimated. When this is done the apparent count rate heard in the speaker will be well below the indicated meter reading.

The Micro "R" Meter, PRM-7, has a 1" x 1" sodium iodide, NaI(Tl), detector. It is a small, light weight, rugged instrument of high sensitivity to gamma rays. It is quite energy dependent, requiring careful set up and calibration for proper use.

Larger NaI(Tl) detectors are used in spectrometry systems to define the energies of gamma rays. These systems, employing extensive shielding, elaborate counting equipment and sophisticated data collection and reduction, are used to identify and measure radionuclides.

11.1.4. Scintillation Counters (Cont'd)

Detailed descriptions of the PAC-4S and PRM-7 are included in Appendix D.

11.1.5. Other Instruments

There are, in addition to the types previously described, a variety of instruments employing other detection schemes to provide special measurement properties. Examples are solid state detectors for alpha and gamma spectroscopy, and moderating detectors for neutrons.

11.2. INSTRUMENT CONTROL RECORDS

Records showing the current operating status of all radiation monitoring instruments shall be maintained by Health Physics.

11.2.1. Repair and Calibration Record

The Repair and Calibration Record for Air Samplers and Instruments, Figure 11-1, is used to identify and record the status of all health physics instrumentation employed on the site. This form is initiated by the Health Physics Supervisor when an instrument is received at the site and is maintained in an up-to-date manner during its useful life. This Record will be retained for five years after the completion of the project.

a. Instrument Type includes the name of the instrument and the model number, including any probes used with the instrument.
b. Instrument Number is the serial number of the instrument body and, if applicable, the serial number of the detector.
c. All work performed is described in detail. Any remarks are also listed.
d. The date and person's initials are recorded for each calibration or repair.

REPAIR AND CALIBRATION RECORD-
AIR SAMPLERS AND INSTRUMENTS - WEST CHICAGO FACILITY

INSTRUMENT TYPE _____ INSTRUMENT NUMBER _____

DATE	WORK PERFORMED	INITIALS

Figure 11-1

11.2.2. Counter Background and Standard Source Log

The Counter Background and Standard Source Record, Figure 11-2 is used to maintain daily records of the background and efficiency of the beta and alpha counters used for counting smears and air samples. The form is self-explanatory and the equations are given in the right hand column.

The background count rate in cpm is calculated and then tested against the previous background. The difference between the current background count rate and the previous background count rate must be less than the sum of the 95% confidence intervals ($2s_b$) of the respective rates.

The standard factor has units of dpm/cpm and is the multiplier for the sample count rate to determine dpm on the sample.

The test of the standard factor specifies that consecutive standard factors must agree within 3% of each other. If the counter fails either test, the background standard factor must be re-run and the Health Physics supervisor notified.

11.3. CALIBRATION OF INSTRUMENTS

All instruments used for measuring radiation dose rates shall be calibrated at least semiannually or when maintenance is required that could affect the calibration.

All survey instruments used for decommissioned facility surveys shall be calibrated semiannually or when maintenance is required that could affect the calibration.

Counters used for smears or air samples shall be checked before use or daily, using a calibrated reference source.

Vendors calibration procedures shall be in accordance with ANSI N323-1978 and calibration shall be traceable to NBS.

KERR-McGEE CHEMICAL CORPORATION
WEST CHICAGO FACILITY

KM-4795

COUNTER BACKGROUND AND STANDARD SOURCE RECORD

Instrument ________ Standard dpm ________ (J) Nuclide ________

		BACKGROUND				STANDARD SOURCE					
Date	Time	Min. (A)	Gross Counts (B)	Background CPM (C)	$2\sigma_b$ (D)	Min. (E)	Gross Counts (F)	Standard Factor (G)	$\frac{G_i}{G_{i-1}}$	Initialed By	Equations and Tests
											$C = B/A$ $D = \frac{2\sqrt{B}}{A}$ $G = \frac{J}{(F/E) - C}$ TESTS: Background: $\lvert C_i - C_{i-1} \rvert \leq D_i + D_{i-1}$ Standard Factors: $0.97 \leq \frac{G_i}{G_{i-1}} \leq 1.03$ If either test fails, rerun background or Standard Source and Notify Supervisor

Figure 11-2

12. SURVEYS FOR RADIATION AND RADIOACTIVE MATERIALS

12.1. GENERAL REQUIREMENTS

Radiation surveys are required by 10CFR20.201 which states that

> "Each licensee shall make or cause to be made such surveys as may be necessary for him to comply with the regulations in this Part".

"Survey" is defined as "an evaluation of the radiation hazards incident to the production, use, release, disposal or presence of radioactive materials or other sources of radiation under a specific set of conditions." Specific instructions for performing certain surveys are included in the Control Work Packages for performing the work.

All surveys as required above shall be performed and documented by Health Physics personnel.

12.2. RADIATION SURVEY PROCEDURES

Radiation surveys shall be performed whenever work is done in an area where ionizing radiation may be present at levels greater than 2 millirem in one hour.

Radiation surveys shall be performed at the time a controlled area is established for the performance of work and before work commences. Additional surveys shall be performed as necessary to retain control of the operation. A final radiation survey shall be performed at the completion of the work before release of the area from control.

Radiation surveys used for controlling exposure to radiation shall only be performed with a suitable survey meter that is properly calibrated and in good electronic and mechanical condition.

12.2.1. Monitoring Gamma Radiation

Gamma radiation is monitored with either ion chamber, GM, or proportional ion chamber instruments. When gamma radiation is the only type of radiation present, the instrument response will be the same with the window closed as it is with the window open.

Gamma radiation measurements will ordinarily be "field" measurements made when the radiation intensity is uniform throughout the chamber. There will be no appreciable difference in readings as the instrument is rotated about the center of the chamber so long as this point is held the same distance from the source.

The "field" reading may be read directly on the instrument meter multiplied by the appropriate range setting of the range selector switch.

There are three typical conditions where the "field" conditions do not normally apply. They are beam readings, surface readings, and measurement of sources smaller than the chamber dimensions.

Where a beam of radiation smaller than the chamber dimension is to be measured, the reading must be multiplied by the ratio of the total chamber volume to the irradiated chamber volume.

Contact measurements of sources larger than the chamber do not ordinarily represent the dose rate at contact but rather, are measurements at approximately the center of the detector. This distance should be noted and recorded as measured distance to the source.

Measurement of sources smaller than the detector should be done very carefully since it is easy to have non-uniform radiation intensities within the chamber volume. Small sources should be measured from a distance of 3 detector diameters or more to achieve a "field" radiation reading. The intensity at a closer point (up to 0.1 inch) is then estimated using the inverse square law.

12.2.2. Monitoring Beta Radiation

Beta radiation may only be measured using ion chamber instruments such as the 470A and RO-2. Geiger counters and the PAC-4G-3/AC-21B may not be used as beta dose measuring devices.

12.2.2. Monitoring Beta Radiation (Cont'd)

Beta radiation measurements in mrad/hr may be made if correction is made to the reading for the geometry of the source. The measurement must be made with the beta window open (window thickness 7 mg/cm^2) and, if the source is larger than the detector window, the geometry factors for beta radiation are as follows:

Distance From Source	Correction Factor
0 - 10 cm	1 x BCF or 4
10 cm - 1 m	0.5 x BCF or 2
> 1 m	0.375 x BCF or 1.5

where BCF = Beta Correction Factor for surface calibration with an infinite uranium slab.

Care must be used in the proper choice of correction factors. The BCF is used to estimate surface dose rates. For field readings away from the surface the stated fraction of the BCF quoted above helps correct for side wall absorption in the ion chamber.

For beta sources smaller than the detector (or the same diameter), readings should be made at 10 cm (4"), source to window distance, and the beta correction factor is then taken to be 1.0. Beta measurements of small sources should not be made at distances less than or much greater than 10 cm due to the effect of air absorption of the beta particles and non-uniformity of the ionization within the chamber.

12.2.3. Monitoring Mixed Beta and Gamma Radiation

Monitoring mixed radiation fields where both beta and gamma radiation are present is done as indicated above in paragraph 12.2.1 and 12.2.2. Gamma radiation is measured using the detector with the window closed. Beta radiation is determined by taking the difference in the window-open and window-closed measurements. The appropriate beta calibration factor must be used to convert the beta dose rate to mrad/hr. Results are reported as:

X mrad/hr (beta) plus Y mr/hr (gamma) at Z inches (or cm)

12.2.4. Monitoring Alpha Radiation

Surfaces in most areas of the West Chicago Facility are potentially contaminated with alpha emitters, principally uranium and thorium. Daughter radiations from the extensive alpha emitting decay chains of both uranium and thorium will also be present. See Appendix E for a chart of these decay chains.

Alpha activity may be measured directly on dry, clean, flat surfaces using flat plate proportional or scintillation detectors. The PAC-4G-3/AC-21B is a propane gas flow proportional counter that may also be used for beta surveys. The PAC-4S/AC-3-7, a scintillation counter that is rugged and reliable, can be used under adverse weather conditions. These or similar instruments are suitable for fixed alpha monitoring. All of these instruments are calibrated to read alpha counts per minute on the meter with an effective source to detector geometry of 2π (50%). The actual count rate as seen by the detector is less than this. Typical true efficiencies for these instruments vary from 15 to 25% (that is, 30 to 50% of 2π geometry).

Fixed alpha surveys are possible only on relatively clean, dry surfaces. Water will effectively shield alpha particles from the detector, so surveys should be done on dry surfaces. Also surface dirt or dust can effectively shield alphas from the detector. When surfaces are extremely dirty or coated, a direct measurement will only represent the contamination on the surface material. Such direct measurements may not read contamination present on lower, covered surfaces. To survey these surfaces an appropriate technique is to remove the coating by rubbing with a paper towel or similar wiper and then measuring the activity found on both the wipe material and the surface.

To survey for fixed alpha activity, place the probe face as close as possible to the test surface without touching it (< 1 cm). Watch the meter carefully as the probe is passed slowly across the contaminated surface. If a speaker (SK-1) or earphones are available, use them to listen to the counts.

Resurvey any suspect areas by placing the probe directly over the suspected area and counting the clicks or by visually averaging the meter reading. Record the survey results on the survey sheet in counts per minute.

12.2.4. Monitoring Alpha Radiation (Cont'd)

Whenever surveying highly contaminated surfaces, care should be taken to observe the instrument background periodically, to determine if contamination is present on the probe.

NOTE: With the Eberline Lin-Log instruments such as the PAC-4G the meter readings are calibrated to read 100% of 2π (e.g., the reading is corrected for detection efficiency). When earphones are used, the instrument gives one click per detected event. When speakers (such as the SK-1) are used, the instrument gives one click for every two events detected. The following analysis will be seen to apply:

Assume 100 dpm/100 cm^2 surface contamination (area larger than the detector)
then 50% (2π) will be emitted towards the detector probe
and 50% of that will be detected by the probe.
The earphones will give one click per detected alpha.
The speaker will give one click per two detected alphas.
The meter reading will show an average rate of twice what the detector is detecting.

12.3. CONTAMINATION SURVEY PROCEDURES

Surveys must be performed in a contamination controlled area when the area is established and before any work is performed within the area. Additional surveys are performed as necessary to retain control of the operation. A final contamination survey is performed after cleanup and before the area is released from control

Appendix G of this manual titled "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproducts, Source or Special Nuclear Material" must be followed. These guidelines are copied from a document by the USNRC. The NRC, in Amendment Number 3 to License STA-583 (September 28, 1981), has made these guidelines a condition of the Kerr-McGee West Chicago Facility license.

12.3.1. Monitoring for Removable Surface Contamination

Removable surface contamination is routinely monitored by two related methods: the disc smear, and the paper towel smear. Paper towel smears are quick and are often used to monitor and control decontamination activities or to check for general area contamination for on-the-spot information. Disc smears on the other hand are counted after the fact and the data are less useful for prompt action requirements. Disc smears are used where "measurement" of the surface contamination is required, as for release of equipment from controlled areas.

12.3.1.1. Collection of Paper Towel Smears. Fold a paper towel into a pad about 4" wide by 5" long. Rub the pad over a one square foot (12" x 12") of the surface being tested. Use enough pressure to remove surface dirt but not so much as to damage or abrade the towel.

Carefully place the open window of the GM detector or alpha probe within 1/8 inch of the surface of the towel wipe. Note and record the instrument reading, the location and purpose of the wipe. If the background level is significant, subtract the background from the reading to determine the net count rate. Record the readings as cpm/ft^2.

If the above measurement is greater than about 10,000 cpm of beta activity, the paper towel should be surveyed with an ionization chamber instrument (window open) and the radioactivity on the smear should be reported in mrad/hr per ft^2.

12.3.1.2. Collection of Paper Disc Smears. Paper disc smears are used to measure surface contamination. Sisalkraft discs are used where chemical analysis of the contaminant will not be required and where damp or rough surfaces are to be tested.

In all other cases Whatman 1 filter papers may be used. However, these will disentegrate when wet. If wet strength is required, use Whatman 41 filter paper.

The paper disc is wiped over the surface to be surveyed. Use enough pressure to remove loose materials from the surface. A smear sample should cover a surface area of 100 cm^2 (about a 4 inch square).

12.3.1.2. Collection of Paper Disc Smears. (Cont'd)

Note: Experience at reactor facilities has indicated that paper towel smears and disc smears are roughly comparable techniques. That is, the reading of a paper towel smear read by a side wall GM tube such as the HP-270 in cpm per ft^2 and the reading of the disc smear in cpm/100 cm^2 are approximately the same for wipes taken under similar conditions.

Disc smears should be placed individually between the pages of a small pad of paper or in individual envelopes to prevent cross contamination between smears and to provide adequate identification of the smear samples, since there will be a delay between collection and analysis.

The smears should be counted using a suitably calibrated counter and analyzed using calibration techniques appropriate for the activities that may be present on the smear as described in Section 12.

12.3.1.3. Collection of Smears for Tritium (RESERVED)

12.3.2. Monitoring for Fixed Surface Contamination

Fixed surface contamination is surface radioactivity that is not readily removed by wiping the surface of the item in question. Fixed contamination is the difference in the direct meter reading, which includes removable and fixed contamination, and the removable contamination. Direct measurement of surface contamination is the instrument reading before smear surveys have been taken. To obtain the direct measurement hold the open window of an alpha or beta detector 1/8 inch from the surface to be monitored.

When removable activity is determined by a smear survey, this is subtracted from the direct reading to derive the fixed activity.

If fixed contamination is greater than about 10,000 cpm, the beta and gamma dose rates should be determined using an ion chamber instrument.

Parts and equipment that exhibit any detectable direct reading using this method may not be released for use in unrestricted areas without monitoring for removable contamination.

12.3.3. Monitoring Internal Surface Contamination

Parts and equipment that have been used in contamination controlled areas must be monitored before release from the controlled area. If the equipment can be contaminated internally it must be handled carefully to allow assessment of the potential internal contamination. (See Appendix G for guidance).

12.3.4. Monitoring Equipment or Vessels to Determine Contained Activity

Often estimates of the quantity of radioactivity contained in a vessel or a piece of equipment must be made. This is particularly important for shipments of radioactive materials.

All estimates of contained activity must be based on samples collected from the contaminated materials in the packages.

12.4. RECORD KEEPING FOR SURVEYS

All survey data are recorded on a Radiological Survey Data Sheet as shown in Figure 12-1.

The item description section is used to identify without ambiguity the area, equipment, vehicle or materials which are being surveyed. In addition to the description, a sketch of the area for survey is made on the reverse side of the sheet. Poloroid photos may also be attached for descriptive purposes.

The survey reference number is used to identify each survey specifically and incorporates the date of the survey and the code number for the item or area to be surveyed. The survey number is assigned sequentially.

RADIOLOGICAL SURVEY DATA SHEET — WEST CHICAGO FACILITY KM-4739

ITEM DESCRIPTION (Sketch item on reverse side)

00 ☐ Vehicle

98 ☐ Equipment

☐ Building
Bldg. No.

99 ☐ Other

SURVEY DATE | Reference No. | YR MO DAY ITEM NO. | PERFORMED BY

BETA-GAMMA INSTRUMENT | SERIAL NO.

ALPHA INSTRUMENT | SERIAL NO.

LOCATION OF READING	SMEAR NO.	ALPHA ACTIVITY (dpm/100 cm²)			BETA-GAMMA DIRECT
		DIRECT	REMOVABLE	FIXED	

REMARKS

REVIEWED BY | DATE

FIGURE 12-1

SURVEY DATE		SURVEY REFERENCE NO			
LOCATION OF READING	SMEAR NO.	ALPHA ACTIVITY (dpm/100 cm²)			BETA-GAMMA DIRECT
		DIRECT	REMOVABLE	FIXED	

SKETCH OF ITEM

FIGURE 12-1 (reverse side)

12.4. RECORD KEEPING FOR SURVEYS (Cont'd)

The surveyors' names are recorded in the space provided.

The survey instrument used for measurement of radiation is entered in the appropriate place and the serial number is also entered. If both alpha and beta-gamma instruments are used for a particular survey then information for both instruments is recorded.

Actual survey data are recorded in the body of the form. Beta-gamma measurements, as well as removable and fixed alpha activity, are taken and noted in the correct column. Smear numbers are shown on the sketch to clarify the location of each measurement. Direct alpha activity in cpm/100 cm^2 is read from the instrument and recorded along with the correction factor of the instrument, or the activity in dpm/100 cm^2 may be recorded directly. Removable activity is determined from counting the smear taken at the location, and fixed activity is the difference between the removable and direct activities. Direct beta-gamma is the reading taken directly from the instrument. Be sure that the correct units are entered for the direct beta-gamma measurement. Units will depend on the instrument used and may be in cpm or mrad/hr.

The remarks section is used for any other information which may be pertinent to the survey. The SWP number is entered here if the survey is being done to fulfill a requirement for an SWP. Other information may include: work area preparation, disposition of tools, equipment or waste (particularly if the survey is being used to fulfill release criteria), boundaries established, or any other unusual situation.

Surveys are reviewed by the Health Physics Supervisor and signed if satisfactory.

12.5. MONITORING AIRBORNE RADIOACTIVITY

12.5.1. Purpose of Monitoring Airborne Radioactivity

The purposes of air sampling are threefold:

a. To provide records of airborne radioactivity in work areas. These surveys provide radiological control information. They also may be used after the fact as legal documentation in radiation injury claims cases.

12.5.1. Purpose of Monitoring Airborne Radioactivity (Cont'd)

b. They call attention to poor work procedures, faulty processes or worsening conditions. Corrective changes can be made to reduce the impact of working in an airborne radioactivity area. Air sampling also proves the effectiveness of these changes.

c. Air sampling is used to measure releases of airborne radioactivity to the environment. These samples are used to ensure that people living in the vicinity of the facility are not exposed to radiation exceeding established limits.

During incidents, air samples are necessary to evaluate the consequences of the release.

In addition, an air sampling program should monitor the general level of airborne radioactivity in working areas. It should be possible, based on the air sample survey form, to evaluate individual exposures. Finally, it should be possible to rapidly detect high levels of airborne radioactivity during accidental releases.

12.5.2. Air Sampling Principles

Air samples must be representative of the volume of air that is being sampled.

12.5.2.1. Representative Samples of the Work Zone. Samples that are to represent the work zone of workers should be taken from one or more points in the breathing zone of the worker. They should sample for the duration of the work period. Keep in mind that the worker is the point source generator of an aerosol that diffuses out in all directions. The concentration is decreased as a function of the distance from the source. Also the worker's clothes generate a microclimate in his breathing zone. Warm air from his body rises along the surface of his clothing bringing airborne radioactivity right into his breathing zone.

The location of air samples should be as close to the breathing zone as practical without interfering with the work or the worker. Just as important, the sample should not be taken so close to the work that the data are meaningless.

12.5.2.1. Representative Samples of the Work Zone. (Cont'd)

Filter heads may be used on hoses and may be placed on the worker or just above and in front of him. Protect the filter from gravity settling of large particles. It is best to keep the filter paper in a vertical plane.

It is necessary to have enough air samplers to collect the samples needed.

12.5.2.2. Fractionation or Differentiation by Particle Size or Chemical Composition. Sometimes it is necessary to sample for particular components of airborne radioactivity. The physical and chemical characteristics of the radioactive materials are used to select the material of interest.

a. Particle Size. Particulate samples are generally collected undifferentiated. That is, we try to collect a sample that is representative of all the dust size fractions present. When very heavy particles are present this kind of sampling may overestimate the exposure hazard. Special samplers that collect various size fractions should be used in this case to identify the radioactivity on the respirable fraction of the material. However, sampling of the work area must be done without particles size separation unless it is specifically authorized in the license.

b. Radioiodines (RESERVED)

c. Radioactive Gases. The two isotopes of radon produced in the decay chains of uranium and thorium ores are radon (Rn-222) and thoron (Rn-220). Radon is a noble gas and is chemically inert. Radon is not efficiently collected or retained by simple mechanical filters. Radon concentrations in air are normally determined by collection of its particulate radioactive daughters which are present in air as a result of radon decay.

12.5.3. Sample Programming

12.5.3.1. Sensitivity of the Method. Sampling sensitivity is dependent on a combination of factors, the flow rate of the sampler, the fraction of the sample to be analyzed, the type of analysis and the ultimate sensitivity of the counting procedure.

Sample volume should be large enough so that the necessary accuracy and precision are obtained. However, sampling should not continue past the work interval. If greater sensitivity is indicated, the counting time for the sample may be increased.

12.5.3.2. Permissible Levels. Sampling should be performed so that one tenth of the MPC may be detected readily. For some nuclides, particularly the Group I nuclides including the radiums, the MPC's are very low and the sampling time, sample size, and counting time should all be coordinated to obtain suitable samples.

12.5.3.3. Radioactive Decay. Radioactive materials by virtue of their nature decay during collection, following collection, and during counting. The half-lives of the various nuclides may dictate sampling intervals, decay periods to be used and counting procedures. The decay corrections must be used unless the time for sampling, decay and counting are very short compared to the half-life.

An elaboration of the general air sampling equation is found in Section 12.5.6. Interference by natural radioactive emitters is discussed in the next section.

12.5.3.4. Activity of Long Lived Alpha Emitters in the Presence of Natural Background. For counting samples containing long lived alpha activity the following set of equations may be used.

The sample is counted four (or more) hours after the end of sampling. This sample, A_1, now contains all the long lived activity, A_L, and the activity from the Pb-212 decay chain, A_s, with a half life of 10.64 hours (λ_s = 0.0651 hr^{-1}).

12.5.3.4. Activity of Long Lived Alpha Emitters in the Presence of Natural Background. (Cont'd)

The sample is allowed to decay for more than one Pb-212 half life, and is recounted. The sample activity now, A_2, still contains all the long lived activity (decay is assumed to be insignificant) and less of the Pb-212 daughter chain.

The long lived activity is estimated from

$$A_L = A_2 - \left[\left(\frac{e^{-\lambda_s t}}{1-e^{-\lambda_s t}}\right)(A_1 - A_2)\right]$$

The error in A_L, estimated standard deviation, s_L, is given by

$$s_L = \left\{ s_2^2 + \left[\left(\frac{e^{-\lambda_s t}}{1-e^{-\lambda_s t}}\right)^2 (s_1^2 + s_2^2)\right]\right\}^{\frac{1}{2}}$$

where s_2 = estimated standard deviation of A_2, and s_1 = estimated standard deviation of A_1. (See Section 12.9.4.)

12.5.4. Sampling Methods

While air sampling is accomplished by many different methods (e.g., gas bubblers, cold traps, grab samples, filtering, etc.) this section will concentrate on the filter methods through which air samples are drawn.

12.5.4.1. Filter Samples for Particulate Activity

a. Cellulose Filters (W-41). Cellulose filters such as Whatman 41 (W&R Balston, Ltd. England) provide a convenient filter material to remove particulates from the air for measurement. They exhibit initial low air resistance which increases as dust loading occurs. The collection efficiency ranges from 64% to 98% (.3u) as air flow velocity is increased. This is not a good alpha collector due to deep particle penetration in the filter. They are mechanically strong and the least expensive of the various filter media.

12.5.4.1. Filter Samples for Particulate Activity (Cont'd)

b. Glass Fiber Filters. Glass fiber filters such as Gelman Type E provide very high collection efficiencies (>99%). The particle penetration is low making them good for alpha collection and measurement. The major drawback to these is that they are relatively fragile.

c. Membrane Filters. Membrane filters are characterized by very high efficiencies (>99%) and low particle penetration. The pore size variation is very tightly controlled during production. The main drawbacks of these filters is that they are very fragile aand require low sample flow rates. This can increase the sampling time significantly. Since they are made of dry gels of cellulose ester (acetates, nitrates, etc.) they are soluble in organic solvents and easily decomposed by oxidizing acids. The pore size runs from 10 n meters to 10 μ meter. At the very large pore sizes, the efficiency can drop off to as low as 90%.

12.5.4.2. Sampling Radioactive Gases. Because radon is a noble gas it is not effectively trapped or retained by filters. However, as radon decays, its radioactive daughters will attach to dust particles in the air. These radioactive particulates may be filtered using normal particulate filtering techniques and counted for alpha activity. Methods for direct counting of radon and its daughters without filtering are in development and include track-etch devices and the Lucas cell which uses a direct scintillation detection system.

12.5.5. Air Sampling Equipment

There is a large variety of air sampling equipment available. The following should be considered when choosing such equipment for air sampling.

12.5.5.1. Pumps. An important consideration in selecting a pump for air sampling is the specific sampling job required. In general two broad categories exist. A high volume pump used for short duration (on the order of minutes) or a low volume pump used for long duration at low sampling volumes. High volume pumps used for radiation protection air sampling typically pull 10 to 20 cubic feet per minute (cfm) (300-600 liters per minute). Low volume pumps typically pull 2.5 cfm or about 70 lpm. Personnel monitoring pumps which run on batteries usually collect at a flow rate of about 2 liters per minute.

High volume small motor samplers are subject to frequent maintenance problems. It is good practice to have several spares on hand. The turbine type sampler (such as Staplex) is generally preferred over centrifugal pumps, however, both kinds frequently require brush changes. If possible, use pumps which have separate cooling air fans for the motor, as this avoids pressure gauge adjustment problems.

Keep in mind that if a high volume sample is necessary, the entire sample should be used. If a small section of a high volume sampler is cut out of a large filter, the use of a lower volume sampler may produce the same sensitivity. A two inch circle cut from a four inch high volume sample is equivalent to the same two inch sample collected at one fourth the flow rate.

Other considerations in obtaining air sampling systems are flow rate range and adjustability, noise level during operation, size and weight, power requirements (110 AC, 12 DC, 24 DC), maintenance, weatherproofing, and mounting capability (such as above ground).

12.5.5.2. Air Flow Meters for Air Sampling. There a several types of meters available for use with air monitoring systems. The rate type meters measure either mass flow per unit time such as bypass flow meters or air velocity by measuring pressure or vacuum. Integral type meters such as dry gas meters measure the total volume of air passing through them. In the air velocity type meters, using pressure gauges, consideration must be given to heating of air by the pumps. Dry gas meters provide high accuracy and excellent service length free of maintenance when used at ambient pressure with dry air. These meters need less calibration than most.

12.5.5.2. Air Flow Meters for Air Sampling. (Cont'd)

Wet test meters are very precise and may be used to calibrate other meters such as dry gas meters. The calibration of a wet test meter from the vendor is sufficient to use it as a standard for calibration if the wet test meter is set up and used according to the manufacturer's instructions.

12.5.5.3. Calibration of Air Flow Meters. Systems used for air sampling are calibrated against accepted standards. For field measurements a wet test meter can be used as a primary standard to calibrate other meters such as dry gas meters. Dry gas meters, once calibrated hold their calibration for long periods of time. Individual field samplers are calibrated before their first use and then on a periodic basis thereafter. They should also be calibrated after any long term extensive sampling as an added precaution. Primary standards such as a wet test meter have sufficient precision to accept the vendor's calibration as accurate. These may be recalibrated by sending them to the vendor on a yearly basis.

Flow meters in systems may be calibrated using a wet test meter or a standard dry gas meter used in series with the flow meter. A marriotti bottle may also be used with a stop watch and a graduated cylinder.

Higher flow rates are normally calibrated using a standard sharp edge orifice plate and a manometer. These systems are suitable for field calibration of air samplers such as the Staplex.

12.5.5.4. Filter Holders. Choose filter holders that are compatible with the gas being sampled. Stainless steel fiber holders are widely available, are clean, and do not corrode easily. Aluminum and plastic filter holders are good choices where corrosion or solvent vapors are not a problem. They are also less expensive than stainless steel.

Most filter media are available in 47 mm size and in larger 4 inch round filters and 8" x 10" rectangular sizes. Where you can, choose the size that is acceptable directly in the counter. Many detectors are available in only a few sizes. These sizes limit the choise of filters that should be used. Silicon surface barrier detectors are available in sizes up to about one inch diameter. Pancake GM tubes are about 1-3/4 inch diameter (44 mm). ZnS(Ag) detectors can be made in just about any size and shape but 1", 2" and 3" diameters are commercially available.

12.5.5.4. Filter Holders. (Cont'd)

Choose filter holder with quick connection retaining rings. Screw type rings will frequently tear the sample when it is removed. Also, replaceable backing plates should be available since these are occasionally lost or clogged. Of course, filter holders should not provide any bypass air flow paths around the filter media or through the connector.

Both open and closed filter holders may be used. If closed holders are used the procedure must account for material lost in the sampling mechanism ahead of the filter holder.

12.5.5.5. Use of the Staplex High Volume Air Sampler. The Staplex Air Sampler is used for taking grab samples in a zone occupied by workers. This type of sampling system will normally be used during maintenance work where short, non-routine operations are being performed. The sample collected must be large enough to permit one-tenth of the permissible concentration to be determined. For the Staplex with a flow rate of 20 cfm through a four inch diameter filter paper from which a two inch diameter circle is cut for counting in a beta counter (or for a sample collected on a 47 mm filter paper at 4 cfm), the minimum sampling time is 2 min. The Staplex Air Sampler should not run for more than one hour with the 4 inch filter or 15 minutes with the 47 mm filter to prevent overheating and damage to the sampler.

12.5.5.6. Use of the Low Volume Air Sampler. The Low Volume Air Sampler is used for taking air samples in a zone occupied by workers when the work time is on the order of an entire shift. A low volume air sample may be obtained by using a personnel, or lapel, monitor pump.

The minimum sampling time must be long enough to permit one-tenth of the permissible level to be determined. The sample interval should not exceed the shift duration.

12.5.6. Counting Air Samples

Air Samples must be interpreted on the basis of counting time after sampling to account for the decay of shorter lived nuclides. We expect some short lived nuclides to be present in the facility during demolition. Short lived radioactivity collected will be from radon and thoron radioactive daughter products. These include Pb-214 (26.8m), Bi-214 (19.7 min), and Po-214 (164 μ sec) in the shorter lived radon decay chain with a composite half-life of about 30 minutes; and Pb-212 (10.64 h), Bi-212 (60.5 m), Po-212 (short), and Tl-208 (3.1 min) in the longer lived thoron decay chain, whose half life is controlled by the 10.64 hr Pb-212.

A sample counted immediately after collection will contain naturally occurring radioactivity from both of these chains and may have longer lived radioactivity present which we also seek to evaluate.

A second count may be done after 4 hours decay to evaluate the sample after radon (but not the thoron) daughters have decayed. By this time the activity consists of thoron daughter and possibly long lived radioactivity. Again it is interpreted as long lived activity for control purposes.

An evaluation is made by counting the sample after 72 to 96 hours decay to permit all thoron daughters to decay. After three weeks the sample may be counted for an evaluation of Th-nat content, or alpha spectroscopy may be used for Th-nat evaluation.

Alpha and beta counting may be useful for prompt evaluation of air samples since in both the radon and thoron daughter activity chains there are two beta particles emitted for each alpha particle.

12.5.6.1. Air Sample Record. Records of air samples will be kept on the Radiological Air Sample Data form as shown in Figure 12-2.

The top section of the form is used to record collection data. Identification of the location and purpose of the sample is listed in the appropriate spaces. If the sample is used to monitor personnel exposure, list the name of the person. The date and time the sampler is turned on is used to identify the sample. The average flow rate is determined from the beginning and ending flow rates. Units of volume should be consistent, and conversion factors should be given.

RADIOLOGICAL AIR SAMPLE DATA - WEST CHICAGO FACILITY

SAMPLE LOCATION | REASON FOR SAMPLE | DATE/TIME SAMPLER ON | DATE/TIME SAMPLER OFF

Average Flow Rate _____ X Total Sample Time _____ = Sample Volume _____

DATE	TIME	INSTRUMENT/SERIAL NUMBER	TOTAL COUNTS	COUNT TIME	CPM	BKGD CPM	CCPM	CF	µCi/m³	SIGNATURE

REMARKS

REVIEWED BY | DATE

Figure 12-2

12.5.6.1. Air Sample Record. (Cont'd)

The remainder of the form is used to record counting data and to determine short lived and long lived radioactivity.

The remarks section may be used to record any pertinent information, such as work conditions, sampler type and number, filter medium, SWP number or other information.

A series of counts taken of the sample will aid in the identification and determination of airborne concentrations of radioactive materials present.

The Health Physics Supervisor will review all air sample data and computations.

12.5.6.2. General Equation for Air Sampling. For particulate radioactive materials sampled from a constant concentration the rate of collection of the material on the filter is proportional to the concentration and the sample flow rate less the quantity of the collected material that decays.

$$\text{Collection Rate} = \frac{dq_i}{dt} = C_i F - \lambda_i q_i \qquad (1)$$

where q_i = the quantity of the i th nuclide

C_i = the concentration of the i th nuclide

F = the sample flow rate

λ_i = the decay constant for the i th nuclide

The amount of radioactive material on the filter at the end of the sampling interval, t_s, is given by

$$q_i = C_i F (1 - e^{-\lambda_i t_s}) / \lambda_i \qquad (2)$$

12.5.6.2. General Equation for Air Sampling. (Cont'd)

When the sample is counted at some time, t_d, after collection the activity on the filter is

$$q_i = C_i F (1-e^{-\lambda_i t_s}) (e^{-\lambda_i t_d}) / \lambda_i . \quad (3)$$

Therefore, the concentration is given by

$$C_i = \frac{\lambda_i q_i e^{\lambda_i t_d}}{F (1-e^{-\lambda_i t_s})} \quad (4)$$

which is the general equation for air sampling.

12.5.6.3. Samples with Long Half-Life. In the case of very long half lives the term $\lambda_i t_d$ approaches zero $e^{-\lambda_i t_d}$ approaches 1. Similarly, the term $1-e^{-\lambda_i t_s}$ approaches $\lambda_i t_s$. Substituting these values in Eq. 4 above gives

$$C_i = q_i/Ft_s \text{ or } q_i/V \quad (5)$$

where V is the sample volume

which is the equation for long lived radioactive materials.

12.5.6.4. Samples with Short Half-Life. In the case of short half-life radioactivity, as the sampling time becomes long compared to the half life, the activity on the filter paper approaches saturation and decays as fast as it is collected. The term $1-e^{-\lambda_i t_s}$ approaches 1 and the equation becomes

$$C_i = \frac{q_i \lambda_i e^{\lambda_i t_d}}{F} \quad (6)$$

12.5.6.4. Samples with Short Half-Life. (Cont'd)

When the identity of the nuclides in the mixture is not known, the above equation can be used to establish that the longer-lived beta emitters are not present, allowing the use of 3×10^{-9} as the applicable MPC without further identification. To do this count the sample twice allowing about 30 minutes for decay, then estimate λ_i from the apparent half life and correct the count rate accordingly.

$$\lambda_i(\text{est}) = \frac{0.693}{t_{\frac{1}{2}}\,(\text{est})} = \frac{\ln \frac{A_{t1}}{A_{t2}}}{(t_2 - t_1)}$$

where A_{t1} and A_{t2} are the activities in cpm at the counting times t_1 and t_2.

12.5.7. Working Levels for Radon Daughter Exposure

A Working Level (WL) is defined as any combination of short-lived radon-222 daughters (polonium-218, lead-214, bismuth-214 and polonium-214) per liter of air without regard to equilibrium which will result in the emission of 1.3×10^5 MeV of alpha energy. One WL is also defined as the potential alpha energy present in a liter of air containing 100 pCi each of the short lived radon-222 daughters. Only 8 pci of radon-220 (thoron) in equilibrium with its short lived daughters is equivalent to one WL (see figure 12-3).

The WL concentration is an exposure level. Cumulative exposure is given in Working Level Hours or Working Level Months. An average exposure to 1 WL for 8 hours is equal to 8 WLH. An average exposure to 1 WL for 173 hours is equal to 1 WLM. The maximum permissible concentration for radon-222 in air may be given in units of activity radon (combined with its short lived daughters) per volume air or by Working Levels.

a. MPC_{40} for radon-222 in air = 3×10^{-8} µCi/ml or 1/3 WL

b. MPC_{168} for radon-222 in air = 3×10^{-9} µCi/ml or 1/30 WL

WORKING LEVEL EQUIVALENTS FOR RADON AND THORON

1. RADON (Rn-222)

   a. Each atom of Po-218 contributes 13.7 MeV in decaying through Po-214 (6.0 MeV for the Po-218 decay and 7.7 MeV for the Po-214 decay).

   b. Each atom of Pb-214 and Bi-214 contributes 7.7 MeV in decaying through Po-214.

100pCi Po-218 = $100 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{3.05\text{ min}}{0.693}$ = 977 atoms

100pCi Pb-214 = $100 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{26.8\text{ min}}{0.693}$ = 8585 atoms

100pCi Bi-214 = $100 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{19.7\text{ min}}{0.693}$ = 6311 atoms

100pCi Po-214 = $100 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{2.73\times10^{-6}\text{min}}{0.693}$ = 0.0009 atom

Total potential alpha energy

Po-218	977	X	13.7 MeV	=	13,400 MeV
Pb-214	8585	X	7.7 MeV	=	66,100 MeV
Bi-214	6311	X	7.7 MeV	=	48,600 MeV
Po-214	0				

Total potential alpha energy = 128,100 MeV $\approx$ 1WL

(1WL = 1.3×10^{5} MeV potential alpha energy).

Figure 12-3

WORKING LEVEL EQUIVALENTS FOR RADON AND THORON(continued)

2. THORON (Rn-220)

a. Each atom of Po-216 contributes 14.7 MeV of alpha energy in decaying through Po-212 or Tl-208. (6.8 MeV for the Po-216 decay plus 7.9 MeV for the weighted average of the Bi-212 and Po-212 decays).

b. Each atom of Pb-212 and Bi-212 contributes 7.9 MeV (the weighted average of the Bi-212 and Po-212 decays).

c. Each atom of Po-212 contributes 8.9 MeV alpha energy.

d. Each atom of Tl-208 contributes no alpha energy.

8pCi Po-216 = $8 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{2.7\times10^{-3}\text{min}}{0.693}$ = .07 atoms

8pCi Pb-212 = $8 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{636\text{ min}}{0.693}$ = 16,299 atoms

8pCi Bi-212 = $8 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{60.5\text{ min}}{0.693}$ = 1,550 atoms

8pCi Po-212 = $8 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{3\times10^{-7}\text{min}}{0.693} \times 0.663$ = 5×10^{-6} atoms

8pCi Tl-208 = $8 \times \frac{2.22\text{dpm}}{\text{pCi}} \times \frac{3.1\text{ min}}{0.693} \times 0.337$ = 26.8 atoms

Total potential alpha energy

Po-216	0.07 x 14.7 MeV	=	1 MeV
Pb-212	16299 x 7.9	=	128,800 MeV
Bi-212	1550 x 7.9	=	12,200 MeV
Po-212	5×10^{-6} x 8.9	=	0 MeV
Tl-208	26.8 x 0	=	0 MeV

Total potential alpha energy = 128,800 x 12,200 = 141,000 $\simeq$ 1WL
(1WL = 1.3×10^5 MeV potential alpha energy).

Figure 12-3 (cont'd.)

12.5.7.1. Working Level Determination for Radon Daughters. Radon daughter concentrations are measured using the method described in Radiation Monitoring, U.S. Department of Labor, Mine Safety and Health Administration, 1979. The radon decay chain is shown in Figure 12-4.

a. Radon daughter particulates are filtered from 10 liters or more of air in a period of exactly 5 minutes:

b. The alpha activity on the filter paper is counted between 40 and 90 minutes after the end of sample collection using an appropriately calibrated instrument. After 40 minutes only the alpha particles from the decay of Po-214 are counted because virtually all of the Po-218 ($t_{\frac{1}{2}}$ = 3.05 min.) has decayed.

c. Disintegrations per minute per liter of air is derived by dividing the total counts per minute by the counter efficiency. The counter should be calibrated for gross counting of Po-214 7.7 MeV alpha particles. The total sample volume in liters is divided into the total activity in disintegrations per minute.

d. To convert to Working Levels a correction factor depending on the time elapsed from sample time to count time is used. These correction factors are determined graphically in Figure 12-5. This factor is based on the assumption that equilibrium existed between Po-218, Pb-214, and Bi-214 at the time of sampling. The factor relates dpm per liter of air from 40 to 90 minutes after sampling to the activity which would be present from an initial concentration of 1 WL.

e. A sample calculation is as follows:

Sample volume: 10 liters (2.0 lpm)
Time at end of sample: 10:15 am
Time of counting: 11:05 am
Elapsed time: 50 minutes
Count rate: 250 cpm
Gross counter efficiency: 30%
Alpha dpm: 250 ÷ .3 = 825 dpm
Dpm/liter: 825 dpm ÷ 10ℓ = 82.5
Time factor (from Figure 12-5): 130
WL = 82.5 dpm/l ÷ 130 = 0.63 WL

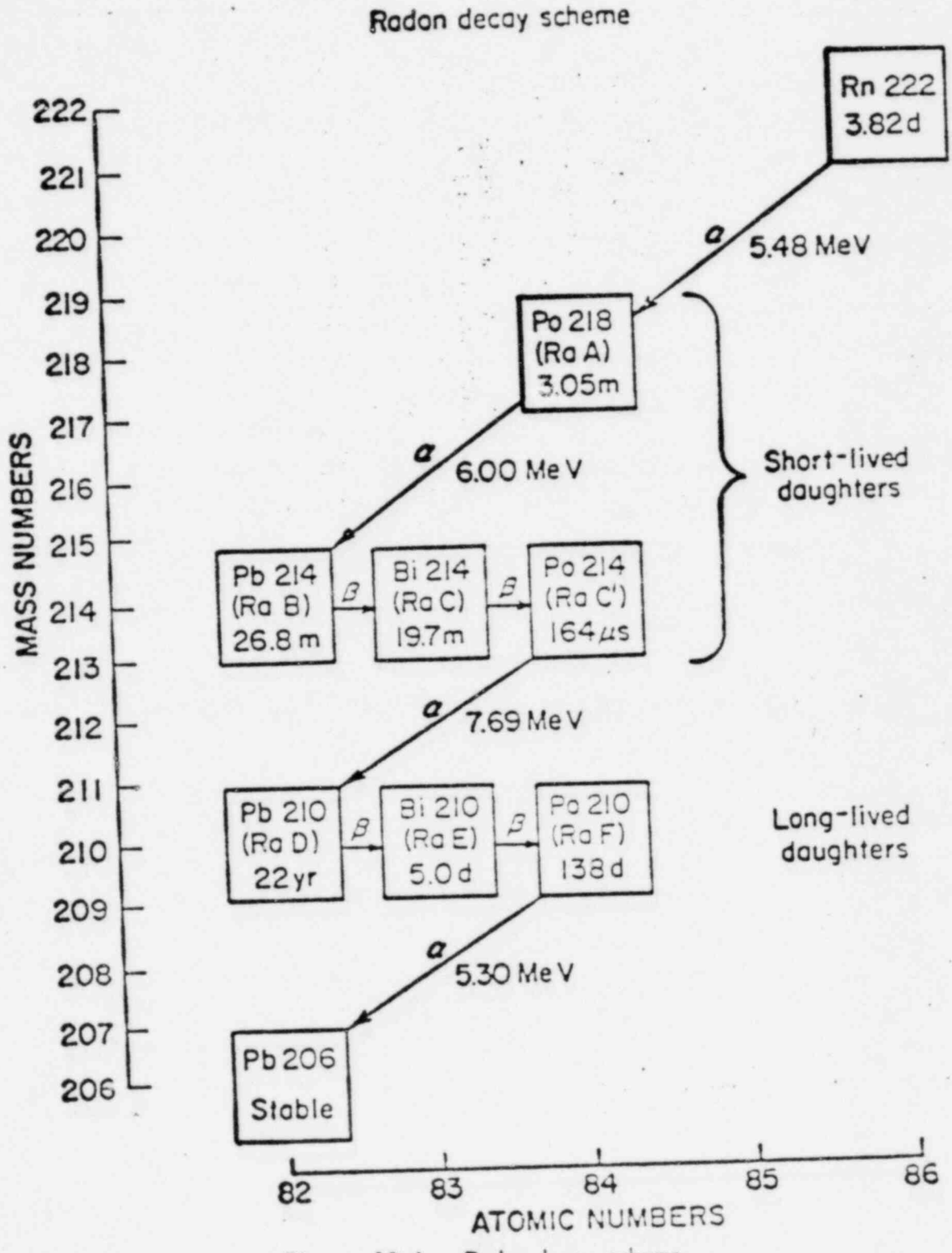
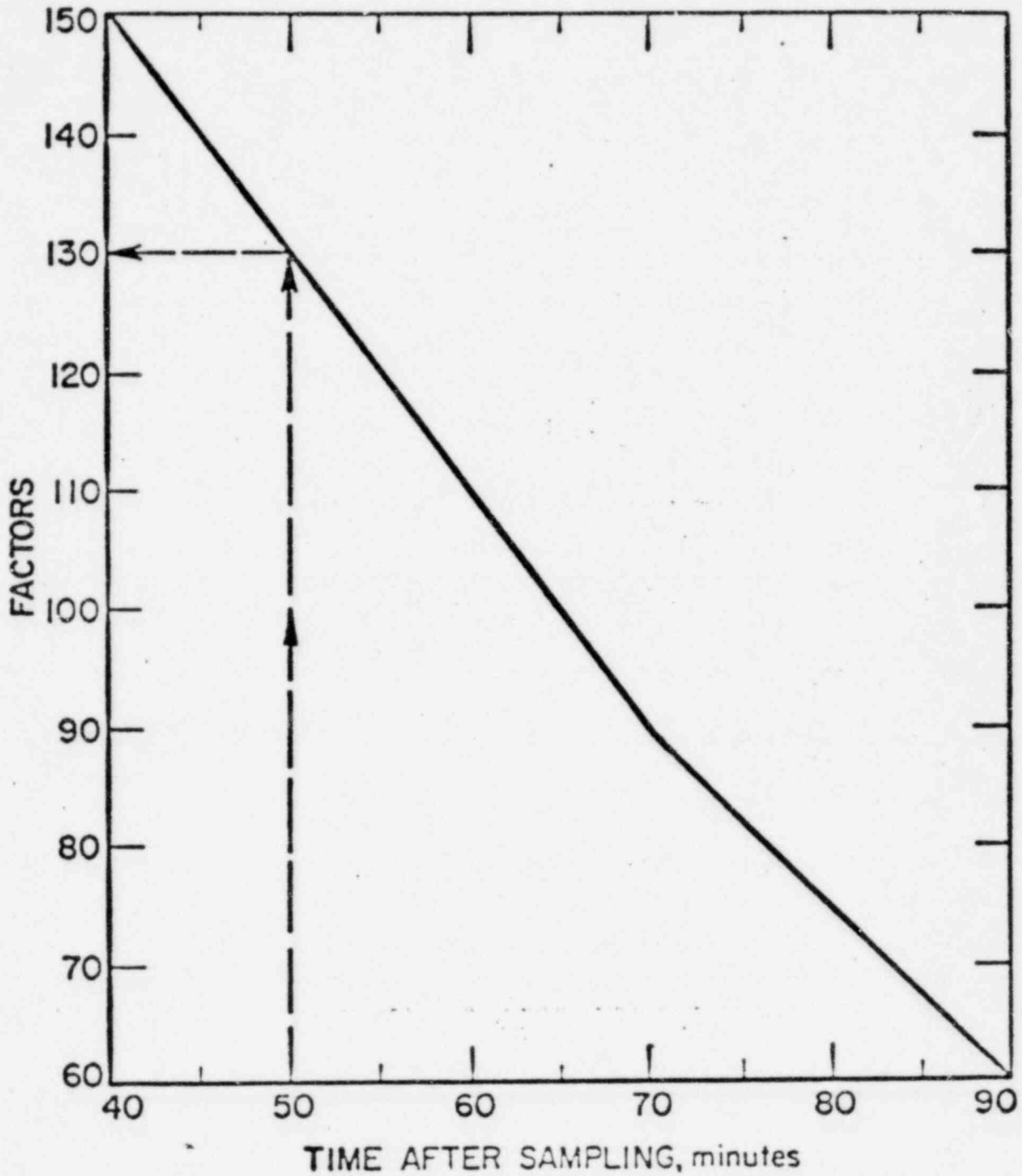


Figure 12-4. Radon decay scheme.



Time factors versus time after sampling for radon daughter samples.

Fig 12-5

12.5.7.2. Working Level Determination for Thoron Daughters. An analagous method is used to determine thoron daughter concentrations in air. The thoron decay chain is shown in Figure 12-6.

a. Thoron daughter particulates are filtered from 10 liters or more (preferably about 50 liters) of air in a period of up to 1 hour.

b. The alpha activity on the filter paper is counted between 5 to 17 hours after the end of the sample using an appropriately calibrated instrument. After 5 hours, Pb-212 and Bi-212 are in equilibrium so that the combined alpha counts of Bi-212 and Po-212 may be directly related to the number of atoms of Pb-212 present on the filter.

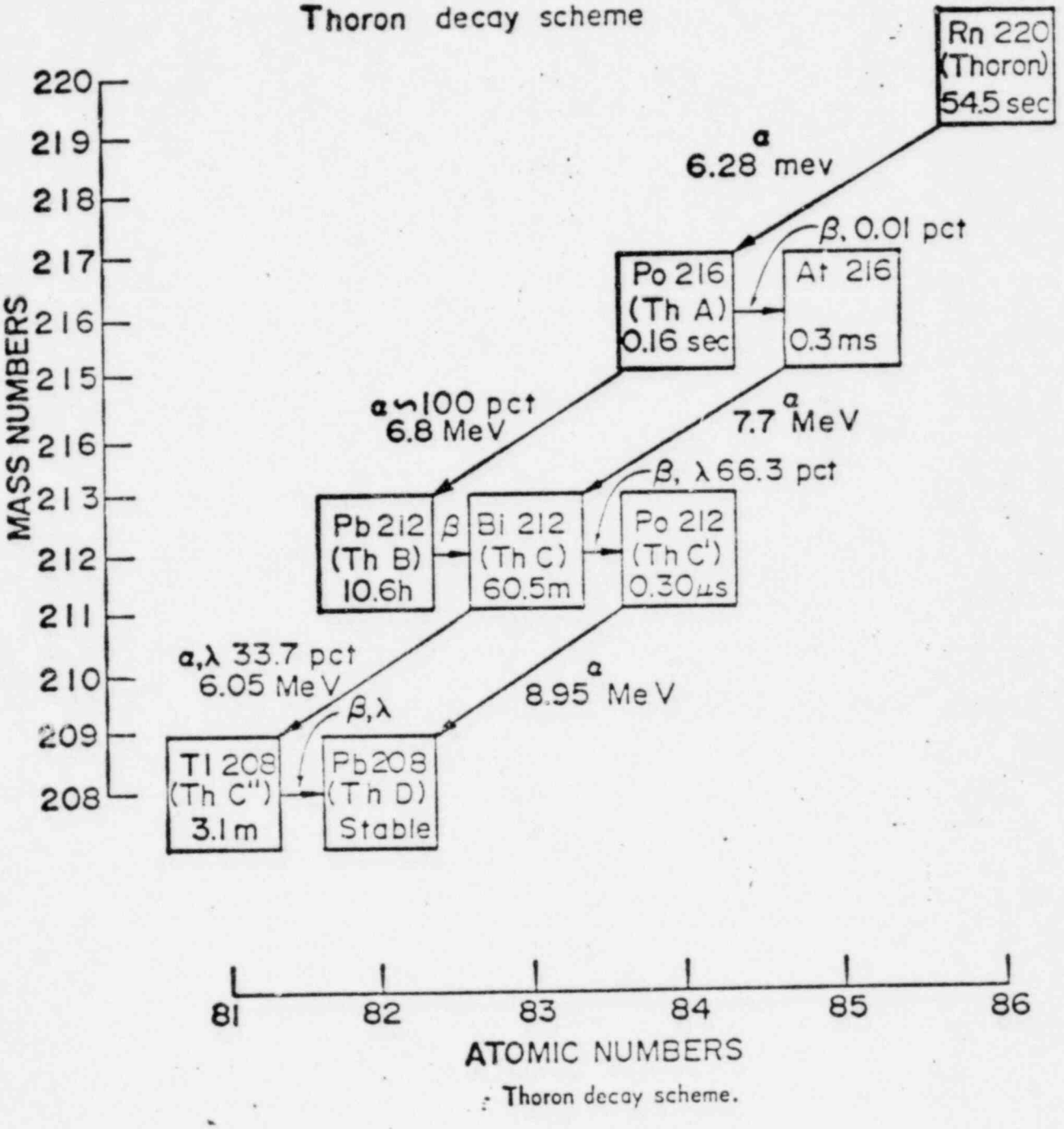
c. Total counts per minute on the filter are converted to dpm per liter of air by dividing total counts by counter efficiency and by the total volume of air filtered, in liters.

d. Activity (dpm) per liter of air is converted to Working Levels by dividing by the time factors given in Figure 12-7.

e. The following is a sample calculation:

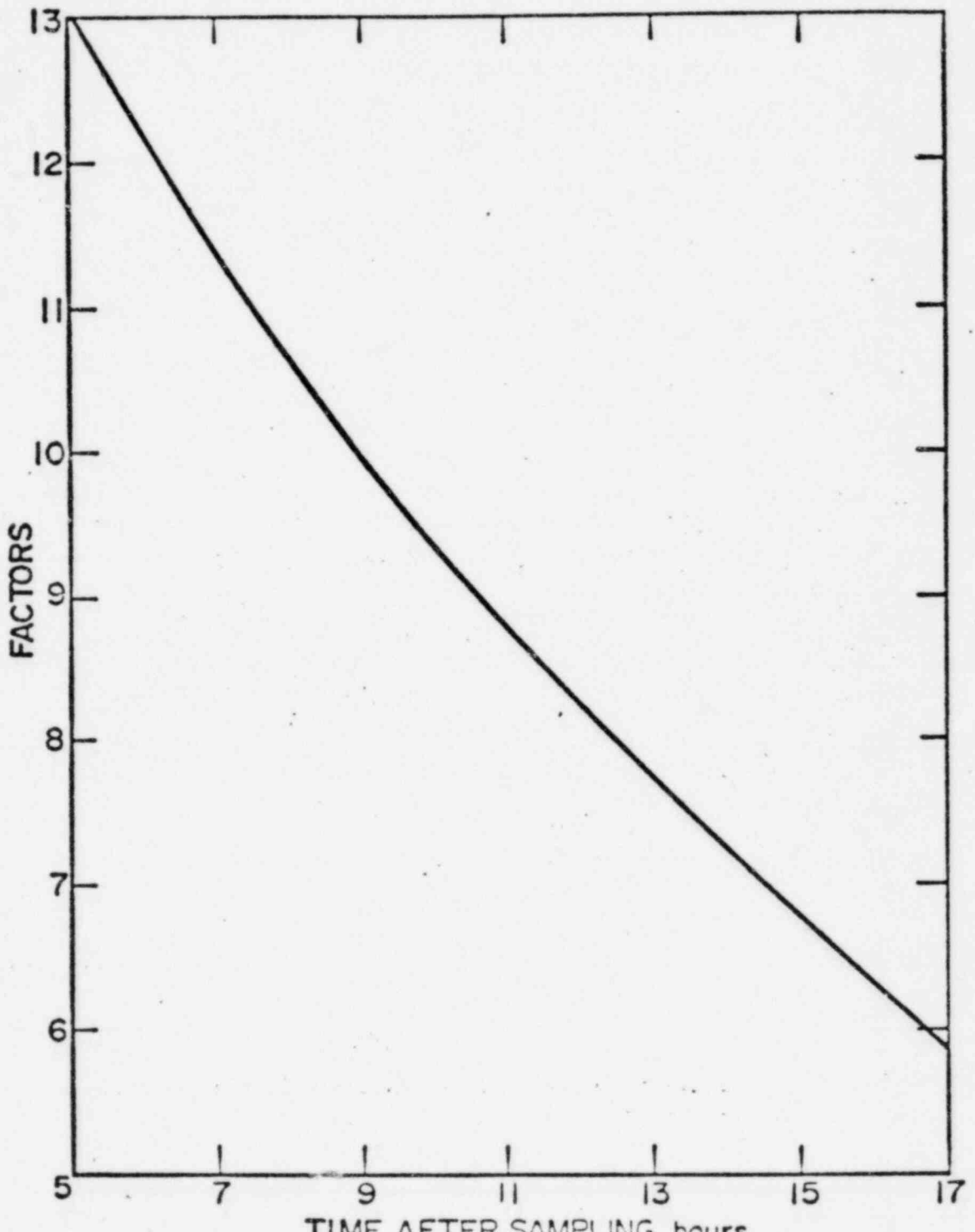
Sample volume: 50 liters (2.0 lpm, 25 min.)
Time at end of sampling: 10:00 am
Time of counting: 3:00 pm
Elapsed time: 5 hours
Counts (5 min.): 502
Count rate: 502 ÷ 5 = 100 cpm
Gross counter efficiency: 30%
Alpha dpm: 100 ÷ .3 = 330
Dpm/liter: 330 ÷ 50 = 6.6
Time factor (from Figure 12-7): 13
WL: 6.6 ÷ 13 = 0.51 WL

12.5.7.3. WL Corrections for Mixtures of Radon and Thoron. No correction is needed for thoron daughter calculations when mixtures of radon and thoron are present. However, adjustments are necessary to determine true radon daughter concentrations. Figure 12-8 lists corrections which must be subtracted from radon daughter activity per liter (dpm/liter) for thoron daughter activity adjustment.



Thoron decay scheme.

Fig. 12-6



Time factors versus time after sampling for thoron daughter samples.

Fig 12-7

Dpm per liter of air which should be subtracted when calculating radon daughter working levels mixed with thoron daughter working levels 1/

Measured Thoron Daughter Working Levels	Elapsed Minutes After Sampling When Radon Daughter Dpm Per Liter of Air Was Counted					
	40	50	60	70	80	90
0.1	2	2	2	2	2	2
0.2	3	3	3	3	3	3
0.3	5	5	5	5	5	5
0.4	7	7	7	7	6	6
0.5	8	8	8	8	8	8
0.6	10	10	10	10	10	10
0.7	12	12	12	11	11	11
0.8	13	13	13	13	13	13
0.9	15	15	15	15	15	14
1.0	17	17	17	17	17	17
1.2	20	20	20	20	19	19
1.4	23	23	23	23	23	22
1.6	27	27	26	26	26	26
1.8	30	30	30	29	29	29
2.0	34	33	33	33	32	32

1/ Based on the assumption that ThC is nearly at equilibrium with ThB. Generally, this will result in a conservative estimate of radon daughter working levels, especially at counting times of between 40 and 60 minutes. An underestimate of more than 10 percent should not result under the high equilibrium conditions where most screening samples will be taken. Compensation for low initial Bi-212 to Pb-212 equilibrium commences to be significant only above one working level of thoron daughters.

Fig. 12-8

12.6. MONITORING RADIOACTIVITY IN LIQUIDS

12.6.1. Sampling of Radioactivity in Liquids

This method is suitable for sampling industrial water, process water, tanks, in addition to wells, streams, lakes, rain runoff and other natural water supplies. Sampling locations and frequencies as well as sample counting procedures should be done according to written, approved procedures.

12.6.1.1. Handling Precautions. Information on specific radiation hazards associated with collecting the sample or with the sample itself must be obtained and evaluated before collecting the sample. Appropriate protective clothing must be worn. Rubber, vinyl or latex gloves will always be worn for sampling radioactive liquids. If dissolved gases or volatile materials are present in the water, then adequate preventive measures must be taken to avoid premature loss of these constituents and the inhalation of radioactive vapor. Shielding, coolers or special collection devices may be required to collect the sample and reduce radiation exposure. Precaution must be taken to prevent spilling, leaking, or contamination spread during sampling.

12.6.1.2. Sampling Apparatus. Sampling lines should be as short and as small as possible to expedite flushing and reduce time lag. The line material must be compatible with the sample and sample conditions.

Valves should be made from similar materials as the sampling lines. A shut-off valve shall be placed immediately after the sampling point so that the sample line may be isolated.

Pumps required for sample withdrawal must be built of materials that will not contaminate the sample. Filters in the pump should not be used. Pump suction sampling lines should slope downward over their entire length to prevent gas traps from forming.

Sample containers must be cleaned sufficiently so as not to contaminate the sample. Polyethylene is a suitable material for most samples except those containing radon gas. One hundred milliliter to one liter polyethylene bottles or jars may be used. Closures should be clean and have new liners.

12.6.1.2. Sampling Apparatus. (Cont'd)

Sample labels shall contain the following information:

a. Facility
b. Sample Number (pre-numbered)
c. Date and Time of Sample
d. Source of Sample
e. Sampling Point (in sufficient detail to permit a second sample to be collected)
f. Temperature (if applicable, i.e., >130^{o}F)
g. Sample Temperature (if applicable, i.e., >130^{o}F)
h. Container Radiation Level _____ mR/hr
i. Signature of Person Collecting Sample
j. Radiation symbol and words "Radioactive Materials"

12.6.1.3. Sampling Frequency. Sampling frequency and duration will depend on the intended purpose of the analytical result. Sampling programs should be defined in advance with goals, reports, and action points specified in the program directive.

12.6.1.4. Composite Samples. Composite samples should be obtained and composited proportional to total flow. To estimate radioactive decay, the time of collection and the quantity of each sample comprising the composite shall be noted.

12.6.1.5. Sampling Point. Choose the sampling point carefully so that a representative sample may be obtained. When a large volume of water is to be sampled, several samples may be combined to obtain a representative sample.

12.6.1.6. Preparation of Sample Containers. Sample bottles shall be cleaned. They shall be rinsed with distilled or demineralized water and dried in air. Treatment to avoid absorption losses on the container wall will depend on the purpose of the subsequent analysis and the total estimated mass of solids in the sample. Treatment might include addition of HCl, EDTA, or addition of stable carriers to the bottle before collection or immediately following filtration.

12.6.1.7. Collecting the Sample. Flush the sample line to eliminate "dead" sample. Flush the sample bottle with sample several times. Leave a slight air space in the bottle. Cap the bottle to prevent leakage. Clean or re-package the sample bottle to prevent subsequent contamination of equipment.

12.6.1.8. Time Between Collection and Analysis. If short lived activity is of interest analysis should be made as rapidly as possible to minimize radioactive decay. If only long-lived activity is of interest, measurement may be delayed to allow time for short lived interferences to decay away (10 half-lives).

12.6.2. Measurement of Beta Radioactivity in Water

Measurement of beta activity in water shall be in accordance with ASTM D 1890, "Standard Method for Measurement of Beta Particle Radioactivity of Industrial Water and Industrial Waste Water". Alternative methods may be used with approval of Kerr-McGee. Beta activity is recorded on Water Sample Results forms, Figure 12-9.

12.6.3. Measurement of Alpha Radioactivity in Water

Measurement of alpha particle radioactivity in water shall be done in accordance with ASTM D 1943, "Standard Method for Measurement of Alpha Particle Radioactivity of Industrial Water and Industrial Waste Water". Alternative methods may be used with approval of Kerr-McGee. Alpha activity is recorded on Water Sample Results forms, Figure 12-9.

12.7. MONITORING RADIOACTIVITY IN SOIL

Generally, soil radioactivity may be measured directly in place or by sampling and analytical laboratory methods. For decontamination decision-making, a direct measurement may be sufficient to make a go-no-go decision. For documentation of contamination levels or for comparison with concentration guidelines, an analytical approach is necessary.

WATER SAMPLE RESULTS - WEST CHICAGO FACILITY

DATE COLLECTED	pH	TSS (mg/ℓ)	TDS (mg/ℓ)	CONDUCTIVITY (μmhos/cm)	SO_4 (mg/ℓ)	Cl (mg/ℓ)	LOCATION / SITE NUMBER	F (mg/ℓ)	GROSS ALPHA	GROSS BETA

See reverse side for notes and comments.

Fig. 12-9

12.7. MONITORING RADIOACTIVITY IN SOIL (Cont'd)

Direct measurements using portable survey meters are suitable for locating and defining spills and the major concentrations of radioactivity in soil systems. Beta-gamma surveys may use end window pancake G-M tubes, preferably a shielded probe such as the Eberline HP-210. Alpha surveys are done with a ZnS (Ag) probe with a screened face to protect the window so that the probe can safely contact the soil. Where gamma emitters are present, larger areas can be surveyed using NaI(Tl) detectors of reasonable size. The largest normally used on survey meters is about 2" x 2". Most are somewhat smaller. The choice of detector size depends in part on the expected energy of the radionuclides. Higher energy emitters require somewhat larger detectors.

Direct soil surveys for gamma emitters can also be performed using spectrometry equipment in the field. For large area surveys this can be cost-effective compared to sampling and analysis expenses. Both NaI(Tl) and intrinsic germanium detectors are used for this purpose.

When direct surveys are not sensitive enough to detect soil contamination, then simple sampling techniques and sample preparation can be used to chase contamination or to define contamination boundaries. Samples can be collected and prepared as infinitely thick specimens and counted in laboratory counting equipment. This method produces a level of sensitivity ten times greater than direct measurements using rate meter circuit instruments. This method, however, is unsuitable for determining precise soil concentrations, particularly of mixtures of radionuclides.

A complicating factor in all soil sampling is the inherent radioactivity of the soil from the naturally occurring radionuclides such as potassium-40, uranium, thorium, and radium and its daughters. Also, these nuclides are not uniformly distributed and appear in a variety of soils with widely varying concentrations.

12.7. MONITORING RADIOACTIVITY IN SOIL (Cont'd)

Because of this natural radioactivity of all soils, it is necessary to use reference soil samples of the same type for comparison. Reference samples must be collected from similar strata but not from locations that are potentially contaminated.

Soil can be very non-uniform over very small distances. Runoff areas or areas that pond and dry after rain can accumulate significant radioactivity compared to higher ground. Sand, silt, clay and rocks can be found in layers in close proximity to each other. Also, during construction work, some backfill may come from areas remote from the site being sampled. Sand fill around underground piping is an example.

12.7.1 Collecting Soil Samples

Sampling soil for radioactivity requires careful consideration of what information is needed. The soil sampling scheme to be used should be carefully documented and approved before samples are collected. Otherwise the effort may not produce the desired information. Background samples from similar uncontaminated soils must be collected for comparison.

All samples must be representative of the soil type and location. If vertical profile information is necessary the sampling method must not disturb the soil vertical matrix. Sampling locations must be carefully and clearly defined, especially if repeat sampling for comparison will be required in the future. Suitable coring procedures are given in ASTM D1586 and 1587.

Sample locations must be defined by measurement using a tape measure and a compass from a fixed location or monument. If possible the sample site should be marked with a numbered stake with a flag.

Collect enough sample material to have an excess over that required for the analytical procedures, particularly if rocks or vegetation are present in the material. Sample size should be approximately four times the quantity necessary for all analytical procedures. This will permit necessary duplicates or re-runs of selected procedures.

12.7.1. Collecting Soil Samples (Cont'd)

Soils are heavy. Sample containers must be large enough and strong enough to contain the sample and to keep it securely sealed during handling. Polyethylene jars and paint cans lined with plastic bags have been successfully used in the past. Unsupported plastic bags are fragile and may puncture or tear and should not be used for samples weighing over 500 grams (one pound).

Rocks and large roots in the soil mass are not necessarily representative of the soil. Pebbles the size of quail eggs (two centimeters) and smaller may be collected as part of the soil. Larger rocks should not be collected but should be noted in the sampling remarks on the survey report.

Sampling equipment for soil sampling will include the following:

Compass (You may use a Silva or Kunto orienteering compass)
Tape measure (30 meters or 100 ft. steel tape)
Stakes, numbered, with flags
Notebook or survey report forms
Camera (Automatic 35 mm or Polaroid)
Map, sketch, or drawing of area
Shovels, trowels, ruler, knife
Survey meters
Plastic bags
Sample containers
Labels for samples, and marking pens

Place the sample in a strong water-tight container and label the sample with the following information:

Date	Type of Sampler
Sample Number	Weather
Location	Remarks
Depth	Name of Surveyor

12.7.2 Gross Radioactivity in Soil

This procedure uses infinitely thick soil samples and standard alpha and beta counting equipment to measure radioactivity in soil down to the naturally occurring levels of thorium, uranium and potassium-40. The radioactivity determined by this method is a relative quantity and is suitable for locating spills or chasing contamination down to background levels. It is not suitable for measuring the concentration of specific radionuclides.

To determine the background radioactivity of soil in the area, collect seven to ten samples from locations with similar soils in the vicinity of the sampling area but in locations not expected to be contaminated. Determine the activity of these samples in net counts per minute (or hour). Order the values of these samples and plot the data on semi-log probability paper as activity versus percent of samples less than or equal to the sample value. (The highest value will not be plotted). Draw the best fit line through the data points.

The 95 percentile is taken to be the expected normal upper bound for background for those samples. That is, 95% of all background samples will be equal to or less than the 95 percentile value. Samples exceeding this value are considered to be contaminated. (Five percent of the time this decision will be incorrect.)

Sample preparation is done as follows:

a. Spread the soil sample on a clean surface to dry. Weigh the dry sample.
b. Remove and weigh stones and large organic matter. Record the weight of this material.
c. Divide the sample into quarters and combine opposite quarters. Repeat until about 30 to 40 grams of soil are available for the sample.
d. Moisten the soil with only enough distilled water to make a thick mud.
e. Spread the mud into a 2" diameter 1/2" thick stainless steel planchet labeled with the sample number and smooth the surface of the mud even with the top of the planchet rim. Use a disposable spreader such as a tongue depressor or popsicle stick.
f. Dry the sample to constant weight at $105^{o}F$.

12.7.2. Gross Radioactivity in Soil (Cont'd)

g. Count the sample for alpha and/or beta activity for approximately one hour. (Less time is necessary for samples with significant radioactivity. However, at least 600 net beta counts should be collected and at least 60 net alpha counts should be accumulated).

h. Count the background immediately before and after counting the sample. Count the background for a total time equal to the sample counting time evenly divided before and after. Do not use this background for any other samples. Each sample must have its own background determination before and after the sample count.

The reason for this is that radon and its daughters are constantly being evolved from the soil specimen. The radon daughters will adhere to the face of the detector and count with very high efficiency. The background, therefore, tends to increase as samples are counted. When samples are not being counted the radon daughters decay away and disappear within a day or two. It is not a good idea to leave soil samples in the counter any longer than necessary as the radon daughter contamination continues to increase as the sample sits by the detector window.

Evaluate the samples by determining the net counts per minute and comparing this to the 95 percentile of the background samples. If the sample value exceeds the background upper limit, the soil in that sampling location is probably contaminated (95% confidence level) and corrective action may be necessary.

12.7.3 Soil Analysis for Specific Nuclides

For all analyses performed by vendors the reported error in the result must include all errors including counting errors, measurement and other errors in the analysis. Chemical recoveries of spikes or carriers shall be given. Results of standard samples must be given.

12.8. DEMOLITION SURVEYS

Surveys performed for the purpose of documenting that radiation and contamination levels meet the levels specified in Appendix G and summarized in Table 12-1, Acceptable Surface Contamination Levels, shall be performed and documented as specified in this section and in the referenced Control Work Packages.

12.8.1. Preliminary Surveys

Survey records of preliminary demolition activities shall be documented and retained.

12.8.2. Covering or Painting Surfaces

For materials or equipment to be released no paint or other covering material shall be applied to radioactive surfaces or equipment until it is known that contamination levels are below the levels in Table 12-1. Such contamination levels shall be determined by a survey and documented as described below. However, marking of contaminated areas for segregation is acceptable.

12.8.3. Surveys of Pipes or Ducts

Radioactivity on the interior of pipes, or ducts (but not drains) is determined by making measurement of representative areas of inlets, outlets, dampers, reducers, or other areas necessary to adequately determine the contamination levels of the entire pipe, or duct system. Contamination levels are documented on survey reports.

The important aspect of duct and piping surveys is that the survey be representative. If there is reason to believe that they may be contaminated, then do both a direct and indirect survey. If necessary, cut openings in the ducts to get to areas where dust or contamination may hold up. In pipes, a smear survey is insufficient; fixed contamination may be present, even in piping that is bare metal clean. The direct survey is always necessary.

TABLE 12-1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[b,c,f]	MAXIMUM[b,d,f]	REMOVABLE[b,e,f]
U-natural, U-236, U-238 and associated decay products	5,000 dpm α/100cm^2	15,000 dpm α/100cm^2	1,000 dpm α/100cm^2
Th-nat, Th-232, Ra-223, Ra-224[g], U-232	1,000 dpm/100cm^2	3,000 dpm/100cm^2	200 dpm/100cm^2
Ra-226, Ra-228	100 dpm/100cm^2	300 dpm/100cm^2	20 dpm/100cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$/100cm^2	15,000 dpm $\beta\gamma$/100cm^2	1,000 dpm $\beta\gamma$/100cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate director for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived from each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

[g] Ra-224 not supported by Th-228 or Ra-228 precursors.

12.8.4. Inaccessible Areas

Surfaces of equipment or premises which may be contaminated but are inaccessible for measurement are assumed to be contaminated in excess of the limits of Table 12-1. (See Appendix G for further guidance).

12.8.5. Survey Techniques for Fixed Alpha Radioactivity

Flat, essentially clean and dry surfaces may be surveyed for fixed alpha activity. Water or any significant residue will interfere with the measurement. If the surface can be dried or wiped clean using a paper towel, do so, then check for fixed contamination. These survey results may be used to meet release criteria. If wet or damp or soiled surfaces are measured directly, the alpha activity is partly or complete absorbed in the water or dirt on the surface and the reading will be much lower than the true activity present. These measurements may be made but must always be qualified in the survey report as wet or dirty measurements. These results cannot be used to meet release criteria.

A variety of probes may be used for fixed alpha surveys. Scintillation and gas or air proportional detectors are commonly used. The Eberline AC-3-7 scintillation probe is typical as is the AC-24 air proportional probe and the AC-21 gas flow (propane) proportional probe. All these probes have similar areas, about 60 cm^2, but window thicknesses vary somewhat. Eberline equipment is calibrated to read 100% of 2π geometry directly on the meter. Actual efficiencies vary from 10 to 25%. Gas proportional counters generally have thinner windows and higher counting efficiencies. They are generally more sensitive than scintillation counters.

The meter reading for each measurement should be recorded. These may then be converted directly into contamination levels by multiplying by the ratio of the area of the probe to the reference area (100 cm^2) and by the conversion factor for 2π cpm to dpm for the nuclide of interest. For a nuclide with one alpha particle per disentegration this factor, k, is:

$$k = 2 \times 100/60 = 3.3$$

12.8.5. Survey Techniques for Fixed Alpha Radioactivity (Cont'd)

Thus a reading of 100 cpm is equal to 100 x 3.3 or 330 dpm/100cm^2.

To evaluate lower count rates, the number of counts observed on the meter may be noted or the number of clicks may be counted. (Double the clicks for the Lin-Log type meters, since they give a click for every other count). This number is divided by the probe 2π efficiency factor and is then treated as given above. Where the count rates are very low and very low limits must be detected, such as Group I nuclides, it will probably be necessary to subtract the probe background in cpm before calculating the contamination level.

Small surfaces may be monitored but the correction for surface areas must be used. Just substitute the area of the object being monitored for the probe area used earlier. Record this data for the survey.

12.9. SURVEYS FOR RELEASE OF MATERIALS

All materials released from the West Chicago Facility must be surveyed for radiation and contamination. Radiation and contamination limits for materials taken offsite are determined by the destination of the materials. Release criteria are established for materials to be released for unrestricted use. Radioactive waste shipment requirements are specified in Section 17. Different requirements are established for the transfer of materials to other licensees or licensed facilities.

All materials sold or transferred from the West Chicago Facility will have documentation of the transfer. A Record of Sale or Transfer (Figure 12-10) is completed for materials released from the site.

12.10. GROSS SAMPLING COUNTING

12.10.1. Smear and Sample Counting

Counting is accomplished by placing the smear into a sample holder (planchet). The planchet is inserted into the counter for analysis.

RECORD OF SALE OR TRANSFER - WEST CHICAGO FACILITY

DATE

TRANSFERRED OR SOLD TO

SALES PRICE

ADDRESS

METHOD OF PAYMENT
☐ Check ☐ Cash

SALES TAX @

TAX COLLECTED
$

IF TAX NOT COLLECTED INDICATE ILLINOIS SALES TAX NO

ITEM DESCRIPTION

INTENDED USE AND LOCATION

SURVEY RESULTS

SURVEY DATA SHEET REFERENCE NO	SURVEYED BY		DATE
DATE OF NRC NOTIFICATION	SURVEYED BY NRC ☐ Yes ☐ No	DATE OF NRC APPROVAL	BY WHOM

Approved By:

KERR-McGEE CHEMICAL CORPORATION - PROJECT MANAGER

KERR-McGEE CHEMICAL CORPORATION - HEALTH PHYSICIST

Received By:

NAME

COMPANY

Figure 12-10

12.10.1. Smear and Sample Counting (Cont'd)

In alpha counting, the smear should have high surface retentivity to prevent the particles from penetrating too deeply into the filter matrix. The alpha radiation has a very short range and must be near to the surface to the counted. Background levels in fixed alpha counter are of the order of 0.1 counts/minute. Detection efficiencies are quite high ($\sim$ 40%) for those alpha's which penetrate the detector.

In beta-gamma counting, background levels are of the order of 10 to 50 counts per minute, depending on location and shielding. Special techniques, such as the use of windowless gas flow proportional counter, must be employed for low energy beta particle counting such as the Ra-228 55 keV maximum beta.

12.10.2. Counting Time

The length of time that a sample is counted is determined by the need to obtain meaningful information. Samples of sufficient activity are ordinarily counted long enough to accumulate 1000 to 4000 counts. When accurate counts of low activity samples are required, particularly in the presence of significant backgrounds, long counting times may be required. The counting error (see 12.9.3) provides a useful indication of the significance of the measurement. Statistics and the treatment of counting data is a subject that cannot treated in depth in this manual. More complete explanations may be found in the literature, such as ANL 7291 by Moe, et al, Chapter 11, or NCRP Report No. 58.

12.10.3. Counting Errors

Successive counts of a sample will vary. The variation is a consequence of the statistical nature of radioactivity. The fluctuation is most significant at lower counts and can, if not taken into consideration, lead to misinterpretation of the data.

A statement of the error associated with a measurement enables one using the data to evaluate it. The error terms most used are called the standard error and the 95% Confidence Level.

12.10.4. Standard Error (Standard Deviation)

The variance of any count is the same as the count, no matter how long the counting time. This is useful because the standard deviation is the square root of the variance. We will use this to generate all the estimated standard deviations (s) in this procedure.

$$\text{Var}(N) = N \quad (1)$$

$$s_N = \sqrt{\text{Var}(N)} = \sqrt{N} \quad (2)$$

If a sample is counted for time t, the count rate r, is

$$r = N/t \quad (3)$$

The standard deviation of the count rate, s_r is

$$s_r = s_N/t = \sqrt{N}/t \quad (4)$$

This can easily be shown to be the same as

$$s_r = \sqrt{r/t} \quad (4a)$$

For example, if we count a sample for 4 minutes and we observe a total count of 4096 counts (2^{12}), then

N = 4096 counts,

Var (N) = 4096 counts,

t = 4 minutes,

$r = N/t = {}^{4096}/_{4} = 1024$ counts per minute,

$s_N = \sqrt{4096} = 64$, (Units are counts)

and $s_r = 64/4 = 16$. (Units are counts/min)

also $s_r = (1024/4)^{1/2} = (256)^{1/2} = 16$.

We can say that the sample has an activity of 1024 cpm with a standard deviation of 16 cpm.

12.10.5. 95% Confidence Level

Ordinarily we will use a 95% confidence interval. This is defined as 1.96 σ for a normal distribution. Sigma, σ, is the symbol for the true standard deviation or theoretical deviation. Since we are estimating σ from short observation we will estimate σ and refer to our estimate as s. We used s_N and s_r above for this reason. Because we are estimating s we will round our 95% confidence interval from 1.96 σ to 2s. (This makes many calculations simple.)

12.10.5. 95% Confidence Level (Cont'd)

The 95% confidence interval defines the range of values that we expect our measurement to include: Our example becomes

$r = 1024 \text{ cpm} \pm 32 \text{ cpm}$, 95% CL.

This could also be written as

$922 \leq r \leq 1055$, 95% CL.

Both mean exactly the same thing.

12.10.6. Evaluating the Count

The total count (N), divided by the count time (t), is the count rate (r). Using the technique of the previous section we can compute the error. Having completed that quantity and its precision (error) we may have to interpret it and make a decision. Is the material from which this smear was taken contaminated enough to require decontamination or storage, or can it be released for unrestricted use? The many factors affecting these decisions (background, release criteria, counter efficiency, etc.) are considered in the development of the Counting and Analysis forms and procedures established for the specific counting room instruction.

13. SPECIAL WORK PERMIT (SWP)

All jobs to be performed within a radiologically controlled area require a Special Work Permit (SWP), Figure 13-1.

13.1. PURPOSE OF THE SPECIAL WORK PERMIT

The SWP is used to control the conditions under which work is performed in Radiation Areas, Contamination Control Areas, and Airborne Radioactivity Areas. It serves as a record of the radiological safety conditions imposed upon the workers performing the task and the radiation exposure and contamination conditions that existed while performing that particular work. It also provides for notification of the work to be done and approval of the work and conditions by Health Physics, the Project Superintendent and the Project Manager.

13.2. OBTAINING A SPECIAL WORK PERMIT

To obtain a work permit the supervisor of the work to be done (such as the craft supervisor or Project Superintendent) originates the Special Work Permit (SWP) by completing the top portion of the form. The form is then submitted to Health Physics for completion of the body of the form.

Health Physics will perform the surveys required to provide the necessary information for the body of the SWP and will enter these data as applicable. Health Physics will specify the clothing or other protective equipment requirements by checking the appropriate blocks or adding special instructions. Health Physics will also check, as necessary, the radiation and airborne radioactivity exposure status of each individual who is to enter the controlled area to ensure that no person will receive an exposure above facility limits.

When the Health Physics requirements are completed the form is signed as approved by Health Physics and is returned to the supervisor for his signature (and initials as required for special instructions). This signature acknowledges the HP requirements as specified.

White - Job Site
Canary - Health Physics File

SPECIAL WORK PERMIT KM-2420-A NO. 7706

LOCATION

JOB DESCRIPTION

VALID: FROM / TO / SUPERSEDES

Nuclear Criticality Safety Limits and Controls Considered ☐ Yes ☐ No

RADIATION CONDITIONS

RADIATION MONITORING REQUIREMENTS

INDUSTRIAL SAFETY ITEMS TO CONSIDER ON BACK OF SHEET)

PROTECTIVE EQUIPMENT REQUIREMENTS

	✓	ITEM		✓	ITEM		✓	ITEM
HEAD		Safety Glasses	FEET		Safety Shoes	RESPIRATIONS		Half Face Mask
		Face Shield			Shoe Covers			Full Face Mask
		Cap			Canvas Boots			Scott Air Pac
		Hood			Rubbers			Fresh Air
		Hard Hat			Rubber Boots			
		Goggles	HANDS		Surgeon Gloves	DOSIMETERS		Film Badge
BODY		No Personal Outer Clothing			Canvas Gloves			Neutron Badge
		Smock			Leather Gloves			Gamma Pencils
		One Pair Coveralls			Rubber Gauntlet			Finger Rings
		Two Pair Coveralls			Asbestos Glove			

SPECIAL INSTRUCTIONS

WORK COMPLETED BY

OPERATIONS APPROVAL | MAINTENANCE APPROVAL | HEALTH PHYSICS APPROVAL

Return form to Area Operations Supervisor when work is completed

Figure 13-1

13.2. OBTAINING A SPECIAL WORK PERMIT (Cont'd)

The original of the SWP is provided to the supervisor for posting. A copy of the SWP should be retained in the HP office until the original is returned.

13.3. USE OF THE SWP

The original of the SWP is posted in a location where all workers involved in the job can read the requirements, or it is taken to the job site and posted at the entry to the work area. All personnel on the job who enter the controlled area shall sign the SWP. The signature shall indicate that the person has read the instructions on the SWP and agrees to follow them. Below the name on the sheet the person should indicate his craft or job classification.

Changes in work conditions such as opening pipes or vessels or removing or installing tents or ventilation may change the work conditions as specified on the SWP. Health Physics will periodically monitor conditions in the work area and if the changed conditions warrant it, he may terminate the SWP and re-assess the required conditions for continuing work in the area. Any changes in SWP requirements (for example respiratory protection) shall be given personally to all individuals listed on the SWP.

13.4. CLOSING AN SWP

An SWP is closed automatically at the end of the calendar month or when the job is completed, whichever occurs first. An SWP may be reissued if the job is not completed by the end of the month. After an SWP is terminated, the original SWP shall be returned to the HP office by the supervisor. The duplicate copy of the SWP may then be destroyed.

An SWP shall be terminated when the work in the job description cannot be properly performed under the prescribed conditions. A new SWP must be issued to describe the new work or conditions.

14. RECORDS AND REPORTS

The Health Physics staff is responsible for generating and maintaining records and reports relating to the radiation protection program at the West Chicago Facility.

14.1. HEALTH PHYSICS RECORDS

The following files shall be established and maintained by the Health Physics staff:

14.1.1. Procedures

a. Licensing documents as issued by the USNRC, including the license, license conditions, documents incorporated into the license, operating procedures, notices of violations, and responses to violation notices.
b. General radiation protection standards and procedures, including applicable Parts of Titles 10 and 49, Code of Federal Regulations.
c. Manufacturer's operating manuals for all Health Physics equipment and instrumentation.

14.1.2. Training Records

a. Records of attendance of all training sessions given for workers.
b. Records of written, oral or practical testing to workers in conjunction with training sessions, including scope of material covered by the testing.

14.1.3. Resumes

Resumes of all Health Physics personnel indicating formal training, on the job training, experience, education and other qualifications.

14.1.4. Personnel Monitoring Records

a. Form NRC-4 or equivalent for each employee, and supporting records.
b. Form NRC-5 or equivalent for each employee, including bioassay data if applicable.
c. Self-reading Dosimeter Log.
d. Dose Evaluation Report for lost or damaged film badge, TLD or dosimeter.
e. Film badge exposure reports from processor.
f. Airborne Radioactivity MPC-hour Exposure Record for employees working in Airborne Radioactivity Areas.

14.1.5. Radiation Monitoring Equipment Records

a. Instrument calibration and maintenance records.
b. Daily instrument standardization records.
c. Calibration certificates for instruments.
d. Calibration standard sources certificates.

14.1.6. Radioactive Materials Shipment Records

a. Radioactive Materials Shipment Records, including shipper's certification and shipment inventory.
b. Shipment Load Diagrams.
c. Shipment survey records.
d. Copy of Bill of Lading.
e. Record of routing and notifications to State Police.
f. Notification of shipment to receiving party.
g. Notification of receipt by receiving party.
h. Record of Hazardous Materials - Drivers Instructions received by driver.

14.1.7. Medical Services and Accident Records

a. Physical examination records, or medical release or rejection statements.
b. Accident investigation records.
c. First aid log.
d. Log of occupational injuries and illnesses (OSHA100) and supplementary record (OSHA101).

14.1.8. Radiation and Contamination Survey Records

a. Surveys performed in controlled areas.
b. Surveys performed in clean areas.
c. Surveys performed in unrestricted areas.
d. Personnel and personal effects contamination records.
e. Contamination monitoring (frisking) records.
f. Survey records for all materials released to unrestricted areas.

14.1.9. Radioactive Material Sampling Records

a. Records of air sampling.
b. Water and drainage sampling records.
c. Soil sampling records.

14.1.10. Radioactive Waste Records

a. Solid radioactive waste disposition records, including waste shipments and disposals.
b. Liquid radioactive waste disposition records, including releases to the sanitary sewerage system.

14.1.11. Respiratory Program Records

a. Procurement documentation.
b. Maintenance and use records.
c. Training and fitting program records.
d. Documentation of adequacy of the program.

14.1.12. Records of Sale or Transfer

A record of all materials and equipment released from the West Chicago Facility.

14.2. HEALTH PHYSICS REPORTS

This section describes the requirements for, information needed for, the distribution of, and retention of Health Physics reports. Complete and accurate reports are required in the following instances.

14.2.1. Routine Reports

a. Annual report of personnel exposure to ionizing radiation made to the individual at the individual's request.

14.2.2. Non Routine Reports to the USNRC

a. Personnel radiation exposure or airborne radioactivity exposure exceeding limits of this manual or the limits as specified in 10CFR20.
b. Report of any incident involving radioactive materials which results in loss of working time in an area exceeding 24 hours or a substanial property loss.
c. Report of excessive concentrations released to unrestricted areas.

14.2.3. Exposure Reports Requested by Individuals

a. A former employee's radiation exposure at the facility provided to the individual upon request.

b. A written report of radiation exposure or an estimate of exposure at the time of work termination provided to the individual upon request.

14.3 RECORDS AND REPORTS RETENTION

All Health Physics records and reports shall be retained until the USNRC and Kerr-McGee Chemical Corporation (Legal Department) authorize their disposition.

15. DECONTAMINATION

15.1. GENERAL

Decontamination is the removal of radioactive materials from materials where it is unwanted. This may be on a person's skin or on tools or equipment that are worth saving or on floors and walls or other building areas.

Decontamination can be time consuming and expensive. Consequently, every effort should be made to minimize and control contamination in order to reduce the amount of decontamination required. A judgement should be made on whether or not to decontaminate, considering time, cost and resulting benefit.

No single decontamination technique will be suitable for all situations. Generally, the choice of methods will depend on the nature of the surface to be cleaned, the chemical and physical form of the contaminant, the requirements for preventing damage to the equipment or item and the degree of contamination.

Health Physics can provide guidance in selecting methods of decontamination. The total volume and ultimate disposal of waste materials generated from the cleaning operation should also be considered and provisions made for adequately handling the expected waste.

Decontamination efforts at the West Chicago Facility will be limited due to the fact that exposure rates and contamination levels are already low. Decontamination efforts will be primarily aimed at preventing the spread of the radioactive materials during demolition and material removal. Dry vacuuming with HEPA filtered vacuums is effective for loose dusty contamination. Efforts should be made to minimize disturbing the dust and creating airborne problems. Painting contaminated surfaces to fix the contamination may also be a valuable technique to minimize the spread of materials.

15.2. PERSONNEL DECONTAMINATION

If substantial skin contamination occurs on an individual working with radioactive materials, specific procedures should be followed to prevent fixation of the material in the skin or absorption of the radioactivity through the skin.

15.2.1. Immediate Action

Notify Health Physics personnel, who will supervise the decontamination. If contamination is spotty, HP will supervise the cleaning of the individual spots with swabs, soap, or water. If the contamination is general, HP may recommend washing the area gently in warm or cool water (not hot) using hand soap (not detergent) for one minute. Rinse, dry and monitor for radioactivity. This soap wash step may be repeated three times.

15.2.2. Evaluation

If the above procedure fails to remove all the skin contamination, the treatment should cease. An evaluation of the skin contamination should be performed by Health Physics including an estimate of the dose commitment to the skin, and the quantity and identity of the nuclides contaminating the skin. If additional decontamination steps are necessary, they are performed and documented by Health Physics. The Contaminated Personnel or Personal Effects Report, Figure 15-1, shall be used to document the steps used and the investigation of the contamination. The guidelines for Personnel Decontamination in the Radiological Health Handbook, HEW 1970, beginning on Page 194 can be used as applicable. CAUTION: Do not use chemicals for personnel decontamination until full evaluation of the contamination is made by the HP Supervisor.

15.3. DECONTAMINATION OF TOOLS AND EQUIPMENT

Tools and equipment that become contaminated must be cleaned before release to uncontrolled areas as described earlier. Some examples of generally acceptable techniques are given below.

CONTAMINATED PERSONNEL OR PERSONAL EFFECTS REPORT KM-2928-A

DATE OF INCIDENT

TIME OF INCIDENT

NAME | BADGE NO | PLANT

LOCATION OF INCIDENT (ROOM)

DESCRIPTION

DESCRIBE IN DETAIL ANATOMICAL LOCATION, CONTAMINANT, TYPE OF INJURY, OR CONTAMINATED ARTICLE

CONTAMINATED ARTICLE OR AREA	DECONTAMINATION AGENT USED	INSTRT	SURVEY RESULTS Before	SURVEY RESULTS After	FINAL DISPOSITION OF ARTICLES

WOUND COUNT /5 min | BKGD COUNT /5 min | B-GP SOURCE COUNT /5 min

SAFETY MEASURES

PERTINENT SAFETY MEASURES IN EFFECT ☐ Yes ☐ No | IF NO, EXPLAIN

REMARKS

EMPLOYEE SIGNATURE

HEALTH PHYSICS

Figure 15-1

15.3. DECONTAMINATION OF TOOLS AND EQUIPMENT (Cont'd)

Small equipment, especially glassware or stainless steel tools or items can be cleaned by soaking in Alconox (R), or Radiac-Wash (R) solution. Ultrasonic cleaners or electropolishers can be used to remove contamination imbedded in cracks and crevices of small equipment. Items should be carefully wiped down using damp rags or wipes, folding the used surfaces in frequently, and disposing of the rags frequently.

Often the use of Dow Bathroom Cleaner (R), which contains EDTA and foams to lift materials away from the surface, is very effective for cleaning smaller items.

Always wash equipment from the top down, to prevent recontaminating already cleaned surfaces. Scrubbing with brushes or cloths is often more effective than just flushing. Equipment should be well washed and dried before monitoring for radioactive contamination, especially when monitoring for alpha activity which may be attenuated by dirt or water. All interior surfaces which may become contaminated must be monitored and cleaned if necessary.

15.4. DECONTAMINATION OF PREMISES

In some cases decontamination of premises will be desirable to reduce the possibility of radioactive materials becoming airborne. Decontamination procedures will be developed on a case by case basis. These procedures will be encorporated into the control work packages for each job.

Decontamination will be performed under the direction of Health Physics personnel. Appropriate signoffs may be required as part of the Control Work Package.

16. STORAGE OF RADIOACTIVE MATERIALS

16.1. GENERAL

Storage and use of radioactive materials are controlled by license conditions. No unauthorized use shall be made of any radioactive materials.

Radioactive materials may not be stored in clean areas such as office or administrative areas or in areas used for smoking, eating or drinking.

16.2. STORAGE OF RADIOACTIVE EQUIPMENT DURING DEMOLITION

A radioactive materials lay-down area may be established for the control and processing of radioactive materials, particularly radioactive wastes to be prepared for shipment during the demolition work. If feasible, radioactive materials are packaged for handling, to prevent the uncontrolled release of radioactive materials before transfer to the lay-down area. Efforts should be made to maintain lay-down areas as free from contamination as possible.

Health Physics must check each package or component for contamination and radiation if the item is to be moved through uncontrolled areas.

16.3. MONITORING AND TAGGING RADIOACTIVE MATERIALS

All radioactive materials are monitored and tagged by Health Physics before they are delivered to the lay-down area. A survey tag is used to record the following information on items that may contain radioactive materials greater than the quantities specified in Table 16-1:

a. Item description.
b. Dose rate on contact.
c. Loose surface contamination on item.
d. Loose surface contamination on package.

TABLE 16-1

QUANTITIES REQUIRING RADIOACTIVE MATERIALS LABELS

Radioactive materials below the following limits do not require a Radioactive Materials Label. These quantities are derived from Appendix C, 10CFR20, listing exempt quantities for the nuclides. Uranium and thorium daughters separated from parent nuclides have different exempt quantities.

Nuclide	Limit (microcuries)
U-nat	1,000
Th-nat	1,000

16.3. MONITORING AND TAGGING RADIOACTIVE MATERIALS (Cont'd)

e. Remarks.

f. Date.

g. Signature of HP.

As the item is prepared for shipment by cleaning, cutting, or repackaging, the survey information on the tag is kept up-to-date to show current status.

16.4. SEGREGATING RADIOACTIVE MATERIAL

Radioactive materials stored in the lay-down area should be segregated as much as possible to reduce cross contamination and radiation hazards. Health Physics supervises the storage of all radioactive materials.

The following guidelines are established for setting up storage areas:

a. Clean materials segregated by type, such as wood, metal, concrete.

b. Contaminated materials also segregated by type.

c. Equipment or other materials which are to be decontaminated and prepared for release.

Additional storage areas may be established as necessary.

16.5. HANDLING DURING PACKAGING

All radioactive materials that are processed or re-packaged for shipment are handled in a contamination control zone to help prevent the spread of contamination.

16.6. RADIOACTIVE WASTE INVENTORY CONTROL

Radioactive waste inventory control will be regulated by detailed, specific procedures. Because of the large volume and the variety of waste materials expected from the facility, procedures specific to each job and each type of waste will be developed in conjunction with the control work packages.

16.6. RADIOACTIVE WASTE INVENTORY CONTROL (Cont'd)

Procedures will include survey, labelling, storage and disposition requirements for waste produced throughout the site.

17. RADIOACTIVE WASTE DISPOSAL AND TRANSPORT

17.1. REFERENCE

All radioactive waste shall be handled and transported in a safe manner and in compliance with

10CFR71
49CFR173
10CFR20
USNRC Regulatory Guide 7.1

17.2. WASTE CLASSIFICATIONS

17.2.1. Transport Group

The transport group of a radionuclide is one of seven groups into which normal form (non-encapsulated) radionuclides are classified according to their relative radiotoxicity and potential hazard in transport. Examples are

Group I	Ra-226, Ra-228, U-232
Group II	Rn-222, U-233, U-233, U-234, Th-234
Group III	Th-nat, U-nat, Th-232, U-238
Group IV	Rn-220

The prevalent radioactive materials at the West Chicago Facility are thorium and uranium from naturally occurring ores. Natural thorium and uranium and concentrates of these materials are classified as low specific activity (LSA) materials and fall into the Group III transport group.

17.2.2. Radioactive Waste

Radioactive means any materials which spontaneously emit ionizing radiation. Materials in which the estimated specific activity is less than 0.002 microcuries per gram of material and in which the radioactivity is essentially uniformly distributed are not considered to be radioactive materials for transportation purposes.

17.2.3. Limited Quantity

Packages of limited quantities of radioactive materials are restricted in their total activity per package. Limited quantities are radioactive materials in normal form not exceeding:

0.01 millicurie	Group I nuclides
0.1 millicurie	Group II nuclides
1 millicurie	Group III, IV, V and VI nuclides

Limited quantity materials are exempt from some packaging requirements.

17.2.4. Low Specific Activity (LSA) Materials

Low specific activity materials are materials in which the radioactivity per unit volume or mass is relatively low. The amount of radioactivity permitted per unit mass varies with the radionuclides present. Low specific activity materials include: (1) unirradiated natural or depleted uranium and unirradiated natural thorium, and (2) materials in which the activity does not exceed 0.0001 millicuries of Ra-228, Ra-226 or other Group I nuclides per gram of material, and is fairly equally distributed.

17.2.5. Other Classifications

Materials not meeting classifications for LSA or limited quantity must meet more stringent packaging requirements as listed in 49CFR173.

17.2.6. Hazardous Materials

Hazardous wastes which are not radioactive are disposed of as hazardous wastes at authorized disposal sites. Precautions required for hazardous waste are specified by Department of Transportation and the USEPA and local regulations. Hazardous wastes that are radioactive may require special handling and special labelling. Consult 49CFR172.

17.3. CONTROLLING WASTES BEFORE PACKAGING OR DISPOSAL

17.3.1. Survey

Materials must be surveyed in preparation for disposal. Survey report forms shall be completed as required.

17.3.2. Marking of Materials

Results of surveys will establish clean or contaminated condition of the material. Materials for disposal are then marked with paint or labels as clean or contaminated as outlined in Section 10.

Building rubble and soil and other wastes must be segregated as clean or contaminated.

Materials should also be segregated by type of material, as different materials will require different disposal or packaging requirements. Examples of types of materials are: concrete, brick, wood and metals.

17.4. PACKAGING DRY LSA WASTE

Most waste at the West Chicago Facility will be LSA waste. The specific packaging requirements for LSA are given in 49CFR173.392 which are in general that LSA is shipped in strong, tight containers that can withstand handling normally incident to transportation. Maximum radiation levels are also specified.

Take special care to prevent the contamination of the outer surfaces of the container or the area in which the packaging is being done.

Almost all LSA packaging procedures will require an SWP (see Section 13).

The type of container or package required is determined at the time of packaging consistent with the levels of radiation, radioactive contamination and the size and weight of the material.

17.4.1. Packaging in Wooden Boxes

With the approval of the Health Physics personnel, solid radioactive contaminated waste may be packaged in a strong well built cleated wooden box that has a cover which closes the box securely. The box should be built to conform to DOT Specification 19A. Protect the exterior of the box from contamination. Prevent leakage of materials by caulking all seams or lining the box with polyethylene sheet, taping all joints made by lining the box. The polyethylene lining must be large enough that the items boxed can be completely sealed by overlapping the sheets of polyethylene and taping them together, thus preventing uncontrolled release of radioactive material. Secure the cover on the box.

For LSA shipments, survey the outside of the box and record the highest radiation reading obtained on each side of the box. Label as Radioactive LSA and provide an identification number for the package. An inventory control log is maintained for all packages.

17.4.2. Packaging in Steel Drums

With the approval of the Health Physics personnel, solid radioactive contaminated waste may be packaged in 5, 30, or 55 gallon steel drums with removable heads that meet DOT Specification 17-H. The material may be bagged in polyethylene bags and sealed before placing it in the steel drum if desired, but is not a requirement for packaging. The outside of the drum may be protected from contamination by placing the drum in a larger plastic bag with the bag folded into the drum. Do not use damaged drums. After packing the radioactive contaminated solid waste in the steel drum, the removable drum head is placed on the drum taking special care that the removable drum head gasket is properly placed and is capable of sealing the drum. Install the bolted type closing ring and secure the drum cover by tightening the bolt in the seal ring forming a leak tight seal to prevent release of radioactive materials.

For LSA shipments, survey the outside of the drum and record the highest radiation reading obtained on the outside of the drum. Label as Radioactive LSA and provide an identification number for the package. An inventory control log is maintained for all packages.

17.5. INCINERATION

Incineration of LSA organic materials must be specially authorized by license by the USNRC. Contaminated organics include materials such as paper, wood and natural fibers. Gases given off by the incinerator must be filtered before release to the atmosphere. Resulting ash materials are handled as LSA radioactive wastes. Ash should be kept wet to control the release of dust when the incinerator is emptied.

17.6. LIQUID LSA WASTE

Free standing liquids are not to be shipped for disposal at LSA burial facilities. Liquids must be solidified before shipping. Current regulations of the destination burial facility will give specific requirements.

Materials released to the sanitary sewerage system must meet release criteria as specified in 10CFR20. Documentation of releases must show compliance with these criteria.

17.7. RADIOACTIVE NON-LSA WASTES (RESERVED)

17.8. MONITORING AND LABELLING OF WASTES

Waste containers for shipment of radioactive wastes must be monitored for radiation and external removable contamination.

External contamination must be less than:

	Contamination Limit	
	Total	Removable
Contaminant	dpm/100cm^2	dpm/swipe*
U-nat, Th-nat		
Beta-gamma	220,000	22,000
Alpha	22,000	2,200
All other beta-gamma emitting nuclides	22,000	2,200
All other alpha emitting nuclides	2,200	220

* Limit per swipe (100cm^2), assumes a 10% collection efficiency.

17.8. MONITORING AND LABELLING OF WASTES (Cont'd)

These contamination limits are set forth by the Department of Transportation. Efforts will be made to keep removable contamination on waste shipment containers from the West Chicago Facility below the following limits:

Removable alpha activity	220 dpm/100 cm^2
Removable beta-gamma activity	2200 dpm/100 cm^2

Radiation levels of the package determine the Transportation Index of the package. Radiation levels may not exceed these levels:

	Radiation Levels	
Transportation Index Label	on contact	at 3 feet
Radioactive White I	0.5 mrem/hr	-
Radioactive Yellow II	50 mrem/hr	1.0 mrem/hr
Radioactive Yellow III	200 mrem/hr	10 mrem/hr

Packages must be labelled as Radioactive LSA or have the appropriate Transportation Index labels on the package, depending on the mode of shipment.

17.9. EXCLUSIVE USE SHIPMENTS OF LSA MATERIALS

Exclusive use shipments are also called sole use or full load shipments. This means that the entire shipment comes from only one source, that the party initiating the shipment has exclusive use of the transport vehicle for the duration of the shipment, and that the shipment is not loaded or unloaded except under the direction of the party initiating the shipment or the receiver of the shipment.

17.9.1. Special Requirements for LSA Exclusive Use Shipments

To be able to ship as LSA exclusive use these requirements must be met:

a. All materials are LSA materials
b. Exclusive use requirements are all met
c. Package and vehicle contamination levels are limited and radiation levels of the vehicle must also meet the same criteria as non exclusive use shipments
d. Each package is labelled RADIOACTIVE - LSA
e. Instructions are provided to the shipper explaining all sole use requirements during transporting
f. There are no loose materials
g. Vehicle is placarded
h. Uranium and thorium ores and concentrates and materials of low radioactivity concentration are exempt from some of these requirements. See 49CFR173.392.

17.9.2. Special Exemptions for LSA Exclusive Use Shipments

When materials are shipped as LSA exclusive use, some special exemptions from packaging requirements are acceptable. These shipments are exempt from:

a. Specification packaging. Packages must be strong, tight and able to withstand normal handling.
b. Dimension limitations.
c. Shielding and internal bracing requirements.
d. Marking and labelling requirement, except that each package must have RADIOACTIVE - LSA marked on it.
e. Seal requirement.

17.10. LSA SHIPMENTS OTHER THAN EXCLUSIVE USE

LSA materials for shipment as individual packages, that is not a full load shipment, must meet all packaging, labelling, and sealing requirements for type A or B quantities as specified in 49CFR172 and 49CFR173.

17.11. SHIPPING DOCUMENTS

The following documents are required for transport of radioactive materials:

a. Bill of Lading.
b. Radioactive Materials Shipment Record, including the shippers certification.
c. Shipment Load Diagram.
d. Hazardous Materials Driver's Instructions.
e. Radiation and Contamination Survey Records.
f. Receipt of Materials Letter.

17.11.1. Bill of Lading

The Bill of Lading is the contractual agreement of the shipper to deliver the shipment of materials. A standard Bill of Lading short form may be used and is shown in Figure 17- 1 . The Bill of Lading is carried with the shipment.

17.11.2. Radioactive Materials Shipment Record

The Radioactive Materials Shipment Record is a complete record of the materials and the sender, carrier and receiver of the materials. Figure 17- 2 shows a sample form. If the materials to be shipped are waste for disposal, this form should be obtained from the burial facility in advance to assure that all information required by that facility is on the form. If the materials are not waste, the information may be recorded on a facility form.

Snap off

CARBON FORM 3743 — **Quadruplicate Form**

ORIGINAL – NOT NEGOTIABLE

STRAIGHT BILL OF LADING - SHORT FORM

Shipper's No. _____

(Name of Carrier) Carrier's No. _____

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading.

At _____ 19 ____ FROM _____

The property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its own road or its own water line, otherwise to deliver to another carrier on the route to said destination. It is agreed, as to each carrier of all or any of said property over all or any portion of said route or to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Uniform Freight Classification in effect on the date hereof, if this is a rail or a rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment.

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

CONSIGNED TO _____

(Mail or street address of consignee—For purposes of notification only.)

DESTINATION _____ STATE _____ COUNTY _____ DELIVERY ADDRESS _____

(If to be filled in only when shipper desires and governing tariffs provide for delivery thereat.)

ROUTE _____

DELIVERING CARRIER _____ CAR OR VEHICLE INITIALS _____ NO. _____

No. Packages	Kind of Package, Description of Articles, Special Marks, and Exceptions	*WEIGHT (Subject to Correction)	Class or Rate	Check Column

Subject to Section 7 of Conditions of applicable Bill of Lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of Consignor.)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Received $ _____ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per _____

(The signature here acknowledges only the amount prepaid.)

Charges Advanced

$ _____

C.O.D SHIPMENT

C. O. D. Amt. _____

Collection Fee _____

Total Charges _____

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is carrier's or shipper's weight.

NOTE— Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ per _____

† The Fibre Boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Consolidated Freight Classification. ‡ Shipper's imprint in lieu of stamp; not a part of bill of lading approved by the Interstate Commerce Commission.

SHIPPER PER _____

AGENT _____ PER _____

Permanent post-office address of shipper _____

TOPS 3743
LITHO-USA

Figure 17-1

Figure 17-2

FROM Company Name _____
Contact _____
Address _____
_____
_____
Telephone # _____
TO _____
_____

BARNWELL WASTE MANAGEMENT FACILITY

Operated by: CHEM-NUCLEAR SYSTEMS, INC.

P. O. Box 726, Barnwell, South Carolina 29812
(803) 259-1781

RADIOACTIVE SHIPMENT RECORD FORM

Page _____ of _____

Carrier Name _____
Driver Signature _____
Date & Time Rec'd _____

Shipping Date _____

Customer Survey No _____

(16)

Type of Cask _____

Trailer # _____

CNSI USE ONLY

Arrival Date _____ Survey No _____
Date Buried _____ By _____
Radiation Reading _____ Weight _____
Trench No _____ WCC _____
LOC Code _____ Items _____
Total PERS EXP _____

(1) Item Number	(2) Radio-nuclide	(3) Physical Form	(4) Chemical Form	(5) Waste Description	(6) SNM (Grams)	(7) Source (Pounds)	(8) Activity (Millicuries)	(9) Gross Weight	(10) Trans-port Group	(11) Container Cu. Ft.*	(12) Container Spec.	(13) Rad. Level (mR/HR) Surface / 3 ft.	(14) External Removable Contamination DPM/100cm² α / βγ	(15) Label Used
TOTAL														

IMPORTANT: This is to certify that the above named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Signature _____
Company _____ Date _____
(See Reverse Side for Instructions for Completing This Form)

Copies: White-Accompany Shipment; Canary-Customer; Pink-Carrier

Certification is hereby made to the South Carolina Department of Health and Environmental Control that this shipment of low level radioactive waste has been inspected in accordance with the requirements of South Carolina Radioactive Material License No. 097 as amended, and the Nuclear Regulatory Commission's License No. 46-13536-01 as amended, and the effective Barnwell Site Disposal Criteria with 48 hours prior to shipment and further certification is made that the inspection revealed no items of non-compliance with all applicable laws, rules and regulations.

Date _____ By _____

Title and Organization _____

Telephone No. ( ) _____

Form No. CNS 201
(9/79)

CHEM-NUCLEAR SYSTEMS, INC.

INSTRUCTIONS FOR COMPLETING RADIOACTIVE SHIPMENT RECORD FORM

NOTE: SHIPMENT MAY BE REFUSED IF CONTENTS, SUPPORTING DOCUMENTATION AND PACKING REQUIREMENTS ARE NOT IN COMPLIANCE WITH CHEM-NUCLEAR SYSTEMS, INC.'S STATE AND FEDERAL LICENSES, THE BARNWELL SITE CRITERIA AND APPLICABLE DOT AND NRC SHIPPING REGULATIONS.

GENERAL
Customer or shipper must provide (printed or typed) information in all numbered column headings.

Indicate company name, contact address and phone number, company name of carrier who is transporting the material and the date of the shipment in spaces provided.

An authorized representative of the company must sign and date the State of South Carolina and DOT Certification statements.

Column heading entries are to be made as follows:

(1) Item or container number - list each container separately. Identification on package itself shall match number in this column.

(2) Radionuclide - list each radioisotope contained in each container (See Note #3). The terms MFP and MCP **are not permitted.** Use as many lines as are required.

(3) Physical State - indicate state - solid, gas, biological.

(4) Chemical Form - reference section 172.203 of 49 CFR.

examples:

	waste	**chemical form**
1.	solidified liquid	urea formaldehyde (UF) (solidification media)
2.	resin	metallic oxide deposited on resin
3.	laboratory trash	Na or KI, SrCl$_2$, etc.

(5) Waste description examples: (evaporator bottoms), (filter materials), (solidified resins), (irradiated metals), (animal carcasses), et cetera.

(6) SNM (Special Nuclear Material) grams - weight in grams of material as defined in 10 CFR Part 20.3 (S.C. Title A 1.2.24) cannot exceed 50 grams per 4.0 cubic feet or larger container.

(7) Source Pounds - weight in pounds of material as defined in 10 CFR Part 20.3 (S.C. Title A 1.2.24).

(8) Record the activity (millicurie) quantity of **each** isotope in **each** container (including the activity of the SNM and Source Pounds).

(9) Gross Weight - weight in pounds of the disposable container (including contents). All packages in excess of 110 pounds must have weight indicated (see 49 CFR 172.310).

(10) See Section 173.390 of 49 CFR.

(11) Record external volume of container (7.5 ft^3 for a 55 gallon drum, 4.0 ft^3 for a 30 gallon drum, and 0.85 ft^3 for a 5 gallon pail).

(12) Indicate DOT/NRC container specification if applicable, such as Spec 7A, Type B package, strong tight container, et cetera.

(13) Record the highest measured radiation levels for each disposable container at the specified distances. Transportation Index Number (T.I.) equals mR/hr reading at 3 feet.

(14) Removable contamination levels on containers shall not exceed levels set forth in Section 173.397 (a) of 49 CFR.

(15) Packages shall be labeled as required by Sections 172.101, 172.300, 172.400, 172.403 and 173.397 of 49 CFR.

(16) Record cask identification number from name plate on cask.

(17) Record the trailer identification number in space provided.

Note: 1) The total line at the bottom of each page must be completed for columns 1, 6, 7, 8 and 11 by the customer.

2) Each resin shipment must be accompanied by an isotopic analysis representing this shipment which includes each isotope, the abundance of each and the total curie content.

3) If more than one container in the shipment contains the same percent abundance of each radionuclide, then a listing of radionuclides and their percentage abundance is required only for first container of this series. Subsequent containers in a series must be so designated. This listing or designation should be in Column #2. In addition, only the total millicurie content for each container in the series need be listed in Column #8.

4) Additional shipping papers may be required - refer to 49 CFR 172.201 through 172.203.

5) Biological shipments must comply with 49 CFR 173.386 through 173.388 in addition to the Site Criteria.

Figure 17-2 (Reverse side)

17.11.2. Radioactive Materials Shipment Record (Cont'd)

The Shipper's Certification must appear on this form and be worded exactly as presented in 49CFR172.204. This states that the originator of the hazardous materials shipment certifies that all requirements for packaging and labelling have been met. The Shipper's Certification states "This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation."

17.11.3. Shipment Load Diagram

A Shipment Load Diagram, as shown in Figure 17-3 requires that all radiation and contamination surveys of the transport vehicle are made. Surveys must be taken before the truck is loaded. The truck shall not be loaded if removable surface contamination exceeds 2200 dpm/100 cm^2 beta-gamma or 220 dpm/100 cm^2 alpha activity, or radiation exceeds 0.5 mrem/hr.

After the materials are loaded additional surveys must be made. These surveys must demonstrate that the vehicle conforms to all requirements in 49CFR173.393. In general,for exclusive use shipments, radition levels must not exceed: 10 mrem/hr six feet from the exterior surface, 200 mrem/hr on contact with the vehicle and 2 mrem/hr in the cab or other occupied portion of the vehicle. The tires of the truck should also be checked for contamination before release from the restricted area.

17.11.4. Hazardous Materials Driver's Instructions

For each shipment of radioactive materials, a Hazardous Materials Driver's Instructions sheet must be given to the driver. This set of instructions must include:

a. A layman's description of the materials in the shipment and their hazards under damaged conditions.

b. A complete set of instructions that the driver may follow in case of an accident, if the material load is damaged, or if the shipment is delayed.

KERR-McGEE CHEMICAL CORPORATION
WEST CHICAGO FACILITY

KM-4794

SHIPMENT LOAD DIAGRAM

SHIPPER	CAB NUMBER	TRAILER NUMBER
SURVEY BY	SHIPMENT NO.	DATE

TRUCK CHECKED FOR CONTAMINATION:

BEFORE LOADING: ☐ <2200 dpm/100 cm^2 beta-gamma ☐ <220 dpm/100 cm^2 alpha

☐ CONTAMINATED TO

RADIATION LEVEL, mR/hr	CONTAMINATION LOCATION

AFTER LOADING: ☐ <2200 dpm/100 cm^2 beta-gamma ☐ <220 dpm/100 cm^2 alpha

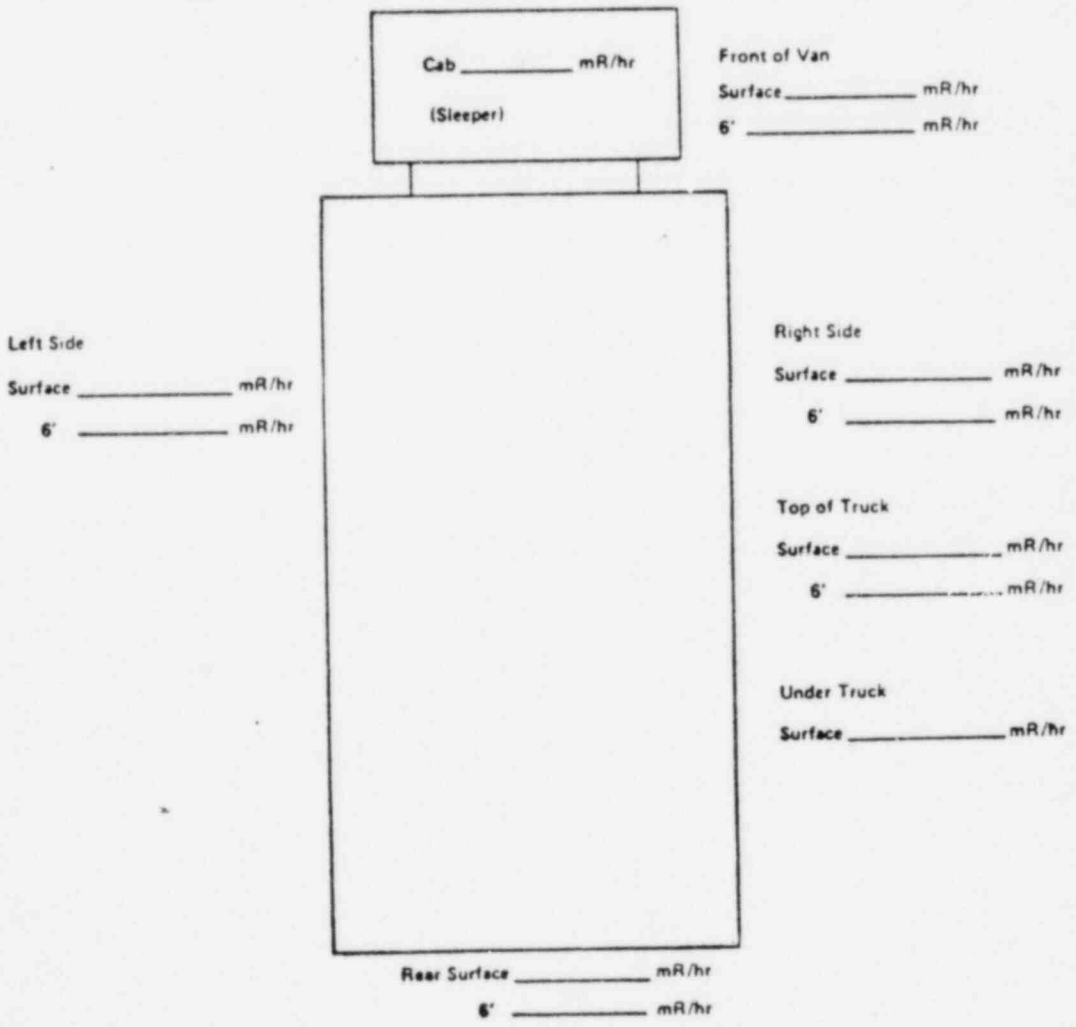


Figure 17-3

17.11.4. Hazardous Materials Driver's Instructions (Cont'd)

c. A routing instruction showing specific routing that the shipment may take must accompany the shipment. The routing must be established before the shipment is released. Local and state authorities in West Chicago and Illinois will give specific routings. Each state that the shipment passes through must be contacted for routing. Some states require prior notice of shipment. All logistics for routing should be planned ahead of shipping date. All instructions must be given to the driver, and he must understand their binding requirements.

d. An emergency call list of personnel to contact in any emergency or unanticipated situation.

e. Instructions regarding exclusive use requirements prohibiting reloading or loading of additional packages, and other requirements.

17.11.5. Radiation and Contamination Survey Records

All shipments of radioactive materials must have documentation that all required surveys have been made according to accepted procedures. Standard survey record forms are used when surveying packages or the shipping vehicle. These survey records are part of the shipment record.

17.11.6. Receipt of Materials Letter

A simple verification letter can be sent with the shipment to serve as a receipt. An original and a copy of the letter and a self-addressed stamped envelope accompany the shipment. The receiving party can then fill in the time and date of receipt of the shipment and send a copy to act as a notification of receipt of the shipment. A sample letter is shown in Figure 17-4.

EXAMPLE ONLY

Date _____

Kerr-McGee Chemical Corporation
Attention: _____
798 Factory Street
West Chicago, IL 60185

SUBJECT: Verification of Receipt of Radioactive Materials

To whom it may concern:

We have received the following radioactive materials shipment.

Customer Survey No. _____

Item Nos. _____

Trailer No. _____

Carrier _____

Time _____

Date _____

_____
Signature

Name _____

Title _____

Figure 17-4

17.12. RADIOACTIVE MATERIALS SHIPMENT PROCEDURES

Instructions contained in this section do not constitute specific procedures for shipment of radioactive materials. It is important that radioactive materials are shipped in a safe manner and in compliance with all federal, state, local and facility regulations. Shipping of radioactive materials, particularly waste materials, must be planned well in advance. Disposal facilities may require several months advance notice, as well as notification just prior to shipment. These facilities may also require additional shipper's certification. States which are to be traversed may have special requirements for routes and notifications. These requirements may change, and it is important that current regulations and licenses are used to develop shipment procedures.

Approved written procedures should be developed to assure compliance with all applicable regulations. Approved written procedures will be strictly followed when shipping radioactive materials.

18. EMERGENCY PLANS

Considering the radiological conditions which exist at the West Chicago Facility, only very limited personnel exposure hazard or environmental impact would result from an emergency situation. The primary health physics concerns in an emergency would be to control the spread of radioactive materials, and to minimize and assess released airborne radioactivity.

In any accident or unanticipated situation Health Physics and the Project Superintendent should be notified immediately.

18.1. ACCIDENTAL SPILL OF RADIOACTIVE MATERIALS

If an accidental spill of radioactive materials occurs, the following procedures are followed:

a. Workers near the location of the spill should stop the spill if possible, leave the immediate area, and should avoid spreading contamination.

b. Potentially contaminated workers should also evacuate the immediate area, but they should remain close enough to avoid tracking contamination farther than necessary.

c. Health Physics will warn other workers of the spill and the area will immediately be isolated.

d. Health Physics personnel will monitor all personnel involved in the accident for contamination. HP personnel will instruct workers as to procedures for personnel decontamination if necessary.

e. HP will monitor the area and set up controlled areas as necessary. Decontamination may be required to prevent spread of the contamination.

18.2. UNANTICIPATED AIRBORNE RADIOACTIVITY RELEASE

Engineering controls will be used whenever practical and beneficial to minimize the release of airborne radioactivity. Dust control methods will be used during decommissioning activities to assure that airborne radioactivity exposure to workers and the public is kept as low as reasonably achievable.

In the unlikely event of an unanticipated release of airborne radioactivity, the following procedures are followed, unless respiratory protective equipment is used.

a. Workers in the immediate area will be evacuated in an upwind direction. Evacuation of offsite personnel will not be warranted for radiological reasons.

b. The area will be isolated and air sampling will be initiated. Air samples being taken when the release occurred will be analyzed. An evaluation of the release will be made.

c. Health Physics will establish control of the area if necessary, and re-entry requirements will be based on airborne radioactivity concentrations and respiratory protective equipment in use. A new SWP may be required.

18.3. FIRE IN A CONTROLLED AREA

Security guards procedures are established for reporting fires at the West Chicago Facility. In the event of fire in a controlled area, the following actions will be taken.

a. Attempts may be made to extinguish small fires. Personnel are trained in the use of extinguishing equipment. Respiratory equipment and protective clothing may be required in extinguishing the fire. Health Physics and the site Superintendent are notified of the fire.

b. Local fire department will be notified if a fire cannot be immediately extinguished.

c. Personnel not engaged in fire fighting will evacuate the immediate fire area in an upwind direction. Determine accountability of personnel to ensure that all workers in the are have been evacuated. Evacuation of offsite personnel will not be warranted for radiological reasons.

18.3. FIRE IN A CONTROLLED AREA (Cont'd)

d. If a fire cannot be quickly controlled the local fire department will enter the area, rescue any injured or trapped personnel and extinguish the fire. Fire fighters will wear respiratory equipment, protective clothing and personnel monitoring devices. Safety belts and lines may also be required. Fire fighting techniques that reduce the spread of contamination, such as CO_2, foam or dry chemical, are preferred over water stream.

e. Health Physics will establish a control boundary and must check all fire fighting equipment and personnel for contamination before they leave the area.

18.4. INJURY IN A CONTROLLED AREA

a. In all cases of serious injury, life saving efforts take priority over health physics considerations. If a contaminated victim is transported to a hospital, health physics personnel will accompany the victim to aid emergency room personnel avoid the spread of contamination. Ambulance and medical equipment are monitored and decontaminated if necessary at the hospital.

b. Victims injured less seriously will be checked for contamination before leaving the site. Superficial decontamination, such as removal of outer clothing, may be performed.

18.5. EMERGENCY AGENCY AGREEMENTS

All offsite agencies which may be called upon during an emergency must provide agreement to perform the requested service. Agreements with fire departments, police, ambulance service and hospital must be arranged. Offsite agencies must be made aware of possible radiation and contamination associated with an emergency on the site.

18.6. EMERGENCY COMMUNICATIONS

During an emergency prompt and accurate communications are essential. Do not tie up communication links with long conversations.

Figure 18-1 is an emergency call list. Agencies and personnel to be notified are determined by the type and severity of the emergency.

EMERGENCY COMMUNICATIONS LINK
ON SITE PERSONNEL

Prompt and accurate communications are essential. Make communications complete, concise, and brief.

Title	Name	Day Phone	Night Phone
Project Manager			
Project Superintendent			
Health Physicist			
Health Physics Personnel			
Safety Engineer			
Security			
Kerr-McGee Corporate (contact at least one individual listed)			

EMERGENCY COMMUNICATIONS LINK
OFF SITE AGENCIES

Prompt and accurate communications are essential. Make communications complete, concise, and brief.

Title	Day Phone	Night Phone
Police - Local		
- County		
- State		
Fire Department		
First Aid		
Ambulance		
Rescue Squad		
Hospital		
Clinic		
Physician		
NRC Region III		
Civil Defense		

Figure 18-1 (Cont'd)

19. MEDICAL PLANS

Medical examinations are required for all people who are to wear respiratory equipment. Medical records of all injuries and contaminated wounds must be retained.

19.1. MEDICAL EXAMINATION

All employees or others who are required to wear respiratory protection must have a medical examination and evaluation in accordance with 10 CFR 20, USNRC Regulatory Guide 8.15 and NUREG-0041. This examination shall identify individuals who have significant attributes that prevent the effective wearing or proper functioning of respiratory protective equipment.

The specific medical examination, evaluation and recording requirements are applicable to the examining physician and the medical staff.

19.1.1. Scheduling and Notification

When medical exams are to be performed facility personnel will arrange an appointment with the physician. The employee and the Superintendent will be notified of the time, date and location of the appointment. The Superintendent will ensure that the appointment is kept. The employee will be provided with a Kerr-McGee Physical Examination Form (Figure 19-1) to take to the physician for the examination.

19.1.2 Health History

The individual shall provide the information necessary to complete the physicians Health History Questionnaire. The physician will supply standard forms.

19.1.3. Physical Examination

A physical examination is required for persons who will be required to wear respiratory protective equipment. The physical examination will be performed as specified in Figure 19-1, Physical Examination Form.

The employee is required to fill out personal data and health condition sections. The examining physician will complete the remainder of the form.

The physical examination shall include, but not be limited to, a medical history; an examination of eyes, nose, throat, heart, and lungs; a chest X-ray, if indicated; a pulmonary function test; CBC, differential, platelet count, and an audiogram. An electrocardiogram may be given if the need is indicated. The data in the questionnaire shall be elaborated on by the examiner whenever necessary to present a more complete picture of the individual's medical history. Special attention shall be paid to prior medical radiation exposure or diagnostic X-ray examination. This history shall be detailed by the examiner in the history remarks.

If indicated, a chest X-ray, 17" x 14" shall be used in the evaluation. All X-rays shall be made in accordance with Guidelines for the Routine Use of Diagnostic X-ray Examination for Employment Purposes; Figure 19-2.

19.1.4. Medical Release Statement

Following the physical examination, if the individual is qualified to use respiratory protective equipment, the physician will sign the Medical Release Statement, Figure 19-3, and shall send it to the Project Superintendent at the West Chicago Facility.

If there are qualifications, such as the need to wear dentures, or prohibition from wearing contact lenses, these shall be clearly stated on the Statement.

If there are conditions found which, on evaluation by the examining physician, disqualify the individual from wearing respiratory protective equipment, the physician shall so indicate on the Medical Release Statement, stating the reasons in the Physician's Remarks Section of the same form.

KERR-McGEE CORPORATION
AND SUBSIDIARY COMPANIES

DATE

JOB-RELATED MEDICAL EXAMINATION

PERSONAL DATA

NAME (PLEASE PRINT) | DATE OF BIRTH
HOME ADDRESS (FOR PERMANENT MAILING) | CITY, STATE AND ZIP
TELEPHONE (AREA CODE-NUMBER) | SOCIAL SECURITY NUMBER

VOLUNTARY STATEMENT OF HEALTH CONDITION

Kerr-McGee Corporation is an affirmative action employer for the handicapped.
Do you wish to be considered a handicapped worker under this program? ☐ Yes ☐ No

LIST ANY PHYSICAL OR MENTAL CONDITIONS THAT WILL REQUIRE SPECIAL JOB ACCOMMODATION

I certify that the answers given above are true, and I understand that any false statements will be considered cause for dismissal. I consent to the Physical Examination and I authorize the physician to communicate all findings to Kerr-McGee and Subsidiaries for their use.

SIGNATURE OF APPLICANT
APPLICANT (Do not write below this line)

TO THE EXAMINING PHYSICIAN
(Must be completed by the person authorizing examination)

DOCTOR: Please familiarize yourself with the "TYPE OF WORK APPLIED FOR." Complete the MEDICAL HISTORY, and perform the TYPE I or TYPE II examination outlined on the reverse side.

TYPE PHYSICAL REQUIRED

☐ I. ROUTINE
☐ II. COMPLETE WITH X-RAYS
(When pregnancy is possible, perform test for pregnancy. If positive, defer X-rays and explain in Comments section.)

PLUS ☐ RESPIRATOR FIT & USE (attach results)
☐ PULMONARY FUNCTION TEST (attach results)

TYPE OF WORK APPLIED FOR: (Give functional statements of job requirements)

NAME OF PERSON AUTHORIZING EXAMINATION (If | ADDRESS
COMPANY | CITY, STATE, AND ZIP CODE

MEDICAL HISTORY
(For Physician's Use)

DOES THE PATIENT HAVE ANY CONDITION THAT REQUIRES PERIODIC ABSENCE FROM WORK? ☐ Yes ☐ No | IF YES, WHAT? | HOW OFTEN? | USUAL DURATION?

DOES THE PATIENT HAVE | IMPAIRED HEARING ☐ Yes ☐ No | IMPAIRED EYESIGHT ☐ Yes ☐ No | A SPEECH IMPAIRMENT ☐ Yes ☐ No

DOES THE PATIENT HAVE ANY OTHER PHYSICAL DEFECTS? ☐ Yes ☐ No (If yes, describe in Comments section) | IS THE PATIENT CURRENTLY RECEIVING MEDICAL TREATMENT? ☐ Yes ☐ No (If yes, describe in Comments section)

DOES THE PATIENT NOW HAVE OR HAS EVER HAD (CHECK EACH ITEM AND GIVE THE YEAR OF OCCURRENCE. WRITE NOW IF APPROPRIATE.)

(CHECK EACH ITEM)	YEAR	(CHECK EACH ITEM)	YEAR	(CHECK EACH ITEM)	YEAR
A Back Deformity		Heart Trouble		Diabetes	
Back Trouble		Chest Pains		Mental Illness	
Foot Trouble		Alcoholism/Drug Addiction		Trouble at Reproductive Organs	
Rheumatism or Arthritis		Rheumatic Fever		Lung Disease	
Allergy		Asthma		Kidney Trouble	
Digestive System Disorder		Difficulty in Breathing		Venereal Disease	
Severe Headache		Hernia or Rupture		Epilepsy	
Contact Lens		Hemorrhoids		Regular Medication	

COMMENTS

MAIL COMPLETED FORM AND STATEMENT OF CHARGE TO THE PERSON AUTHORIZING EXAMINATION

Figure 19-1

FOR PHYSICIAN'S USE

TYPE II. COMPLETE PHYSICAL WITH X RAYS

TYPE I. ROUTINE PHYSICAL

HEIGHT	WEIGHT	PULSE	BLOOD PRESSURE	HEMATOCRIT	SEROLOGY	HEARING (ATTACH AUDIOGRAM)	EKG (IF INDICATED) ATTACH RESULTS
VISION (WITHOUT LENSES) R / L		VISION (WITH LENSES) R / L		COLOR VISION (ISHIHARA COLOR PLATES)		URINALYSIS / ALBUMIN	SUGAR

PLEASE EXAMINE, DESCRIBE OR COMMENT ON EACH ABNORMAL FINDING.

CHECK EACH ITEM	NORMAL	ABNORMAL	CHECK EACH ITEM	NORMAL	ABNORMAL	CHECK EACH ITEM	NORMAL	ABNORMAL
General Appearance			Teeth and Mouth			Extremities		
Head			Lungs and Chest			Spine		
Eyes			Heart			Arteries		
Ears			Abdomen			Nervous System		
Nose and Sinuses			Hernia			Pelvic or Rectal (if appropriate)		
Throat and Teeth			Breasts					

AP AND LAT X-RAY OF LUMBAR SACRAL SPINE

X-RAY OF CHEST (AP AND LAT.)

POSITIVE FINDINGS AND ABNORMALITIES — DESCRIPTION OR DISCUSSION

DURING YOUR EXAMINATION DID YOU OBSERVE ANY SYMPTOM OR PHYSICAL FINDING WHICH MIGHT IN ANY WAY BE AGGRAVATED BY THE TYPE OF WORK APPLIED FOR?

PHYSICIAN'S RECOMMENDATIONS

☐ ACCEPTABLE FOR TYPE OF WORK APPLIED FOR
☐ ACCEPTABLE FOR TYPE OF WORK APPLIED FOR WITH RESTRICTIONS INDICATED BELOW
☐ NOT RECOMMENDED FOR TYPE OF WORK APPLIED FOR

RECOMMENDED RESTRICTIONS

LEG AND FOOT
- ☐ Limited standing/walking _____ hours per day
- ☐ Unable to use foot/leg (R or L)
- ☐ Limited use of foot/leg (R or L)

VISION
- ☐ No depth perception
- ☐ Limited color discrimination
- ☐ Must wear eye protection at all times

HEARING
- ☐ No hearing
- ☐ Limited hearing
- ☐ No exposure to excessive noise

ATMOSPHERIC CONDITIONS
- ☐ No exposure to silica or asbestos dust
- ☐ No exposure to respiratory irritants
- ☐ No exposure to nuisance dust, smoke or fumes

LOSS OF SELF CONTROL
- ☐ No work at elevations
- ☐ No serious hazards to self or others in event of loss
- ☐ No mobile equipment operation

CHEMICALS AND IRRITANTS
- ☐ No exposure to _____

ARM AND HAND
- ☐ Unable to use hand/arm (R or L)
- ☐ Limited use of hand/arm (R or L)

BACK AND GROIN
- ☐ Limited carrying/pushing/pulling
- ☐ Limited stooping/bending

LIFTING LIMITATIONS
- Less than ☐ 25 lbs ☐ 50 lbs ☐ 75 lbs

PHYSICAL EFFORT
- ☐ Limited physical exertion

WORK SCHEDULE — Can work only _____ hours per day; can work any shift except _____; Can work only _____ days per week; Overtime? ☐ Yes ☐ No

PLEASE PRINT PHYSICIAN'S NAME AND TITLE

PHYSICIAN'S SIGNATURE

ADDRESS, CITY, STATE AND ZIP

DATE OF EXAMINATION

Figure 19-1 (Reverse side)

Guidelines for the Routine Use of

Diagnostic X-Ray Examinations for Employment Purposes

1. Prescription of clinically unproductive X-ray examinations should be avoided.
2. Chest X-ray examinations in routine physical examinations or as a routine requirement for employment should not be performed.
3. Prescription of X-ray studies for the purpose of obtaining diagnostic information should be based on clinical evaluation of symptomatic individuals.
4. Routine screening evaluations, without prior clinical evaluation, should not be performed without careful consideration of both benefit and risk.
5. X-ray examinations should only be prescribed by physicians with expertise to evaluate the examinations.
6. The number of standard views should be limited to those necessary to perform the diagnosis for the intended purpose.
7. Prescription of X-ray examinations for pregnant or possibly pregnant women should assure that medical consideration has been given to fetal exposure and that protective measures are taken.
8. The appropriate technique should be used to keep entrance skin exposure for routine chest X-rays to less than 30 mR.

Figure 19-2

KERR-McGEE CHEMICAL CORPORATION
WEST CHICAGO FACILITY

KM-4803

MEDICAL RELEASE STATEMENT

IDENTIFICATION

NAME _____ SOCIAL SECURITY NO. _____

DATE OF BIRTH _____ AGE _____

COMPANY OR CRAFT _____ ID NO. _____

This individual ☐ is ☐ is not found to be physically qualified to wear respiratory protective equipment.

PHYSICIAN'S REMARKS:

_____

_____

_____

_____

_____

_____

EXAMINING PHYSICIAN _____

SIGNATURE _____

DATE _____

ADDRESS _____

CITY AND STATE _____ ZIP _____

TELEPHONE _____

Figure 19-3

19.1.5. Records

All records of the physical examination shall be considered confidential between the employee and the physician. However, records made under this procedure shall be made available to the Kerr-McGee Chemical Corporation's Medical Director upon written request to the physician.

Records shall be retained by the physician for 20 years.

19.2. INJURIES

Treat minor injuries occurring in an uncontrolled area by routine first aid procedures. A record of very minor injuries is not required but should be maintained as good practice.

Serious injuries must be treated by a physician. Medical services for injury victims must be arranged in advance and the phone number of the physician(s), hospital, and insurance company shall be posted in the Health Physics office and the Project Superintendent's office. The Project Superintendent must be notified immediately of any serious injuries.

19.2.1. Injury in a Controlled Area

Accidents that occur within controlled areas must be handled to control complications from contamination and radiation.

If no surface contamination is present the person should be removed from the controlled area as soon as possible to limit radiation exposure. If contamination is present, decontamination is performed as necessary to limit the spread of contamination. Treatment following removal from the controlled area depends on the seriousness of the injury. A survey report shall be prepared describing the incident. Wounds that occur in controlled areas must be checked for contamination. All minor wounds must be monitored by Health Physics and the data recorded. If the wound is contaminated, flush it with cool water to wash as much of the contamination out of and away from the wound as possible. Take care to avoid washing contamination from adjacent surfaces back into the wound. If necessary, seal the wound area and decontaminate the adjacent skin.

19.2.1. Injury in a Controlled Area (Cont'd)

Keep the item causing the wound and the clothing surrounding the wound to help evaluate the degree of contamination in the wound.

A survey report shall be prepared describing the incident.

19.2.2. First Aid

First Aid shall be rendered by holders of a current Red Cross First Aid Certificate or by a physician or registered professional medical person. First Aid includes one-time treatment of minor scratches, cuts, burns, splinters, etc., which do not ordinarily require medical care.

First Aid supplies and instructions will be kept available in the Health Physics office.

A record of all first aid treatment will be kept in the First Aid Log.

19.2.3. Traumatic Injury

Life saving first aid and rescue shall be provided immediately by those in the immediate vicinity. Contamination considerations are secondary to life saving efforts.

The Project Superintendent shall be immediately notified. He shall assume control of subsequent actions including rescue, first aid, notification of medical personnel, physician, etc.

A physician shall be called immediately and shall be advised of the symptoms. He will advise whether local treatment or hospitalization is required.

19.2.4. Radiation Injury (RESERVED)

REFERENCES

1. Code of Federal Regulations

USNRC Rules and Regulations, 10CFR19, Notices, Instructions and Reports to Workers; Inspections.

USNRC Rules and Regulations, 10CFR20, Standards for Protection Against Radiation.

USDOT Rules and Regulations, 49CFR172, Hazardous Materials Table and Hazardous Materials Communications Regulations.

USDOT Rules and Regulations, 49CFR173, Shippers -- General Requirements for Shipments and Packagings.

2. USNRC Regulatory Guides

1.86. Termination of Operating Licenses for Nuclear Reactors

7.1. Administrative Guide for Packaging and Transporting Radioactive Material

7.7. Administrative Guide for verifying compliance with packaging requirements for shipments of Radioactive Materials

8.7. Occupational Radiation Exposure Records Systems

8.9. Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program

8.11. Applications of Bioassay for Uranium

8.13. Instruction Concerning Prenatal Radiation Exposure

8.15. Acceptable Programs for Respiratory Protection

8.22. Bioassay at Uranium Mills

3. USNRC NUREGS

NUREG-0041. Manual of respiratory protection against Airborne Radioactive Materials

NUREG-0706. FGEIS on Uranium Milling

4. ANSI STANDARDS

ANSI NI3.6-1966(RI972). Practice for Occupational Radiation Exposure Records Systems.

ANSI 13.12-1978. Control of Radioactive Surface Contamination on Materials, Equipment and Facilities to be released for uncontrolled use.

ANSI 14.10.1. Administrative guide for packaging and transporting Radioactive Materials.

ANSI N313-1974. Stabilization of Uranium-Thorium Milling Waste Retention Systems.

ANSI N323-1978. Radiation Protection Instrumentation -- Test and Calibration.

5. Other Publications

Moe, H.J., et al, Radiation Safety Technician Training Course, ANL-7291, Rev. 1.

NCRP Report No. 58, a handbook of Radioactivity Measurements Procedures.

Radiological Health Handbook, US Department of Health, Education and Welfare, 1970.

APPENDIX A

OUTLINE OF BASIC RADIATION

PROTECTION TRAINING

APPENDIX A

OUTLINE
BASIC RADIATION PROTECTION TRAINING

1. Radiation and contamination - definition and explanation of differences

2. Radiation types
   a. Beta
   b. Gamma
   c. Alpha
   d. Neutron

3. Units
   a. Roentgen (R)
   b. Rad, Gray
   c. Rem, Sievert
   d. Counts per minute (cpm)
   e. Disintegrations per minute per 100 cm^2 (dpm/100 cm^2)
   f. Curie (Ci), Becquerel (Bq)

4. Protection Against Radiation
   a. Time (including calculation of dose and stay time)
   b. Distance
   c. Shielding

5. Protection Against Contamination
   a. Protective clothing (including demonstration)
   b. Respiratory equipment (general)
   c. Containment (bagging, gloves, bags, tents, papering)
   d. Smoking, eating, drinking in controlled areas

APPENDIX A (Cont'd)

6. Biological Effects
   a. Effects of acute dose
   b. Effects of chronic dose

7. Radiation Zones
   a. Radiation symbol and colors
   b. Controlled Area
   c. Radiation Area
   d. High Radiation Area
   e. Airborne Radioactivity Area (Airborne Radioactivity Area)
   f. Contamination Control Area

8. Personnel Monitoring for Radiation
   a. Film badge
   b. TLD
   c. Dosimeters
   d. Exposure records

9. USNRC Limits (10CFR20) and site limits
   a. Whole body dose
   b. Skin dose
   c. Extremity dose
   d. Airborne activity
   e. Emergency dose
   f. NRC Form - NRC-4

10. Personnel Monitoring for Contamination
   a. Survey when leaving contaminated area
   b. Whole body counting
   c. Bioassay

APPENDIX A (Cont'd)

11. Facility Procedures
    a. Access control
    b. Special Work Permit (SWP)
    c. Change area and step-off-pad procedure
    d. Use of dosimeters
    e. Decontamination methods
        - Area
        - Equipment
        - Personnel
    f. Removal of tools and equipment from controlled area
    g. Facility emergency plans

APPENDIX B

OUTLINE OF MANAGEMENT PRINCIPLES OF RADIATION

EXPOSURE AND CONTAMINATION CONTROL

APPENDIX B

OUTLINE

MANAGEMENT PRINCIPLES OF RADIATION EXPOSURE AND CONTAMINATION CONTROL

1. Regulatory Basis For Control
   a. USNRC Regulations
   b. Facility License
   c. Policy and Rules
   d. Facility Procedures

2. Basis of Radiation Exposure Limits

3. Administrative Action After Over Exposure

4. Basis for Contamination Control

5. Decontamination

6. ALARA Policy

APPENDIX C

a. USNRC Regulatory Guide 8.15
Acceptable Programs for Respiratory Protection

b. USNRC NUREG-0041
Manual of Respiratory Protection Against
Airborne Radioactive Materials

T. Ling

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

October 1976

REGULATORY GUIDE 8.15

ACCEPTABLE PROGRAMS FOR RESPIRATORY PROTECTION

A. INTRODUCTION

Section 20.103, "Exposure of individuals to concentrations of radioactive materials in air in restricted areas," of 10 CFR Part 20, "Standards for Protection Against Radiation," permits licensees to make allowance for the use of respiratory protective equipment in estimating exposures of individuals to airborne radioactive materials provided the protective equipment is used as stipulated in this guide, which describes the elements of respiratory protection programs acceptable to the NRC staff.

B. DISCUSSION

This guide specifies elements of acceptable respiratory protection programs. More detailed advice, including technical needs and background information, may be found in NUREG-0041, "Manual of Respiratory Protection Against Airborne Radioactive Materials,"[a] sections of which are referenced and keyed to appropriate portions of this guide.

The NRC staff will use information in NUREG-0041 in assessing the adequacy of respiratory protection programs pursuant to the guidance provided herein (NUREG-0041, Section 3).

C. REGULATORY POSITION

Pursuant to §20.103 of 10 CFR Part 20, a licensee may make allowance for the use of respiratory protective equipment in estimating exposures of individuals to airborne radioactive materials if the equipment is used according to the following guidance:

1. A written policy statement on respirator usage is to be issued from a high management level. Strong management backing is considered essential to an adequate respiratory protection program. Techniques are to be provided and measures taken to ensure that management policy is carried out. Subjects to be covered by the policy statement include the use of practicable engineering controls instead of respirators; routine, nonroutine, and emergency situations; and periods of respirator use and relief from respirator use (NUREG-0041, Sections 2, 3.2, 12.1).

2. Respiratory protective equipment is to be selected to provide a protection factor greater than the multiple by which peak concentrations of radioactive materials are expected to exceed the values specified in Table I, Column 1 of Appendix B to 10 CFR Part 20. The equipment selected is to be used so that the average concentration of radioactive material in the air that is inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, will not exceed the values specified in Table I, Column 1 of Appendix B to 10 CFR Part 20. For the purposes of this guide, the concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the ambient concentration in air by the protection factor specified in Table 1. If a respirator user's intake of radioactive materials is later determined by other measurements to have been greater than that expected from initial estimates of radioactive materials in the air the user inhales, the greater quantity is to be used in evaluating exposures; if it is less than that initially estimated, the lesser quantity may be used in evaluating exposures (NUREG-0041, Sections 5, 6).

3. The licensee is to advise each respirator user that he may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that might require such relief (NUREG-0041, Section 2.2).

[a] NUREG-0041 is available from the National Technical Information Service, Springfield, Virginia 22161.

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4. The licensee is to maintain and implement a respiratory protection program that includes, as a minimum, the following items (NUREG-0041, Section 3.1.5):

a. Air sampling and other surveys sufficient to identify the hazard, to evaluate individual exposures, and to permit proper selection of respiratory protective equipment (NUREG-0041, Sections 4, 5, 11).

b. Written procedures to ensure proper selection, supervision, and training of personnel using such protective equipment (NUREG-0041, Sections 8, 12).

c. Written procedures to ensure the adequate individual fitting of respirators, as well as such procedures to ensure the testing of respiratory protective equipment for operability immediately prior to each use (NUREG-0041, Sections 7, 8, 12).

d. Written procedures for maintenance to ensure full effectiveness of respiratory protective equipment, including procedures for cleaning and disinfection, decontamination, inspection, repair, and storage (NUREG-0041, Sections 9, 10).

e. Written operational and administrative procedures for control, issuance, proper use, and return of respiratory protective equipment, including provisions for planned limitations on duration of respirator use for any individual as necessitated by operational conditions (NUREG-0041, Sections 2, 9, 10, 12).

f. Bioassays and other surveys, as appropriate, to evaluate individual exposures and to assess protection actually provided (NUREG-0041, Sections 4, 11).

g. Records sufficient to permit periodic evaluation of the adequacy of the respiratory protection program (NUREG-0041, Section 12).

h. Determination prior to assignment of any individual to tasks requiring the use of respirators that such an individual is physically able to perform the work and use the respiratory protective equipment. A physician is to determine what health and physical conditions are pertinent. The medical status of each respirator user is to be reviewed at least annually (NUREG-0041, Section 7.4).

5. The licensee is to use equipment approved under appropriate Approval Schedules in 30 CFR Part 11 of the U.S. Bureau of Mines/National Institute for Occupational Safety and Health and as set forth in Table 1.

5. Where no equipment of a particular type has been approved under the schedules in 30 CFR Part 11 or where there is no existing schedule for approval of certain equipment, such equipment is not to be used without specific authorization by the Commission. An application for such authorization is expected to include a demonstration by testing or on the basis of reliable test information that the material and performance characteristics of the equipment are capable of providing an acceptable degree of protection under anticipated conditions of use.

7. Unless otherwise authorized by the Commission, the licensee is not to assign protection factors in excess of those specified in Table 1 in selecting and using respiratory protective equipment.[a] The Commission may authorize a licensee to use higher protection factors on receipt of an application (a) describing the situation for which a need exists for higher protection factors and (b) demonstrating that the respiratory protective equipment will provide such higher protection factors under the proposed conditions of use.

8. As a minimum, the following additional technical items are to be observed:

a. Respirable air of approved quality and quantity is to be provided and oxygen deficiency is to be avoided (NUREG-0041, Sections 4.1.1, 5.1.2, 5.1.3, 5.2.4.1, 5.2.4.1.1, 5.2.4.1.4, 9.8).

b. There is to be a standby rescue person equipped with self-contained breathing apparatus and communications equipment when supplied-air suits are used (NUREG-0041, Section 5.1.3).

c. No credit is to be taken for use of sorbents against radioactive materials (NUREG-0041, Sections 5.2.2, 5.2.2.2, 5.2.3.5, 5.6.6).

d. Filter media in air-purifying respirators are to be of the high-efficiency type (NUREG-0041, Sections 5.2.2.1, 5.2.2.3, 5.2.3.2, 5.6.1).

e. Air-purifying respirators are not to be used in oxygen-deficient atmospheres (NUREG-0041, Sections 4.1.1, 4.2.3, 5.2.3.1).

f. Adequate skin protection is to be provided (NUREG-0041, Sections 1.2, 5.2.3.2).

g. Air-purifying respirators are not to be used in atmospheres immediately hazardous to life or health (NUREG-0041, Section 5.2.3.4).

---

[a]The factors listed are intended as guides for selection and use of respirators in protection against radioactive materials. Additional precautions must be taken as necessary to protect against concurrent hazards other than radiation.

h. Canisters and cartridges are not to be used beyond service-life limitations (NUREG-0041, Section 5.2.3.5).

i. Facelets are not to be used (NUREG-0041, Section 5.2.3.6).

j. Oxygen and breathing air are not to be used in the same apparatus (NUREG-0041, Sections 5.2.4.1, 5.2.4.1.4, 5.2.4.2).

k. Proper fittings are to be used with supplied-air equipment (NUREG-0041, Sections 5.2.4.1.1, 5.2.4.1.2, 5.2.4.1.3).

l. Equipment is to be used within limitations for type and mode of use (NUREG-0041, Sections 5.2.3, 5.2.4).

m. Only specified equipment is to be used as emergency devices (NUREG-0041, Sections 5.2.4.1.4, 5.2.4.2.1, 5.2.4.2.4, 5.5).

n. Appropriate equipment with proper visual, communication, and other special capabilities is to be provided (NUREG-0041, Sections 7.1, 13).

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the licensee or applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described herein are being and will continue to be used in the evaluation of the respiratory protection programs of licensees who are subject to the requirements of §20.103 of 10 CFR Part 20 until this guide is revised as a result of suggestions from the public or additional staff review.

TABLE 1
PROTECTION FACTORS FOR RESPIRATORS[a]

DESCRIPTION[b]	MODES[c]	PROTECTION FACTORS[d] PARTICULATES ONLY	PROTECTION FACTORS[d] PARTICULATES, GASES & VAPORS[e]	SELECTION OF TESTED & CERTIFIED EQUIPMENT BUREAU OF MINES, NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH APPROVALS
I. AIR-PURIFYING RESPIRATORS				
Facepiece, half-mask[f]	NP	10		30 CFR Part 11 Subpart K
Facepiece, full	NP	50		
Facepiece, half-mask, full, or hood	PP	1000		
II. ATMOSPHERE-SUPPLYING RESPIRATORS				
1. Air-line respirator				
Facepiece, half-mask	CF		1000	30 CFR Part 11 Subpart J
Facepiece, half-mask	D		10	
Facepiece, full	CF		2000	
Facepiece, full	D		50	
Facepiece, full	PD		2000	
Hood	CF		2000[g]	
Suit	CF		h	i
2. Self-contained breathing apparatus (SCBA)				
Facepiece, full	D		50	30 CFR Part 11 Subpart H
Facepiece, full	PD		10,000[j]	
Facepiece, full	R		50	
III. COMBINATION RESPIRATOR				
Any combination of air-purifying and atmosphere-supplying respirators		Protection factor for type and mode of operation as listed above		30 CFR Part 11 § 11.63(b)

[a]For use in the selection of respiratory protective devices to be used where the contaminant has been identified and the concentration (or possible concentration) is known.

[b]Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)

[c]The mode symbols are defined as follows:

CF = continuous flow
D = demand
NP = negative pressure (i.e., negative phase during inhalation)
PD = pressure demand (i.e., always positive pressure)
PP = positive pressure
R = demand, recirculating (closed circuit)

[d]1. The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentration inhaled by the wearer according to the following formula:

$$\text{Concentration Inhaled} = \frac{\text{Ambient Airborne Concentration}}{\text{Protection Factor}}$$

2. The protection factors apply:

(a) Only for trained individuals wearing properly fitted respirators used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters [above 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test] are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) For atmosphere-supplying respirators only when supplied with adequate respirable air.

[e]Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one half of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide; for example:

If the protection factor for a device is:	PF overall for tritium oxide is:
10	1.82
100	1.98
1,000	1.99

(Continued)

(Continued)

Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote g concerning supplied-air suits.

[f]Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentration to reach instantaneous values greater than 10 times the pertinent values in Table I, Column 1 of Appendix B to 10 CFR Part 20, "Standards for Protection Against Radiation." This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask is to be tested for fit with irritant smoke, prior to use, each time it is donned.

[g]The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-over-head. Such aspiration may be overcome if a short cape-like extention to the hood is worn under a coat or coveralls. Other limitations specified by the approval agency must be considered before using a hood in certain types of atmospheres (see footnote h). Manufacturers' recommended pressure settings for the air supply cannot always be relied on to ensure a minimum 6 cfm air flow. Equipment must be operated in a manner that ensures proper flow rates are maintained.

[h]Appropriate protection factors must be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use.

[i]No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

[j]This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure such as skin absorption must be taken into account in such circumstances.

Note 1: Protection factors for respirators, as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH) according to applicable approvals for respirators to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2: Radioactive contaminants for which the concentration values in Table I of Appendix B to 10 CFR Part 20 are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under such circumstances, limitations on occupancy may have to be governed by external dose limits.

PB 258 052
NUREG-0041
FINAL

MANUAL OF RESPIRATORY PROTECTION

AGAINST

AIRBORNE RADIOACTIVE MATERIALS

Office of Standards Development

U.S. Nuclear Regulatory Commission

NUREG-0041
FINAL

Manual of Respiratory Protection Against Airborne Radioactive Materials

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12

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Washington, D.C. 20555

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15. Supplementary Notes

This manual supplements Regulatory Guide 8.15.

16. Abstracts

This manual supplements Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection," which stipulates the use of respiratory protective equipment in estimating exposures of individuals to airborne radioactive materials. Manual sections are referenced in appropriate portions of Regulatory Guide 8.15. The manual includes sections on basic policy, elements of acceptable respiratory protection programs, hazard evaluation, classifications and limitations of respirators, protection factors, wearer requirements and limitations, training, maintenance, quality assurance, bioassay, administration, and special problems. The NRC staff will use the information in this manual in assessing the adequacy of respiratory protection programs pursuant to the guidance provided in Regulatory Guide 8.15.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

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The editors would appreciate any comments that you may have for use in the preparation of future editions.

CHAPTER 1

INTRODUCTION

1.1 PURPOSE

This manual has been prepared to supplement Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection," and to provide technical information to licensees of the Nuclear Regulatory Commission (NRC) on the application of respiratory protective devices for protection against airborne radioactive materials, as provided in § 20.103, "Exposure of individuals to concentrations of radioactive material in air in restricted areas" of 10 CFR Part 20 (Ref. 1). The various elements of a respirator program, including selection and maintenance of equipment and training of personnel, are described in this manual to assist licensees in establishing adequate programs.

1.2 SCOPE

This manual provides broad guidance for the planned use of respirators to protect individuals from airborne radioactive materials that might be encountered during certain operations. The guidance is intended for use by management in establishing and supervising programs and by operating personnel in implementing programs.

Guidance is primarily directed to the use of respirators to prevent the *inhalation* of airborne radioactive materials. Protection against other modes of intake (e.g., absorption, swallowing, wound injection) is, in general, not covered here nor is the use of protective equipment for head,

eye, or skin protection. When such additional modes of intake or concurrent hazards are present, they must also be considered, and equipment capable of providing protection against the combination of hazards encountered must be chosen. For example, if a high concentration of airborne radioactive material is present in an oxygen-deficient atmosphere, it is necessary to select equipment that both protects against the radioactive material and furnishes an adequate supply of oxygen or breathing quality air.

Subsequent chapters frequently refer to requirements specified in NRC or other Federal regulations; these requirements are generally differentiated from other technical information by the use of the words "shall" and "must" instead of "should". "Should" is used to refer to other acceptable practices within the provisions of Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

1.3 BACKGROUND

"American National Standard Practices for Respiratory Protection," ANSI Z88.2-1969, (Ref. 2) was developed and issued by the American National Standards Institute, Inc. (ANSI) in 1969 under the sponsorship of the U.S. Department of Interior, Bureau of Mines. This standard has been adopted by reference in the U.S. Department of Labor's Occupational Safety and Health Standards (29 CFR Part 11, § 1910.134, "Respiratory Protection"). ANSI Z88.2-1969 covers the general use of respiratory protective equipment against industrial hazards and includes some guidance on the use of such devices against airborne radioactive materials. The U.S. Bureau of Mines

and the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education, and Welfare, use schedules and certification requirements (discussed further in Chapter 3) for testing and approving specific types of respiratory protective devices. Until the issuance of Schedule 21B (Ref. 3) by the U.S. Bureau of Mines in 1965, the previously effective schedules did not include any provision for approval schedules and tests applicable to the use of respirators for airborne radioactive materials. However, since the 1940s, both the U.S. Bureau of Mines and the nuclear industry, in particular the contractors of the AEC (now the Energy Research and Development Administration, ERDA), have developed considerable guidance in the form of manuals, guides, and other data regarding such use.

In May 1963, the AEC Division of Licensing and Regulation sponsored a Respiratory Protective Equipment Conference at the Harvard School of Public Health to examine and evaluate practices and other information on the use of respirators for protection against airborne radioactive hazards. After the conference, the AEC decided to prepare a guide covering the aspects of respiratory protection peculiar to the needs of its licensees. A draft was prepared with the assistance of the Harvard University Graduate School of Public Health and a review conference, sponsored by the AEC Division of Safety Standards, was held in April of 1965 at AEC Headquarters.

Also in 1963, the American Industrial Hygiene Association (AIHA) and the American Conference of Governmental Industrial Hygienists (ACGIH)

published a Respiratory Protective Devices Manual (Ref. 4) as a guide for health physicists, industrial hygienists, and other health and safety specialists.

The results of the conferences, together with information from the AIHA-ACGIH manual, information from the AEC's Division of Operational Safety regarding the practices of AEC prime contractors, and information from a draft of a United States of America Standards Institute (now ANSI) code of recommended practice for respiratory protection then being prepared were used extensively in a second draft of this guide, dated October 1967. The second draft of the guide was made available for review and comment in connection with an AEC Notice of Proposed Rulemaking concerning use of respiratory protective equipment (32 FR 15432). Comments received on the proposed rule and draft guide demonstrated a need for development of additional technical information on the use of respirators.

Since 1969, the NRC Office of Standards Development has sponsored a respiratory protection studies project in the Respirator Research and Development Section, Industrial Hygiene Group, at Los Alamos Scientific Laboratory to develop necessary information for final preparation of this manual. As additional significant information is developed, it will also be made available for the guidance of licensees.

CHAPTER 2

BASIC POLICY REGARDING USE OF RESPIRATORS

2.1 USE CONDITIONS

The primary objective of respirator programs considered in this manual is to limit the inhalation of airborne radioactive materials. This objective is normally accomplished by the application of engineering controls, including process, containment, and ventilation equipment. When such controls are not feasible or cannot be applied the use of respiratory protective devices may be appropriate. In general, the use of respirators is less desirable in providing respiratory protection than is the use of process, containment, and ventilation techniques. The use of respirators as a substitute entails both greater likelihood of accidental exposures and greater likelihood that such exposures may go undetected. It might also subject the wearer to additional stress and increase his risk of injury by interfering with his vision, freedom of motion, and ability to communicate. The provision and use of respiratory protective devices are subject to the following considerations regarding circumstances under which respiratory protection may be needed.

2.1.1 Routine Operations

Routine operations are planned activities that are generally repetitive and occur with various frequencies. For such operations, potential sources of airborne radioactive materials should be identified so that respiratory protection may be accomplished by the use of process, containment,

and ventilation measures and by preplanning of work. The use of respirators as a substitute for practicable engineering controls in routine operations is inappropriate. Respirators may be considered for use, however, while engineering controls are being instituted or evaluated.

2.1.2 Nonroutine Operations

Nonroutine operations are activities that are either nonrepetitive or else occur so infrequently that adequate limitation of exposures by engineering controls is impractical. To the extent that process, containment, and ventilation controls are not reasonably feasible in nonroutine operations, the use of respirators to avoid excessive exposure to airborne radioactive materials is appropriate.

2.1.3 Emergencies

Emergencies are unplanned events characterized by risks sufficient to require immediate action to avoid or mitigate an abrupt or rapidly deteriorating situation. Although emergencies are, of course, unplanned, preparations must be made for coping with potential emergencies. Such preparations properly include a program for providing necessary and sufficient respiratory protection for use in potential emergencies that are likely to entail respiratory hazards. The advance preparations appropriate to a particular potential emergency will depend on both its possible consequences and the probability of its occurrence.

Plans for dealing with emergencies should include consideration of postulated durations; quantities and kinds of materials against which

protection must be provided; sizes and other physical characteristics of the hazardous areas; access requirements; numbers of people and technical skills needed; amounts, types, and locations of equipment necessary; and need for and availability of backup and replenishment supplies for use in emergencies.

2.1.4 Other Considerations

Most operations can be readily categorized as "routine," "nonroutine," or "emergency." However, a few activities might be difficult to assign to one category or another. Persons who are responsible for establishing and maintaining respiratory protection programs must exercise sound judgment by providing and using engineering controls where feasible and by avoiding unwarranted use of respirators.

2.2 WORK PERIODS

The periods of time respirators are worn continuously and the overall durations of use should each be kept to a minimum. It is necessary to allow respirator users adequate relief from wearing respirators at reasonable intervals and to limit total time of use. However, it is difficult to realistically assign specific time limits on respirator use because of wide variations in job requirements and in the physical capacities and psychological attitudes of individuals. Such factors must be taken into account in establishing a respirator program. Provision is to be made for the respirator users to leave areas where respirator use is required for relief in case of equipment malfunction, undue physical or psychological distress, procedural or communication failure, significant deterioration of operational conditions, or any other condition that might require such relief.

CHAPTER 3

ELEMENTS OF AN ACCEPTABLE PROGRAM

Respiratory protection programs of NRC licensees are primarily regulated by the NRC "Standards for Protection Against Radiation," 10 CFR Part 20, which includes provisions for respiratory protection against radioactive materials, and by the Department of Labor's Occupational Safety and Health Administration's (OSHA) Standards, 29 CFR Part 1910, which includes requirements for respiratory protection against other hazards. Omission from this manual of any specific requirements of OSHA standards or any other Federal or State regulations governing use of respirators for protection against materials or situations other than those licensed by the Commission does not constitute permission for the licensee to neglect such requirements. Each licensee is obligated to know and follow all such regulations that may govern his operations.

Federal regulations currently in effect are listed in this chapter. (See Section 1.2 for use of "shall" and "should".) No attempt has been made to investigate or to incorporate in this chapter State requirements that might be in effect.

3.1 REGULATIONS PERTAINING TO RESPIRATOR USAGE

3.1.1 General Respirator Program Regulations and Recommendations

3.1.1.1 Occupational Safety and Health Administration

Occupational Safety and Health Administration Title 29, Code of Federal Regulations, Part 1910 (29 CFR Part 1910) sets forth respiratory

protection requirements in Subpart I, "Personal Protective Equipment," of § 1910.134, "Respiratory protection." Requirements are set forth covering "Permissible practice, Requirements for a minimal acceptable program, Selection of respirators, Air quality, Use of respirators, Maintenance and care of respirators, and Identification of gas mask canisters."

Contained in § 1910.134 are references to certain consensus standards. The referenced recommendations contained in these standards are considered to be part of the rule. The following standards are referenced.

3.1.1.2 American National Standards Institute (ANSI) Z88.2-1969, "Practices for Respiratory Protection"

This standard covers all major aspects of a minimum respirator program. Complete familiarity with this standard is essential to anyone supervising a respirator program.

3.1.2 Breathing Air Specifications

3.1.2.1 ANSI Z48.1-1954, "Method of Marking Portable Compressed Gas Containers to Identify the Material Contained"

This standard is referenced in 29 CFR Part 1910, § 1910.134(d), which concerns air quality. Compressed air cylinders for breathing must be marked in accordance with

a. ANSI Z48.1-1954, or

b. Federal Specification BB-A-1034a, June 21, 1968, "Air, Compressed for Breathing Purposes," or

c. Interim Federal Specification GG-B-00675b, April 27, 1965, "Breathing Apparatus, Self-Contained." The applicable standard

or specification should be specified on any purchase orders for such equipment or service contracts.

3.1.2.2 Compressed Gas Association Commodity Specification G-7.1-1966, "Commodity Specification for Air" (Also designated ANSI Z86.1-1972)

Breathing air in gas cylinders must meet the requirement, as a minimum, of Grade D as given in G-7.1 (see Section 5.2.4.1).

3.1.2.3 Department of Transportation, 49 CFR Part 178, "Shipping Container Specification Regulations"

These regulations specify the testing and maintenance requirements for compressed breathing air cylinders.

3.1.3 Bureau of Mines/National Institute for Occupational Safety and Health

Title 30, CFR, Part 11 (30 CFR Part 11), "Respiratory Protective Devices; Tests for Permissibility; Fees," *Federal Register* Volume 37, No. 59, March 23, 1972, replaced Parts 11, 12, 13, 14 and 14a, Subchapter B, Chapter 1, Title 30, CFR (Bureau of Mines Schedules 13E, 14F, 19B, 21B, and 23B). The new 30 CFR Part 11 prescribes the approval procedures, establishes the fees, and consolidates and extends the requirements for getting joint approval of respirators by the Bureau of Mines, Department of the Interior, and the National Institute for Occupational Safety and Health (NIOSH), Department of Health, Education, and Welfare.

Only those respirators approved under the requirements of 30 CFR Part 11 may now be sold as approved devices. However, respirators manufactured under the old Bureau of Mines approvals may be used until the following dates:

Type of Respirator	Bureau of Mines Approval Schedule	Terminal Date For Approved Use
Self-contained	13 - 13E	March 31, 1979
Gas mask	14F	March 31, 1977
Supplied-air	19B	March 31, 1980
Dust, fume, mist	21B	March 31, 1976
Chemical-cartridge	23B	March 31, 1976

Respirators approved under the former Bureau of Mines schedules have approval numbers preceded by the letters "BM". Respirators approved (tested and certified) under 30 CFR Part 11 have numbers preceded by the letters "TC". Those respirators with approval numbers that bear the prefix "TC" may be used for their normal lifetimes; respirators with approval numbers that bear the prefix "BM" are approved for use only until the dates listed above.

While 30 CFR Part 11 is not directly applicable to a licensee's respirator program, it is necessary for him to conduct his program in such a way that the respirator approvals are not voided. The approval for a respirator is automatically voided if:

a. The respirator is not the same in all respects as the respirators that have been approved by meeting the minimum requirements for performance and respiratory protection prescribed in 30 CFR Part 11, and

b. The respirator is not maintained in an approved condition.

3.1.4 U.S. Nuclear Regulatory Commission (10 CFR Part 20)

Where respiratory protection is used to control individual exposures to radioactive materials, all provisions in 10 CFR Part 20, § 20.103 must be followed by the licensee.

3.1.5 Minimum Acceptable Program Requirements Summary

The following are minimum general requirements for any respirator program (details are given in subsequent chapters of this manual and in the regulations previously cited):

a. Written standard operating procedures and a policy statement (see Sections 3.2 and Chapter 12);

b. Proper selection of equipment, based on the hazard (see Sections 4 and 5);

c. Proper training and instruction of users (see Section 8);

d. Proper fitting, use, cleaning, storage, inspection, quality assurance, and maintenance of equipment (see Chapter 9);

e. Appropriate surveillance of work area conditions, degree of employee exposure to stress (see Sections 2.2, 4.2, and 3.4.2);

f. Regular inspection and evaluation to determine the continued program effectiveness (see Section 12.3);

g. Program responsibility shall be vested in one qualified individual (see Section 12.1);

h. An adequate medical surveillance program for respirator users (see Section 7.4);

i. Use of only Bureau of Mines/NIOSH-certified or NRC-authorized equipment (see Section 3.1.3 and Chapter 5); and

j. Maintenance of a bioassay program (see Chapter 11).

3.2 POLICY STATEMENT

No respiratory protection program is considered adequate without a written policy statement on respirator usage issued from a sufficiently high management level to ensure that its provisions may be adequately enforced. Items in Chapter 2 are to be covered in the statement. Strong management backing is essential to an adequate respiratory protection program.

CHAPTER 4

EVALUATION OF RESPIRATORY HAZARDS

In general, the degree of protection against specific respiratory hazards varies with the design of the respirator. Some respirators provide a higher degree of protection than others. Some designs protect only against a single respiratory hazard or a limited number of hazards; others provide protection against a broad class of hazards. Thus, proper selection of respirators requires adequate identification of all respiratory hazards present.

4.1 CLASSIFICATION OF HAZARDS

Respiratory hazards may be classified as follows:

a. Oxygen Deficiency

b. Toxic and Nuisance Atmospheres

(1) Gaseous Contaminants (gases and vapors)

(2) Particulate Contaminants (dusts, fogs, fumes, mists, smoke, and sprays)

(Combinations of these hazards are, of course, possible.)

Radioactive air contaminants may be present either as gases or particulates. Concurrent hazards, such as oxygen deficiency or the presence of nonradioactive toxic airborne contaminants, may also exist. Although this guide deals mainly with airborne radioactive hazards, the use of respirators may involve protection against concurrent chemical and physical hazards. Consequently, it appears appropriate to examine the various types of respiratory hazards in more detail.

4.1.1 Oxygen Deficiency

Normal air contains about 21% oxygen (O_2) by volume. An atmosphere with an oxygen content less than about 16% by volume (at sea level) is insufficient for human needs. At decreased atmospheric pressures or increased altitudes, greater percentages of O_2 are required for human needs. For example, at an altitude of 7000 feet, a minimum of 18% O_2 content is required. Breathing gas used to supply approved supplied-air respirators is required to contain not less than 19.5 volume percent of oxygen (see Section 5.2.4.1).

Sufficient oxygen or breathing-quality air must be supplied to avoid the adverse physiological effects of oxygen deficiency. Oxygen deficiency may result from (1) depletion of oxygen by combustion, chemical reaction, or absorption, (2) displacement of air by other gases or vapors, or (3) use of inert atmospheres. It may also result from the failure of breathing air or oxygen supplies or from rebreathing air in a confined space. Particular care must be taken to avoid the use of air-purifying respirators (e.g., filter types) in oxygen-deficient atmospheres.

Table 4-1 gives the symptoms of O_2 deficiency as a function of oxygen content and altitude.

4.1.2 Toxic and Nuisance Atmospheres

The hazards in toxic and nuisance atmospheres may consist of radioactive contaminants, nonradioactive contaminants, or both. Standards for protection against radioactivity hazards and those for nonradioactivity hazards differ in several important aspects:

TABLE 4-1

SYMPTOMS OF OXYGEN DEFICIENCY vs OXYGEN CONTENT AND ALTITUDE

Symptoms	Sea Level[a] Oxygen Vol. %	5000 ft[b] Oxygen Vol. %	700 ft[b,c] Oxygen Vol. %
Breathing and pulse rate increased	12-16	15-19.5	16-21
Abnormal fatigue upon exertion, disturbed respiration, consciousness continues	10-14	12.5-17.5	13.5-18.5
Nausea and vomiting, inability to move freely, loss of consciousness may occur	6-10	7.5-12.5	8-13.5
Convulsive movements, gasping respiration, respiration stops, death	Below 6	Below 7.5	Below 8

[a] From F. A. Patty, "Industrial Hygiene and Toxicology," 2nd Ed., Interscience Publishers, Inc., N.Y. (Interscience Publishers, Ltd., London), 1958.

[b] Calculated. Based on data from "Physiology of Man in Space," J. H. U. Brown, Ed., Academic Press, N.Y., 1963.

[c] Does not take into account acclimatization, which occurs in 4 to 6 weeks.

a. They are based on different dose-effect relationships.

b. They involve different types or degrees of risk.

c. They are expressed in different and unrelated units.

4.1.2.1 Dose-Effect Relationships

Standards for protection against nonradioactive chemical hazards in industrial atmospheres are generally based on a threshold concept postulating that, although all substances may be toxic or irritant at sufficiently high concentrations, there is some limiting "threshold"

concentration (the "threshold limit value" or "TLV") below which an individual may be exposed repeatedly without any resultant injury (Ref. 5). In contrast to standards for protection against chemical hazards, where the emphasis is on a threshold limit, standards for radiation protection take into consideration a "no-threshold" concept, i.e., it is assumed that every increment of radiation dose, however small, contributes to risk.

Concentration limits for airborne radioactive materials are designed to keep cumulative radiation doses sufficiently low to prevent immediate effects and to make the risk of delayed effects so small as to be acceptable to the exposed individual and to competent medical authorities (Refs. 6-8). "Acceptable" is used in the sense that the risks involved are no greater than those commonly accepted in ordinary activities. This concept has been more fully examined by the National Council on Radiation Protection and Measurements and others (Ref. 9).

4.1.2.2 Differences in Risk Associated with Exposures Over Limits

Generally, the manner in which concentration limits for radioactive and nonradioactive contaminants in air are determined results in levels of risk that differ greatly when individuals are exposed to concentrations substantially in excess of the limits. Concentration limits for hazards other than radioactivity are usually not more than an order of magnitude below those levels of exposure that produce adverse effects (ranging widely from mere discomfort to severe irritation or rapid death) On the other hand, concentration limits for radioactivity hazards relate to levels of exposure that are far below those at which any observable

effect would be expected. Thus, exposure for an hour to airborne radioactive materials at levels two or three orders of magnitude above the maximum permissible concentration would not be expected to result in any acute effects; whereas similar exposure in excess of the threshold limit value for many nonradioactive contaminants would be likely to result in severe irritation, injury to health, or death. Note that these examples are used only to compare the differences in risk represented by the different types of limits. They do *not* imply that exposure to either hazard would be acceptable, even though acute effects would not be expected from exposures to the radioactive concentrations discussed. Within the recommended limits, actual exposures to radioactive contaminants must be kept as low as is reasonably achievable (Ref. 10).

4.1.2.3 Limits of Airborne Concentrations and Their Related Units

4.1.2.3.1 Threshold Limit Values. These are limits on airborne concentrations of a number of chemical and physical agents. Threshold limit values (TLVs) are developed by the Threshold Limits Committee of the American Conference of Governmental Industrial Hygienists (ACGIH) and are published (Ref. 11) with yearly revisions by the ACGIH. Respective limits for gases and vapors are listed in parts per million by volume of the substance in air (ppm at 25°C and 760 mm Hg); limits for liquids and solids as milligrams per cubic meter of air (mg/m^3); and limits for mineral dusts as millions of particles per cubic foot of air (mppcf) as determined by microscopic light field count techniques. The TLVs are published along with

precautionary notes and explanations that are important to their proper use and that must be taken into account.

Before 1963, all TLVs were defined as time-weighted average concentration limits; i.e., the concentrations might vary above and below the TLV over a working day if the average value did not exceed the TLV. However, in 1963, the ACGIH changed certain of the TLVs to upper "ceiling" limits, i.e., an absolute limit below which concentration might fluctuate if the "ceiling" itself were not exceeded. So some TLVs are given in terms of time-weighted average value and others are ceiling limits (listed with a "C" before them in the ACGIH tables). As shown in Table 4-2, TLVs are given "C" rating if exposure for 15 minutes in excess of the TLV would result in certain immediate adverse effects, such as intolerable irritation, chronic or irreversible tissue change, or narcosis sufficient to impair self rescue, increase accident-proneness, or materially reduce work efficiency. If the "test factor" multiplied by the TLV would produce these effects in 15 minutes, the TLV is given a ceiling rating.

TABLE 4-2[a]

CEILING LIMIT TEST CRITERIA

TLV Range (ppm or mg/m^3)	TLV Test Factor
0 - 1	3
>1 - 10	2
>10 - 100	1.5
>100 - 1000	1.25

[a]See Reference 5.

4.1.2.3.2 Maximum Acceptable Concentrations. These are ceiling limits on airborne concentrations of a number of chemical and physical agents. They are developed by the American National Standards Institute (ANSI).

The chief distinction between the TLV and the maximum acceptable concentrations (MAC) is that the MAC is always a ceiling limit[a] below which concentrations may fluctuate whereas the TLV may be either a ceiling value or an averaged value. MACs and TLVs are expressed in the same units; and the types of risk to which they pertain are almost always toxic or irritant effects. Even for TLVs that are not "C" listings, exposure to concentrations somewhat in excess of the TLV for a working day might result in immediately observed effects.

Since the TLVs and the MACs pertain to such a wide range of effects (from mere discomfort to rapid death), they do not represent uniform degrees of risk. For example, the TLV number may represent for one substance a risk of death if the TLV is exceeded by a factor of ten for a short time. For another substance, the same numerical value for its TLV may simply represent a risk of skin irritation if the number is exceeded by a considerably higher factor for a much longer period of time.

4.1.2.3.3 Maximum Permissible Concentrations. For occupational exposure, these are recommended limits on concentrations of radionuclides to

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[a]ANSI has been considering other limits that are not ceiling values. These include concepts such as "acceptable eight-hour time-weighted average," "acceptable maximum for 'peaks' above acceptable base line for continuous exposure," "acceptable concentration to avoid discomfort," and "minimum level for sensory response."

which workers may be exposed. They are issued by groups such as the International Commission on Radiological Protection (Ref. 6) and the National Council on Radiation Protection and Measurements (Ref. 12). Such recommendations may be used as the basis for limits in the regulations of agencies such as the NRC. Maximum permissible concentrations (MPCs) established for air and water are designated as MPC_a or MPC_w, respectively. In this manual the term MPC is used instead of MPC_a for simplicity. MPCs are generally expressed in microcuries per cubic centimeter or microcuries per milliliter ($\mu Ci/cm^3$ or $\mu Ci/ml$). They are generally used as averaged values, although they may sometimes be used as "ceiling," "peak," or "instantaneous" values. For example, in NRC licensing programs:

a. Averaged values over a calendar quarter are specified for reporting individual exposures in excess of limits.

b. Averaged values over not more than 7 consecutive days are used precautionarily to control airborne concentrations and individual exposures.

c. Peak values are specified for selection of respirators.

In contrast to TLVs and MACs, the MPCs are intended to represent a uniform degree of risk for any airborne radioactive material, to the extent that present knowledge permits. It is intended that control to the level of the MPC will limit annual radiation doses to maximum permissible levels, even after exposure to airborne radioactive materials throughout a working lifetime. Such exposures would not be expected to result in any

observable effect on the exposed individual. Further discussion of TLVs and MPCs may be found in Reference 5.

One note of caution to be observed in using MPCs and TLVs is that they are intended for use by people experienced in the field who are fully aware of the range of use, developmental background, and technical implications and limitations inherent in the concepts. Further discussion of respiratory hazards other than radiation is beyond the scope of this manual (Ref. 4,5).

4.1.2.4 Relation of MPC to Mode of Exposure

In most cases, the airborne concentration limits are based on internal dose from the amount of a radionuclide retained in the body (or critical organ) following inhalation. However, airborne concentration limits for large clouds of noble gases or other relatively inert gases are based on the external dose an individual would receive if he were surrounded by a semispherical infinite cloud of radioactive gas. Under these circumstances, the dose to the whole body or to the skin from the radioactive cloud would be higher than that from gas within the lungs or other body organs. The radioactive gases of major significance that have MPCs based on submersion dose to the whole body are argon-41, the kryptons, the xenons, and carbon-14 as CO_2. Lower-energy particle emitters such as argon-37 and hydrogen-3 (as tritium gas) have MPCs based on submersion dose to the skin.

Tritium in the oxide form as HTO vapor (less commonly as DTO vapor) in air presents an additional problem since approximately as much

tritium enters the body by absorption through the skin as enters by inhalation. The airborne concentration limits for tritium oxide vapor are therefore based on this dual mode of entry into the body.

4.2 AIR-SAMPLING PROGRAM

A comprehensive air-sampling program is essential to evaluate the hazards associated with work situations involving potentially toxic materials. In many instances, air-sampling data can also provide the basis for development and evaluation of control procedures and can indicate whether or not operational changes are necessary to provide adequate protection for the worker. In conjunction with a respiratory protection program, air-sampling data are necessary to define the air concentration levels so that the proper respiratory protective equipment can be selected.

Since respirator protection factors vary over several orders of magnitude, it is very important that an initial estimate be made of the air concentration levels, relative to specified regulatory limits. Thus, adequate protection can be provided while necessary inconvenience to the worker wearing a respirator is minimized. Air-sampling programs may also be designed to estimate the release of contaminants to the general work area and to the outside environment.

An air-sampling program directly related to respiratory protection would:

a. Provide an estimate of the potential intake of airborne radioactive materials and resulting exposure of the individual worker.

b. Provide data to assist in the selection of respiratory protective equipment that would provide adequate protection under exposure conditions.

c. Provide data for control of long-term exposures to workers.

d. Provide documentation of personnel exposures for legal or regulatory purposes.

e. Identify and characterize the contaminants and their sources.

f. Provide data for determining the requirements for engineering or administrative controls.

g. Indicate the continuing effectiveness of existing controls, and warn of the deterioration of control equipment or operating procedures.

h. Provide a record of long-term trends showing variations in contaminant levels.

i. Continuously measure the level of airborne contaminants in and about work areas and warn of releases of airborne contaminants to the outside environment.

4.2.1 Considerations in Air Sampling

An air-sampling program must be designed and operated so that the data obtained are directly and meaningfully related to the problem of concern. As part of a respiratory protection program, air-sampling procedures must take into account (a) the physical and chemical state of the contaminant, (b) aerodynamic size characteristics of airborne particulates,

(c) range of contaminant concentration, (d) environmental conditions such as temperature, (e) sampler location relative to the worker and the source of contamination, (f) instrument operating and response characteristics, (g) instrument portability, (h) sensitivity of the associated analytical procedures relative to the specified concentration limits and quantity of material sampled, (i) implications of short-term exposures, and (j) chemical reactiveness of the contaminants with sampling system materials.

For radioactive particulates, it is important to consider particle solubility, chemical composition, and aerodynamic size since these, along with metabolic parameters, determine final deposition sites within the body. These factors were emphasized by the 1959 report of Committee II of the International Commission on Radiation Protection (ICRP) (Ref. 6) and by the 1966 report of ICRP Task Group on Lung Dynamics (Ref. 13). Concentration limits for radioactive particulates such as those specified in 10 CFR Part 20 are based on the 1959 ICRP assumptions as to fractions of inhaled airborne material that will deposit in the lungs. These assumptions are set out in Table 4-3. When aerosols are present for which the deposited fraction retained in the lung is greater than that assumed by ICRP, account should be taken of this increased retention in limiting an individual's intake of radioactive materials.

4.2.2 Sampler Location

In some work situations, properly located fixed air samplers may be used to approximate exposure to the individual worker. However, since air

TABLE 4-3

PARTICULATES IN RESPIRATORY TRACT OF THE STANDARD MAN
(Based on ICRP Assumptions)

Retention of particulate matter in the lungs depends on many factors, such as the size, shape, and density of the particles; the chemical form; and whether or not the person is a mouth breather. When specific data are lacking, it is assumed the distribution is as shown below.

Distribution	Readily Soluble Compounds (%)	Other Compounds (%)
Exhaled	25	25
Deposited in upper respiratory passages and subsequently swallowed	50	50
Deposited in the lungs (lower respiratory passages)	25 (this is taken up into the body)	25[a]

[a]Of this, half is eliminated from the lungs and swallowed in the first 24 hours, making a total of 62-1/2% swallowed. The remaining 12-1/2% is retained in the lungs with a half-life of 120 days, it being assumed that this portion is taken up into body fluids.

concentration varies as a function of time and sampler location, this procedure can be considered to provide only an estimate of actual exposure. Breathing zone samples, which provide a more acceptable estimate of worker exposure, can be obtained by providing the worker with a small battery-operated sampler, using a pump and battery mounted on the worker's belt, and a sampler attached close to the worker's breathing zone. This technique provides the best estimate of individual worker exposure; but the

equipment may create additional inconvenience, and the low sampling flow rate might limit analytical sensitivity. However, these personal samplers detect contaminant concentrations considerably better than do well-located fixed area samplers.

Potential errors of 2- to 30-fold have been measured between personal and fixed air samplers; the fixed samplers tend to read lower. These errors may be even greater for a contaminant released from a point source. Fixed air samplers indicate general area contamination levels or changes in these levels provided that careful attention is directed to their location and mounting relative to the contaminant sources and the working area.

4.2.3 Sampling Procedures

Considerable information is available regarding air-sampling procedures, theory, equipment characteristics and limitations, measurement techniques, and data interpretation. In general, high-efficiency filter media (glass, cellulose, asbestos, and membrane) are used to provide an estimate of gross particulate concentrations. Considerable attention should be directed to the limitations inherent in this type of sample relative to the previously described concept of lung deposition as a function of particle size. Respirable fraction can be estimated by use of presamplers that have been calibrated to separate respirable from nonrespirable particles. Detailed particle size information can be obtained by using impactor samplers. Particle size information can then be compared with the more recent lung deposition model proposed by the ICRP in 1966.

Samples of gases can be obtained by using charcoal or other solid sorbents followed by either (1) radiometric counting or (2) desorption and the appropriate analytical chemistry techniques. In some procedures such as the sampling of noble gases, charcoal may be used under low-temperature conditions provided that sampling efficiency for each noble gas has been established (since adsorption of such gases on charcoal is highly variable). Direct-readout instruments have been developed for some contaminants of concern (e.g., carbon monoxide, ozone, nitrogen oxides), but frequently these instruments are nonspecific and respond also to other materials present.

For some work situations, measurement of the oxygen concentration is of major importance. Several portable direct-reading instruments are available that indicate an abnormal oxygen concentration. Monitoring of this situation is especially critical since air-purifying respirators provide no protection against oxygen deficiency and since a lack of oxygen has adverse effects very rapidly that are, of course, extremely dangerous.

When possible, the use of rapid-response instruments is desirable in work situations that might result in a highly variable level of contamination and where short duration exposures constitute a significant risk. In all cases, the efficiency of air sampling and the associated analytical procedures must be evaluated. High-efficiency filter media are extremely reliable for the measurement of airborne particulate concentrations. The collection efficiency of sorbents such as activated charcoal may vary, depending

on the chemical state of the contaminant and environmental conditions. However, the efficiency of charcoal used in air sampling need not be as high as it must be when charcoal is used for air purification.

Air-sampling data should be related to actual exposures by other techniques, including bioassay programs, and correlation of fixed or portable general air samplers and breathing zone samplers. When sampling results are interpreted, it is most important that consideration be given to (1) the variations inherent in air-sampling data due to changes in airborne contaminant concentration as a function of sampler location, (2) apparent losses due to burial of alpha-emitting particulates in the filter matrix, and (3) the variation inherent when sampling a relatively small number of particles.

Instrumentation techniques and other specifics related to air sampling and data interpretation constitute a separate topic and are not detailed in this manual.

CHAPTER 5

CLASSIFICATION, DESCRIPTION, AND LIMITATIONS OF RESPIRATORS

The degree of protection afforded against radioactive materials by a respirator that is properly fitted and worn depends chiefly on its design and mode of operation.

It should be kept in mind that there are limitations as well as advantages in the use of each of the various types of equipment. The advantages and limitations are summarized in ANSI Z88.2-1969 (Ref. 2). More detailed descriptions of equipment are given in the "Respiratory Protective Devices Manual" (Ref. 4).

5.1 FACEPIECES, HOODS, AND SUITS

Most respirators have an enclosure such as a facepiece, hood, or suit to ensure that the respirable atmosphere furnished by the respirator is conducted to the nostrils and mouth of the user and that the irrespirable atmosphere is excluded. These enclosures are sometimes referred to as "respiratory inlet coverings."

Some respirators utilize a clip to close off the nostrils and a mouthpiece or bit, through which the wearer breathes, connected to a cartridge, canister, or bottled air supply. These devices are intended to be worn where quick exits in emergency-escape situations might be necessary; they are considered unsuitable for any other use against radioactive materials. All other respirators considered here are designed to be used with one or more of the enclosures described in Sections 5.1.1 through 5.1.3.

5.1.1 Facepieces

A facepiece is a tight-fitting enclosure over all or a portion of the face. Two types of facepieces are commonly used: the half mask and the full facepiece mask. (Note: Quarter masks that fit *on* rather than *under* the chin are commercially available. However, they are not acceptable for protection against radioactive materials.)

The *half mask* that fits *under* the chin and encloses the wearer's nose and mouth (Figure 5-1) is the only respirator that is not a full-face type and that is acceptable for protection against radioactive particulates. The facepiece is supported by two headbands with an adjustable four-point suspension. (Note: Two-point suspension is not acceptable because it does not provide a stable and reliable method of maintaining an adequate seal against the face.) Woven elastic headbands are generally more desirable for half masks than rubber because of ease in adjustment and less rapid deterioration.

The *full facepiece mask* completely encloses the wearer's eyes, nose, mouth, and chin (Figure 5-2). This facepiece is supported by a head harness.

Facepieces are generally constructed of rubber or flexible plastic, and full facepieces have one or two transparent lenses for viewing. A full facepiece has a head harness that is attached to the facepiece at five or six points or has an adjustable semirigid "welder's type" suspension attached at the temples at two points.

HALF MASK

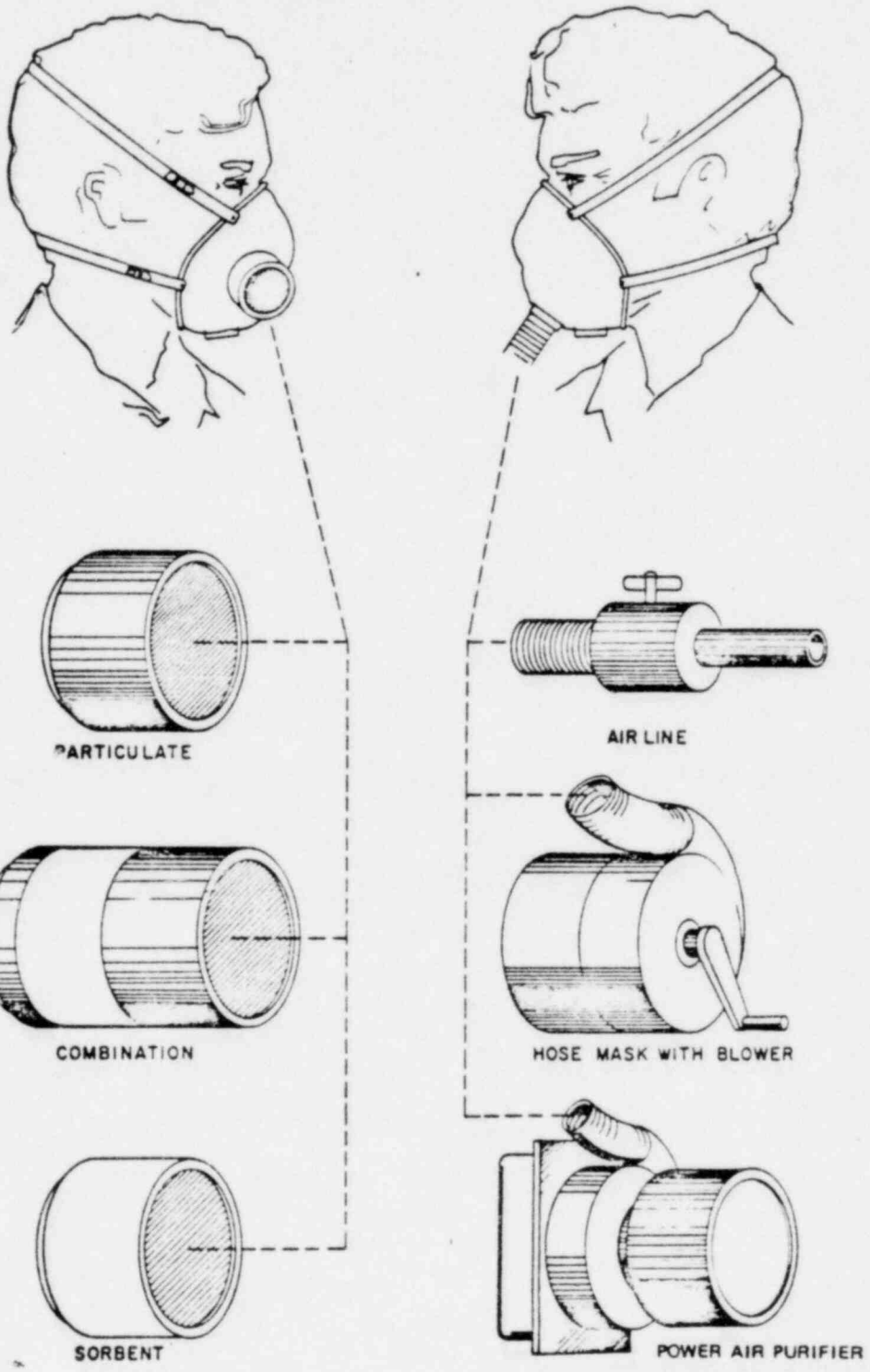

FIGURE 5-1

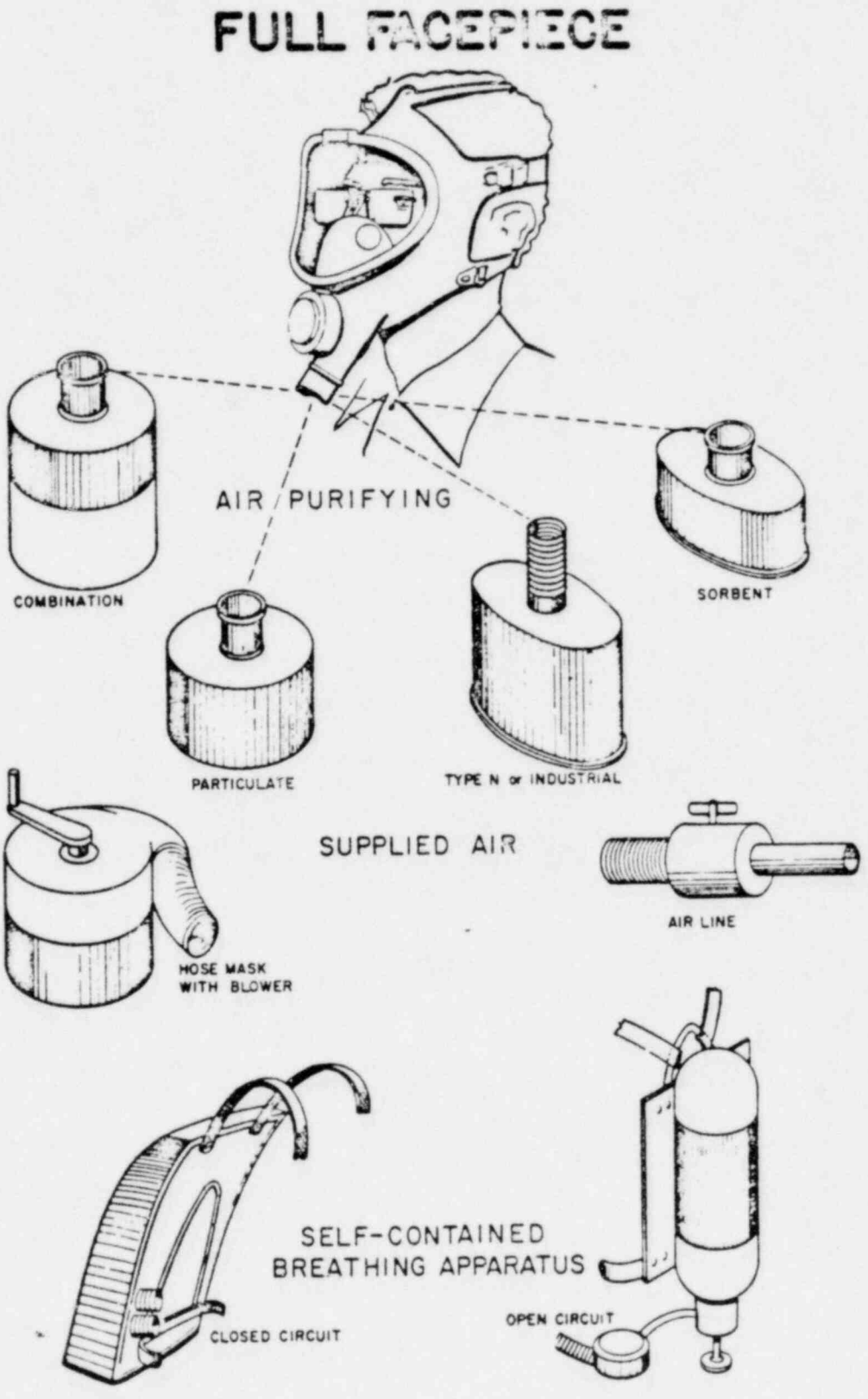
FULL FACEPIECE
AIR PURIFYING
COMBINATION
PARTICULATE
TYPE N or INDUSTRIAL
SORBENT
SUPPLIED AIR
HOSE MASK
WITH BLOWER
AIR LINE
SELF-CONTAINED
BREATHING APPARATUS
CLOSED CIRCUIT
OPEN CIRCUIT

FIGURE 5-2

In an air-purifying facepiece, the airflow is inward through a cartridge or canister and through an inhalation valve that prevents backflow of air through the cartridge during exhalation. An exhalation valve allows release of the exhaled breath to the atmosphere and prevents flow of contaminated ambient air into the facepiece during inhalation. Additionally, there is usually an exhalation valve cover that traps a small amount of clean exhaled air. This trapped clean air serves as a reservoir and is drawn into the facepiece as the exhalation valve closes at the very beginning of the inhalation cycle. Atmosphere-supplying devices generally have only an exhalation valve.

5.1.2 Hoods and Helmets

A hood is a loose-fitting enclosure over the head, neck, and the entire shoulders, gathered around the neck or below the shoulders to ensure a snug fit (Figure 5-3). The hood is generally constructed of light nonrigid plastic or coated or impregnated fabric and has a large transparent viewing window.

A helmet is a similar device of more rigid construction providing some impact protection to the eyes, face, and other parts of the head. Not all helmets are approved as hard hats.

Air to a hood or helmet is introduced into the head enclosure. The air flows past the breathing zone and escapes around the gathering perimeter. This design alleviates the need for an exhalation valve.

SUPPLIED-AIR HOOD

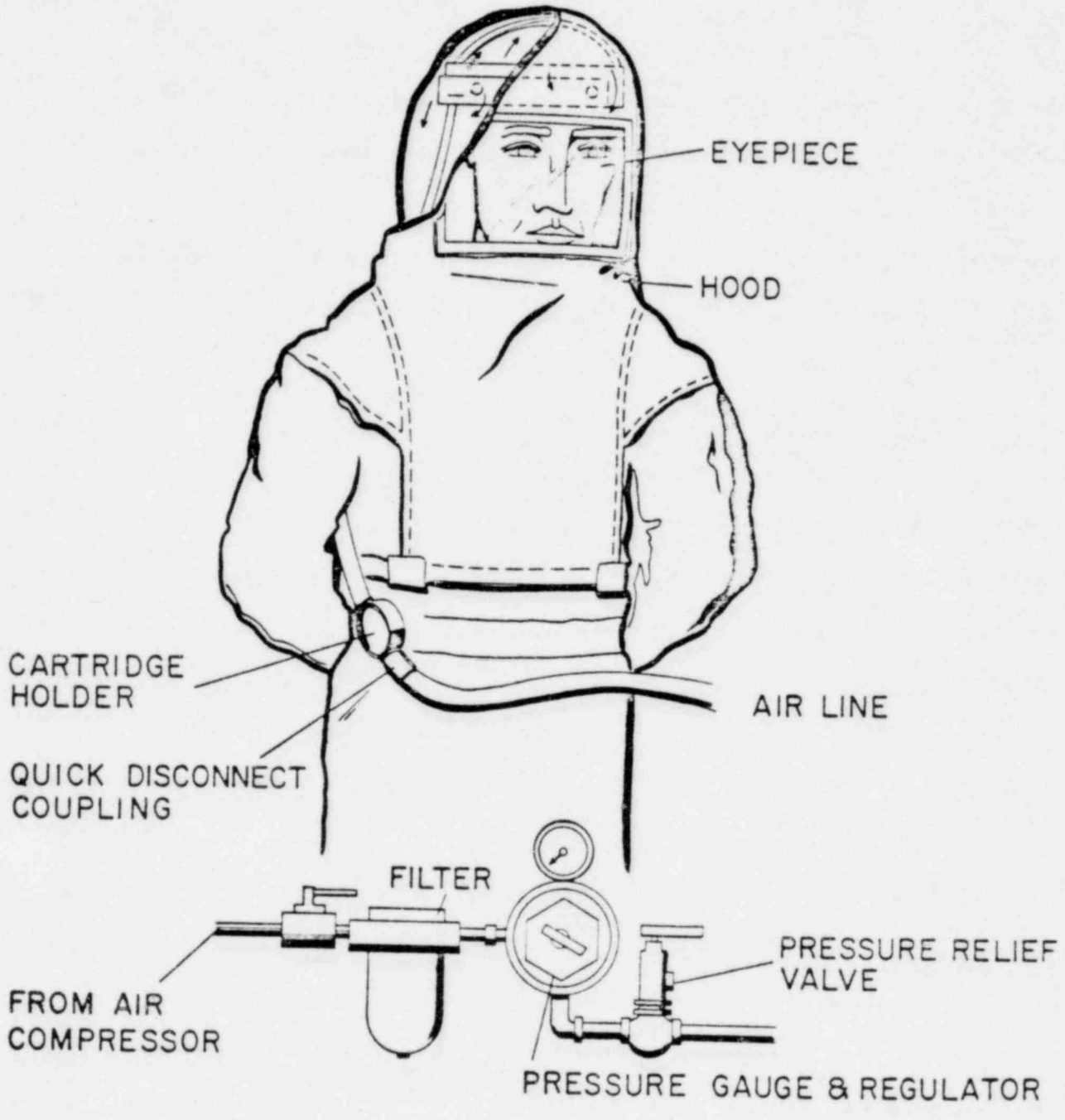

FIGURE 5-3

The hood or helmet acts as a positive pressure chamber that is continuously purged with respirable air at low velocity. There must be enough airflow to prevent contaminants from being aspirated into the hood by a "bellows effect" from the wearer's movements. With some hoods or helmets, this effect may be lessened by placing inside an outer garment hood material reaching below the shoulders (Ref. 12).

Bureau of Mines/NIOSH regulations for approved hoods and helmets in 30 CFR Part 11 require a minimum air supply of 6 cubic feet per minute (cfm) and a maximum not to exceed 15 cfm. Flow rates of 8-10 cfm may well be required to provide reasonable thermal comfort depending on ambient temperatures, circulation of air inside the hood or helmet, and work rate. However, it should be noted that air impact on the face at these higher flow rates is frequently uncomfortable.

Noise from the airflow within a hood or helmet may be a hazard. Hoods must be designed to reduce the noise to acceptable levels (less than 80 dbA) while maintaining the airflow rates required for adequate protection, respiration, and thermal comfort (References 3, 15).

An air-control valve, if provided, is generally located on the wearer's belt in a position where the user may regulate his own supply. However, each air-control valve must be tested to ensure that a minimum flow rate of 6 cfm is provided irrespective of the wearer's setting of the valve's control in actual use.

5.1.3 Suits

An air-line suit (supplied-air suit) consists of a suit of plastic or of coated or impregnated fabric that is maintained under positive pressure by an air-line supply (Figure 5-4). In general, the air is distributed within the suit by a system of ducts to the head, trunk, and extremities, exiting either through the suit closures or through special exhaust valves. Sufficient air must be provided both for breathing and cooling to avoid heat exhaustion. Cooling equipment, such as a vortex tube or a refrigerated air supply may also be required at high ambient temperatures.

The need for an adequate continuous supply of respirable air to such suits is more important than with other air-line respirators. Such a need stems from the potential lack of adequate warning in case of loss of air supply and the difficulties that would be encountered by the wearer in extricating himself from the suit while carbon dioxide, moisture, and heat build up, and oxygen becomes deficient inside the suit. A loss of a continuous air supply and a consequent deficiency of oxygen as a result of rebreathing can cause rapid onset of unconsciousness and death (Ref. 16).

For this reason, and because circumstances in which rescue is required might include extreme respiratory hazards, a second individual equipped with self-contained breathing apparatus shall be stationed in respirable air outside the contaminated area. This individual shall be prepared and trained to render emergency assistance to the individual in the suit in case of failure of the air supply. He shall be in visual, voice, or signal line communication at all times.

ONE-PIECE SUPPLIED-AIR SUIT

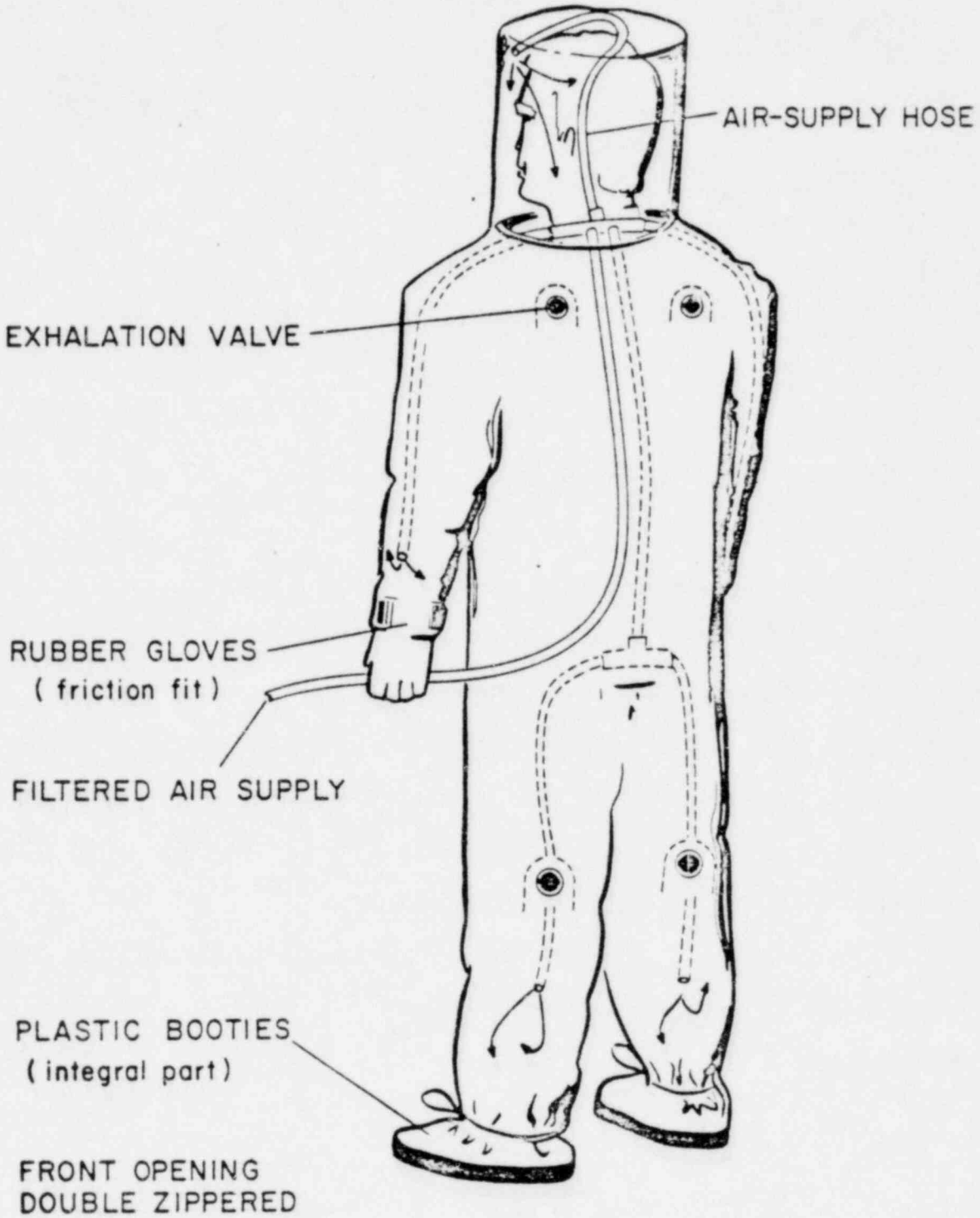

FIGURE 5-4

It should also be recognized that suit materials may have some permeability to chemicals and an associated retention of toxic materials. Such permeability may ultimately result in the exposure of the wearer to a contaminant, even though the suit is continuously maintained at positive pressure (Refs. 17-25).

5.2 RESPIRATOR TYPES, DESCRIPTIONS, AND LIMITATIONS

5.2.1 Air-Purifying Respirators

An air-purifying respirator is one that removes contaminants from the ambient air. The purification of the air is accomplished by mechanically filtering out particulate contaminants with fibrous media or by removing contaminating gases and vapors by chemical means. Cartridges and canisters are available that are capable of removing both types of contaminants. Throughout this manual, "cartridges" refers to the smaller types of air-purifying filters used generally on half-mask respirators, "canisters" refers to the larger capacity devices used on full-facepiece respirators, either attached to the respirator facepiece (chin style) or carried on the chest or back and attached to the facepiece with a flexible hose (Type N or industrial size). The word "filter" generally refers to a mechanical device used to remove particulate contaminants.

Air-purifying respirators generally operate in the negative pressure (NP) mode; that is, a negative pressure is created in the facepiece during inhalation. An exception is a special type of powered air-purifying

respirator that operates continuously in the positive pressure (PP) mode by using a motor-driven blower to drive the contaminated air through an air-purifying filter and/or sorbent cartridge.

5.2.1.1 Air-Purifying Respirator - Negative Pressure Mode

This common type of air-purifying respirator is used with a tight-fitting facepiece. The motive force for passage of contaminated air through the air-purifying media is provided by the wearer's breathing. During inhalation, the facepiece is under negative pressure. This negative pressure results in various degrees of penetration of contaminants by inward leakage through the seal area between the facepiece and the wearer's face (assuming there are no other potential sources of leakage). Full facepieces generally have less penetration through the seal area than half-mask facepieces. During exhalation, the mask interior is at positive pressure. Since the leakage through the filters is generally much less than the potential leakage around the facial seal, the limitations placed upon the several types of air-purifying respirators are based primarily upon the ability to obtain an initial fit of the facepiece and to maintain the quality of the fit during wearing.

5.2.1.2 Air-Purifying Respirator - Positive Pressure Mode

This special type of air-purifying respirator may be used either with a tight-fitting facepiece or with a hood or helmet. The motive force for passage of the contaminated air through air-purifying media is provided by a blower. The blower may be driven by a battery or by a line-powered motor. The interior of the facepiece or hood is

maintained at pressures positive with respect to the ambient atmosphere at all times during blower operation. Thus, inward leakage around the facial seal area is minimized. Respirators of this type, furnished with a tight-fitting facepiece, may be designed to be operated in the negative pressure mode in the event of a power failure.

5.2.2 Filters and Sorbents (Air-Purifying Media)

Air-purifying media consist of fiber filters or sorbents used individually or in combination and contained in a suitable protective casing that is designed for attachment to the respirator facepiece or breathing tube. *Since the efficiencies of sorbents are generally not well established, no credit may be taken for the use of sorbent canisters or cartridges for protection against radioactive gases or vapors.* (See Sections 5.2.2.2 and 5.6.6.)

5.2.2.1 Filters

A filter is a fibrous medium used for the removal of airborne solid or liquid particulates from the airstream entering the respirator enclosure. It may be designed for a single type of particulate or for various combinations of particulates such as dust, fumes, and mists. Filter media used for protection against radioactive particulate contaminants shall be of the high-efficiency type (greater than 99.97% effective by thermally generated 0.3 micrometer dioctyl phthalate (DOP) test). They are *not* effective against gases and vapors.

5.2.2.2 Sorbents

Sorbents are used for chemically removing toxic gases and vapors from the airstream entering the respirator enclosure. They consist of chemicals that attract and hold the gas molecules.

Sorbents may be used singly or in mixture and multiple layers to give protection against a single gaseous contaminant, a class of contaminants (e.g., organic vapors or acid gases), or combinations of gases and vapors. They are *not,* of themselves, effective against particulates. They are not approved for use for protection against radioactive gases or vapors unless their efficiency against the gas or vapor of interest has been well established. Note: If the odor or other warning threshold is above the MPC, as is generally the case for radioactive materials, *sorbent cartridges or canisters may not be used.*

5.2.2.3 Combination Filter - Sorbent Canisters

Canisters used for protection against particulates as well as gases and vapors consist of various combinations of filters and sorbents appropriate to the hazards for which protection is desired. For radioactive particulate contaminants, the filter media shall be of the high-efficiency type.

5.2.3 Limitations on Air-Purifying Respirators

The application of air-purifying respirators for protection against airborne radioactive contamination is subject to the following additional limitations:

5.2.3.1 Oxygen Deficiency

Air-purifying respirators remove a specified contaminant from the inhaled air. These devices *do not* supply oxygen; therefore, they may not be used in atmospheres deficient in oxygen.

5.2.3.2 Nature of Contaminant

Air-purifying respirators offer protection to the wearer by removing a specific contaminant from the inhaled air by means of a particulate filter or sorbent, or both, contained in a canister. The canister media are designed for removal of specified vapor(s) or gas(es), and the components of the canister are chosen to fulfill this purpose. The canister media are, therefore, not universal sorbents and it is vital to ensure that the canister selected is appropriate to the hazard.

Unless a particulate filter element is added, as in the case of the combination filter-sorbent canister, protection against particulates is not provided by a canister designed for gases and vapors. Only a high-efficiency-type canister shall be used for protection against airborne radioactive particulates.

When air-purifying respirators are worn in atmospheres containing substances such as hydrocyanic acid that may be absorbed through the unbroken skin, adequate skin protection must be provided.

5.2.3.3 Physical and Chemical State of Contaminant

The chemical and physical state of the contaminant must be considered in the selection of an air-purifying respirator canister (see Chapter 6 for details on selection). For example, the radionuclide

chlorine-36 may be present as airborne radioactivity in any of the following forms: gaseous (as chlorine gas), vapor (as a chlorinated hydrocarbon vapor), or particulate (as a hydrochloric acid mist or fume or as a dust of a chlorine salt).

A canister containing only a particulate filter may be inappropriate for use with radionuclides that decay from a particulate to a gaseous state or from a gaseous to a particulate state. For example, a filter used to protect against fresh fission products might allow the decay product iodine-131 to pass as a gas through the filter into the lungs.

5.2.3.4 Concentration of Contaminant

Experience has shown that there are maximum concentrations above which a person may not be safely exposed while wearing an air-purifying respirator. *Air-purifying respirators shall not be used in atmospheres immediately hazardous to life or health.* As defined in American National Standards Institute recommendations, conditions "immediately dangerous to life and health" include "...conditions that pose an immediate threat to life or health and conditions that pose an immediate threat of severe exposure to contaminants such as radioactive materials which are likely to have adverse delayed effects on health." This limitation on the use of air-purifying respirators is effectively provided for radioactive materials by limiting the use of such respirators to within peak concentrations that do not exceed specified multiples of the MPC (see Chapter 6 and footnote f to Table 6-1).

The limiting concentration for many particulates would be the one that causes rapid plugging of filter media with resultant increase in breathing resistance. However, for airborne radioactivity, rapid plugging is not generally a problem unless other hazards (e.g., chemicals, dust) are also present.

5.2.3.5 Service Life

Service lives of the filter media of air-purifying respirators are directly related to the capacity of the filter for the contaminant, the concentration of the contaminant in the air, and the respiratory minute volume (amount of air breathed in per minute) of the wearer, as determined by his work rate.

The service life of a particulate filter is limited by the amount of material that can be retained before the resistance to inhalation increases significantly. A second limitation results from the radiation and potential contamination hazard due to the material deposited on the filter.

Sorbent cartridges and canisters may be used only for nonradioactive gases and vapors and should always be kept sealed until installed on the respirator because exposure to high humidities might shorten their useful lifetimes. Unsealed, unused cartridges and canisters may be kept for use for 1 year if attached to a respirator and sealed in a plastic bag. Unsealed cartridges or canisters not so stored shall be

discarded even though unused. The date of removal of the seal should be clearly marked on the cartridge or canister.

Particulate filters used for protection against radioactive particulates may be reused if a quality assurance program (see Chapter 10) is in effect to ensure that the filters meet the requirements for efficiency and resistance to breathing specified for unused filters and that a means is available to determine the extent of radioactive contamination of the filters. *If these criteria are not met, particulate filters shall not be reused.*

Sorbent cartridges and canisters that might have been used for nonradioactive gases and vapors in circumstances in which the sorbent capacity might be diminished shall never be reused, since there is no way of determining the useful service life remaining after use.

5.2.3.6 Knitted Cloth Covers (Facelets)

Knitted cloth covers (facelets) have been used on half-mask respirators for sanitary purposes. *They shall not be used since they cause significant leakage with submicron aerosols.*

5.2.4 Atmosphere-Supplying Respirators, Descriptions, and Limitations

An atmosphere-supplying respirator is one that furnishes respirable air or oxygen to the wearer from an uncontaminated supply such as a compressed-breathing air or oxygen cylinder, an oxygen-generating canister, or a breathing-air compressor that draws its supply from an uncontaminated ambient atmosphere. This type includes air-line respirators and self-contained breathing apparatus.

5.2.4.1 Air-Line Respirators: Continuous Flow, Demand, Pressure Demand

An air-line respirator provides protection against contaminants by providing an adequate supply of respirable air by any of the following three modes of operation:

a. Continuous flow

b. Demand

c. Pressure demand.

Air is supplied in an air-line respirator through a hose to a facepiece, hood, helmet, or suit. The source of respirable air may be either a cylinder of compressed pure breathing air, or a breathing-air compressor located so that the air supplied is uncontaminated and respirable. If the air-supply system pressure for demand-type air-line respirators at the hose connection exceeds 125 psig, a pressure-reduction stage must be used with a pressure-relief device in case of valve failure.

For continuous-flow units additional pressure reduction under the wearer's control may be provided with an air-regulating valve worn at some conveniently reached position. Under current Bureau of Mines/ NIOSH approvals, such an air-regulating valve, at any setting, must not reduce the flow of air to less than 4 cfm for tight-fitting facepieces or to less than 6 cfm for loose-fitting hoods or helmets with the maximum specified length of hose and the minimum specified air-supply pressure.

Detailed requirements on air-supply lines, lengths of hose, airflows, and other components may be found in Table 8 of 30 CFR Part 11, Subpart J., §11.124-7.

While the American National Standards Institute's "Standard Practices for Respiratory Protection" (Ref. 2) recommends that breathing air meet at least the requirements for the specification for Grade D air as described in Compressed Gas Association (CGA) "Commodity Specification for Air," G-7.1-1966, (Ref. 25), it is good practice to supply breathing quality air that meets the requirements for Grade E air in the CGA specification. Grade D specifications should be considered as the limits for air of deteriorating quality. The following are the limiting characteristics for Grade E and Grade D air:

	Grade E	Grade D
% O_2 (v/v) (balance mainly N_2)	Atmospheric (~21%)	Atmospheric
O_2 limits for synthesized air	19-23%[a]	19-23%[a]
Condensed hydrocarbons in mg/m^3 of gas @NTP (Max.)	5	5
Carbon monoxide, ppm (v/v) (Max.),	10	20
Carbon dioxide, ppm (v/v) (Max.)	500	1000

The CGA specifies that breathing air must have no pronounced odor.

Compressed oxygen shall never be used in supplied-air or open-circuit self-contained breathing apparatus in which compressed air has previously been used. Oxygen shall never be used with air-line respirators.

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[a]Bureau of Mines/NIOSH approvals require a minimum of 19.5% oxygen by volume.

5.2.4.1.1 Continuous Flow Type. The continuous-flow air-line respirator may be used with a half-mask facepiece, full facepiece, hood, helmet, or suit. The minimum airflow for a person doing moderate work is 4 cfm for tight-fitting facepieces, such as the half masks and full-face masks, and 6 cfm for a person wearing a hood as specified in the Bureau of Mines/ NIOSH approvals. A suit requires a flow of 6 cfm, or more, depending on the suit design.

5.2.4.1.2 Demand Types. The demand regulator is usually located between the breathing tubes leading to the facepiece and the small-diameter pressure line from a high-pressure air source, such as a compressor (~100 psi) or a breathing-air cylinder (~2400 psi). Sometimes this regulator is mounted directly on the mask. The regulator has a diaphragm-actuated valve that opens on inhalation and permits air to flow into the facepiece only as long as a negative pressure exists. The negative pressure can cause leakage of contaminants into the facepiece where it seals to the face. Therefore, a demand-type device provides no higher degree of protection against contaminants than does an air-purifying respirator with the same facepiece.

During exhalation, the regulator valve shuts off the air supply and the pressure in the facepiece returns to that present in an air-purifying respirator facepiece during exhalation. This pressure condition creates the added hazard of possible inward leakage during inhalation that is not present in the pressure-demand types.

5.2.4.1.3 Pressure-Demand Types. In a pressure-demand air-line respirator, a spring-loaded regulator and exhalation valve combination provides a flow of air into the facepiece which maintains a slight positive pressure at all times. Any outward leakage around the facepiece seal results in a greater air consumption than for the demand types. However, if the facepiece fits properly, there is no increase in air consumption.

Some pressure-demand regulators are supplied with a control so that the respirator may be operated in either the pressure-demand or demand mode. Where such a control is provided, care must be exercised to ensure that the regulator is operating in the appropriate mode.

A pressure-demand device requires a special exhalation valve that is available only on full facepieces. A facepiece fitted with a demand-type exhalation valve cannot be used with a pressure-demand regulator.

5.2.4.1.4 Limitations on Air-Line Respirators. Although most atmosphere-supplying respirators are capable of providing protection against high concentrations of many toxicants, no device is 100% efficient. Some leakage into the facepiece may occur, particularly with apparatus operated in the demand mode where there is negative pressure in the mask during part of the breathing cycle. Many of the air-line devices employing a tight-fitting facepiece use the same facepieces as many of the air-purifying half-mask and full facepiece respirators. Limitations on their

use by persons with beards, eyeglasses, etc., are identical to the limitations on similar use of air-purifying facepieces of the same design (see Chapter 13). Also, respiratory protection fails if the oxygen or air supply fails, unless an auxiliary supply is available.

Air-line respirators generally furnish no protection, other than to the face, against contaminants irritating to the skin or mucous membranes, nor any protection against materials such as tritium oxide vapor or hydrocyanic acid gas that can be absorbed through the unbroken skin. Even supplied-air suits, which may afford more protection against the latter hazards, are permeable to varying degrees, depending on factors such as concentration of contaminant, time of exposure, and the properties of the suit material.

Air-line respirators that rely on an external air source connected by a length of hose or similar device to the facepiece, hood, or suit shall not be used for emergency rescue or escape. The restriction to movement imposed by the hose and the possibility of physical damage to the hose if used in an area where there might be sharp objects (for example, after an explosion or fire) would make the use of an air-line respirator a dangerous procedure. A positive-pressure self-contained breathing apparatus shall be used instead.

The wearer's travel is limited by the length of the air-supply hose; and he must retrace his route in the contaminated atmosphere to return to fresh air while wearing the respirator unless an auxiliary air

tank is provided for escape. Air-line respirators must be used within the limits set by the manufacturer and approved in 30 CFR Part 11 for air-supply hose length, type, and range for pressure applied.

Air-line respirators provide no protection if the air supply fails; therefore, they shall not be used in atmospheres immediately dangerous to life or health. This limitation precludes their use as emergency escape and rescue devices.

5.2.4.2 Self-Contained Breathing Apparatus Description and Limitations

A self-contained breathing apparatus (SCBA) consists of a respirator with the supply of air, oxygen, or oxygen-generating material carried by the wearer. These devices can be either open circuit, such that the exhaled breath passes to the ambient atmosphere through the facepiece exhaust valve, or closed circuit (re-breathing), wherein the carbon dioxide is removed from the exhaled air, oxygen is added, and the recycled air is rebreathed. An open-circuit SCBA operates on compressed air, compressed oxygen, liquid air, or liquid oxygen. A closed-circuit SCBA uses compressed, liquid, or chemically generated oxygen.

Compressed air and oxygen *may not* be used interchangeably in the same apparatus. Compressed air might contain slight amounts of oil that might coat orifice housings; oxygen passing through such an orifice under high pressure could cause an explosion or fire (Ref. 2).

5.2.4.2.1 Demand Type, Open Circuit. The demand-type, open-circuit, self-contained breathing apparatus is similar to the demand-type air-line respirator, except that the source of respirable air is a cylinder of compressed air or oxygen carried by the wearer. This apparatus usually consists of a full facepiece equipped with a demand valve and a pressure-reducing valve connected by a cylinder of compressed air, compressed oxygen, or liquid oxygen. A pressure gauge is located near the demand valve to indicate the pressure in the gas cylinder. An alarm device indicates when the reservoir pressure has dropped below a predetermined point, allowing enough reserve time for the wearer to exit from a contaminated area.

A demand-type SCBA does not provide any higher degree of protection against airborne contaminants than an air-purifying respirator with the same facepiece, but it does provide protection against oxygen deficiency. *A demand type SCBA must never be used as a standby emergency rescue device* because the possibility of facepiece seal leakage does not warrant its use where contaminant concentration is unknown, but potentially high.

5.2.4.2.2 Pressure-Demand Type, Open Circuit. A pressure-demand self-contained breathing apparatus is an open-circuit apparatus similar to the pressure-demand air-line respirator, except that the supply of respirable air is a cylinder of compressed air carried by the wearer.

A loaded regulator and exhalation valve combination maintains a positive pressure in the facepiece slightly above atmospheric pressure at all times. Therefore, any leakage is outward.

Because of the high degree of protection provided by the pressure-demand SCBA, this type of unit is recommended for emergency use, escape, and rescue.

5.2.4.2.3 Recirculating, Closed Circuit. In the recirculating or closed-circuit self-contained breathing apparatus, conservation of oxygen or air supply is obtained by recirculation between the facepiece and a breathing bag or reservoir. Carbon dioxide in the exhaled breath is removed by an absorber. Oxygen is added to the closed circuit as needed from a cylinder of compressed or liquid oxygen. Units of this type can be obtained that have useful lifetimes up to 4 hours.

5.2.4.2.4 Limitations of Self-Contained Breathing Apparatus. The lengths of time that these devices may be used are limited by the air or oxygen supply that the wearer can carry. Units are given nominal ratings for the length of time they would protect an average person doing moderately heavy work. However, these ratings are only a guide; and oxygen or air may be used more rapidly than a rating indicates, particularly under the stress of an emergency. Thus, these units must be provided with a warning device that indicates to the wearer when the remaining service life has been reduced to the point that he should leave the area or replace the supply.

The Bureau of Mines has published information (Table 5-1) on factors affecting the service life of a 30-minute self-contained compressed-air breathing apparatus approved under its schedules.

The demand types of self-contained breathing apparatus rely on a negative pressure being created in the facepiece to actuate the air or oxygen supply. Although these types of apparatus do supply respirable air to the facepiece, thereby protecting against oxygen deficiency, they are no more efficient than an air-purifying respirator employing the same facepiece. Therefore, they should not be used as emergency devices. Concentrations of airborne contaminants can become unpredictably high in an emergency situation.

Further limitations on the use of these devices may result from their size and weight when work is to be done in a very confined space.

5.3 COMBINATION RESPIRATORS

A combination respirator is any respirator that affords the wearer the option of changing from one basic type of respirator operation to another, either by operation of a selector valve or by disconnecting a source of respirable air supply. The degree of protection afforded by the combination respirator is determined by its operating characteristics for the mode being used and the type of facepiece being used. Combination respirators may be categorized in one of the following three classes described in Sections 5.3.1 through 5.3.3.

TABLE 5-1

SERVICE LIFE OF

THIRTY-MINUTE SELF-CONTAINED COMPRESSED-AIR BREATHING APPARATUS[a]

This equipment is approved by the U.S. Bureau of Mines as a "1/2-hour duration" unit, based on the fact that the equipment, when tested by the Bureau on men performing moderate-to-heavy work, was found to last 30 minutes or more in each of the different types of work tests.

The user should not expect to obtain exactly 30 minutes service life from this apparatus on each use. The work being performed may be more or less strenuous than that used in the Bureau of Mines tests. Where work is more strenuous, the duration may be shorter, possibly as short as 15 minutes.

The duration of the unit will depend on factors such as:

(a) the degree of physical activity of the user;

(b) the physical condition of the user;

(c) the degree to which the user's breathing is increased by excitement, fear, or other emotional factors;

(d) the degree of training or experience that the user has had with this or similar equipment;

(e) whether or not the cylinder is fully charged at the start of the work period;

(f) the possible presence in the compressed air of carbon dioxide concentrations greater than the .04% normally found in atmospheric air;

(g) the atmospheric pressure; if used in a pressurized tunnel or caisson at 2 atmospheres (15 psi gage), the duration will be one-half as long as when used at 1 atmosphere; and at 3 atmospheres will be one-third as long.

(h) the condition of the apparatus.

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[a] From the U.S. Bureau of Mines.

5.3.1 Air-Line Respirator - Air-Purifying Respirator

This type of combination respirator is designed to be operated either (1) as a continuous-flow or as a demand air-line respirator, or (2) as an air-purifying respirator, negative pressure (NP). The selector switch may be manually operated or may operate automatically if there is a failure of the air-line supply.

5.3.2 Self-Contained Breathing Apparatus - Air-Purifying Respirator

This type of combination respirator utilizes a full facepiece and consists of a self-contained breathing apparatus of the demand or pressure-demand type with appropriate valving so that the respirator may be operated in the air-purifying (NP) mode. The operation of the selector switch may be manual or automatic.

5.3.3 Self-Contained Breathing Apparatus - Air-Line Respirator

This type of combination respirator uses a full or half-mask facepiece. It generally consists of a demand- or constant-flow air-line respirator with additional valving so that a small cylinder of compressed air, attached to the unit, may be used to supply respirable air if the air-line supply is interrupted. Generally, the small cylinder (5 to 7 ft^3) is suitable only for escape purposes.

5.4 HOSE MASKS WITH AND WITHOUT BLOWER

This type of mask consists of a full facepiece connected by one or more flexible breathing tubes to a large-diameter hose (approximately 1 inch inside diameter). In a hose mask with blower, the large-diameter hose is connected to a blower operated in respirable air; in the hose mask without blower, the inlet end of the large diameter hose has a filter screen and is anchored in respirable air. Hose masks are generally unsuitable for

protection against radioactive materials owing to the difficulty of keeping the inlet ends of the short hoses in uncontaminated air.

5.5 EMERGENCY USE, ESCAPE, AND RESCUE DEVICES

Because an emergency is an unplanned event (see Section 2.1.3), it must be assumed when contaminant air concentrations can not be evaluated that they may be "immediately dangerous to life" (ANSI Z88.2-1969, Section 4, Table I). Therefore, devices for use during escape, firefighting, rescue, and emergency re-entry should provide a high level of protection (Figure 5-5).

5.5.1 Self-Contained Breathing Apparatus

Generally, only the pressure-demand type SCBA should be selected for emergency use, rescue, and re-entry into a contaminated area to perform emergency shutdown or maintenance of equipment. The pressure-demand type with a positive pressure in the facepiece provides a much higher level of protection (protection factor = 10,000+) than the demand type with a negative pressure in the facepiece during inhalation.

The Bureau of Mines/NIOSH approves a 5- or 10-minute SCBA for emergency escape only. These devices are lighter and may be donned rapidly with proper training.

5.5.2 Air-Purifying Respirator

A Type N gas mask is approved for emergency use; however, the protection factor (see Chapter 6) for radioactive particulates is no greater than the protection factor of a full facepiece equipped with a high-efficiency filter. Comparison of the half-mask with the full-facepiece

EMERGENCY ESCAPE & RESCUE

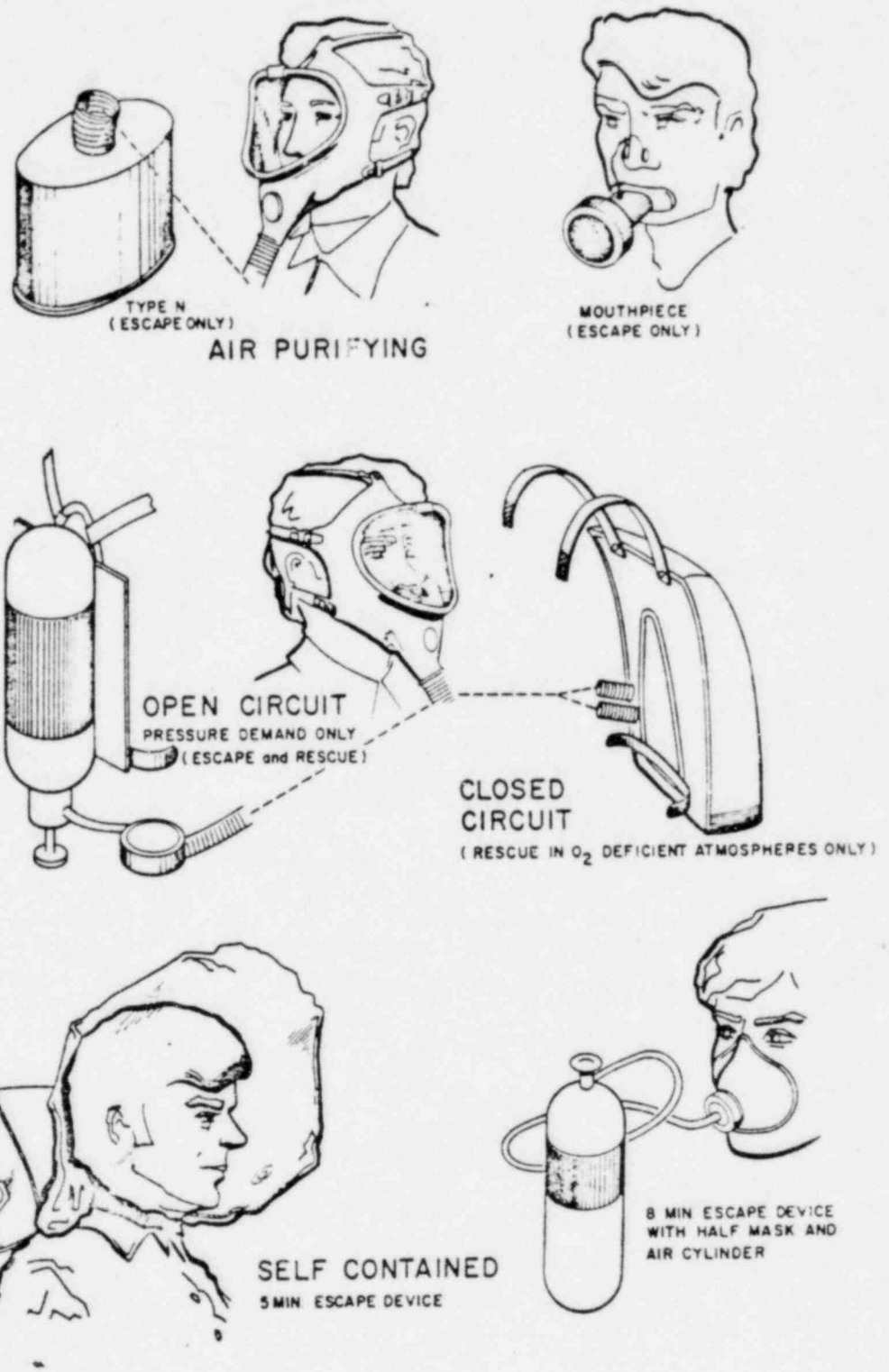


FIGURE 5-5

respirator shows that the half-mask respirator (with high-efficiency filter) protection factor is only one-fifth (PF = 10) that of the full-facepiece respirator and obviously provides the least protection of any approved device for escape from radioactive particulates.

5.5.2.1 Mouthpiece Respirators

A mouthpiece respirator is a compact device designed for quick application when the atmosphere unexpectedly is contaminated with a hazardous material. It normally consists of a housing with a mouthpiece and a single canister or cartridge, a nose clamp, exhalation and inhalation valves, and a neckband. These devices can be carried on the belt, in a laboratory coat pocket, or around the neck. When properly used, there is little inward leakage when breathing through the mouthpiece with the nose clamp in place. These devices are available with high-efficiency filters and various types of sorbent cartridges.

Mouthpiece respirators shall never be used as a routine means of protection against radioactive contamination or for re-entry into a contaminated area during an emergency.

5.5.3 Combination Respirators

There are combination air-line respirators with an auxiliary self-contained air supply that are recommended for atmospheres immediately dangerous to life. The degree of protection provided depends on the mode of operation. Because of its air-line hose, such a device is not satisfactory for emergency escape.

A combination pressure-demand, or continuous-flow-type, air-line respirator with an auxiliary self-contained air supply provides a high degree of protection. The combination demand-type air-line respirator with an auxiliary self-contained air supply provides a much lower level of protection owing to the negative pressure in the facepiece.

5.6 SELECTION OF APPROVED OR ACCEPTED EQUIPMENT

5.6.1 Subpart K, 30 CFR Part 11, and Bureau of Mines Schedule 21B

Respirators that are specifically certified under Subpart K of 30 CFR Part 11 for use against radioactive particulates are listed, along with devices that are certified under other Subparts of 30 CFR Part 11, in "NIOSH Certified Personal Protective Equipment" (NIOSH) 75-119 (Ref. 26). Supplements to (NIOSH) 75-119 are issued periodically to keep the list updated. Respirators that were formerly approved under Bureau of Mines Schedule 21B, and other Bureau of Mines Schedules, are listed in Bureau of Mines Circular 8559 (Ref. 27). Equipment is referred to as "approved" under older Bureau of Mines regulations and as "certified" under 30 CFR Part 11. (See Section 3.1.3 for terminal dates of approval under the older schedules.)

When a negative-pressure, air-purifying device is used, it shall have been certified under Subpart K specifically for radionuclides, including the separate certifications for use against radon daughters. (A device offering a greater protection factor may be selected; see Chapter 6.) The air-purifying devices used must have a high-efficiency (99.97% efficient

for 0.3 micrometer DOP aerosol) particulate filter. Devices with a less efficient filter shall never be used for radioactive particulates.

5.6.2 Other Subparts and Schedules

Four additional Bureau of Mines Schedules (Refs. 28-31) and five Bureau of Mines/NIOSH Subparts cover self-contained breathing apparatus, gas masks, supplied air respirators, chemical cartridge respirators, and pesticide respirators. These additional schedules and subparts can be used for guidance, provided that an evaluation has not shown that the radiological characteristics of the hazard present a circumstance for which the particular respirator is inappropriate. Such circumstances could occur, for example, where airborne radioactive concentrations present submersion or absorption problems or where a short-lived radioactive particulate may decay into a gas.

5.6.3 NRC Testing Programs

An extensive amount of field testing of respirators has been performed by various NRC contractor laboratories and other laboratories. Most of these testing programs, including the tests in the field, have been reported in the public literature and may be used for guidance in the selection of respirators (Refs. 16-23, 32-37).

5.6.4 Selection Guidance From Other Resources

The recommendations of competent groups such as the American Industrial Hygiene Association, the American Conference of Governmental Industrial Hygienists, the American Society of Safety Engineers, and

American National Standards Institute, who have applied the use of respirators towards protecting against chemotoxic agents, should also be considered in respirator selection (Ref. 24).

5.6.5 "Accepted" Devices

The NRC permits use of other than approved or certified devices for use against airborne radioactive materials only in the following circumstances (Refs. 1, 38):

a. Where no equipment of a particular type has been approved or certified or where there is no existing schedule for approval of certain equipment, and

b. When the licensee has demonstrated to the Commission by testing or on the basis of reliable test information that the material and performance characteristics of the equipment are capable of providing an acceptable degree of protection under proposed conditions of use.

5.6.6 Sorbent Cartridges and Canisters

Sorbent cartridges and canisters shall not be used for protection against radioactive gases or vapors for the following reasons:

a. The efficiencies of the various sorbents for most radioactive gases and vapors are not known.

b. The length of time that a particular sorbent cartridge or canister offers protection against a given radioactive gas or vapor concentration is unknown in most instances.

c. The threshold of odor for most radioactive gases and vapors is above the MPCs, often by several orders of magnitude. Thus, when a breakthrough through the sorbent occurs there is no warning.

Studies are planned to test sorbent cartridge efficiencies against some radioactive gases and vapors. As results become available, it may be possible to assign protection factors in some instances and to permit the use of sorbents in certain cases. Studies conducted at Lawrence Livermore Laboratory (Ref. 39) indicate that organic cartridge breakthrough may occur in less than a minute, even at low concentrations of some non-radioactive organics (e.g., methyl alcohol). When efficiencies and breakthrough times are unknown, extreme caution must be exercised when using any sorbent cartridge or canister device.

CHAPTER 6

SELECTION GUIDES (PROTECTION FACTORS)

The overall protection afforded by a given respirator design is defined in terms of its protection factor (PF). The PF is a measure of the degree of protection afforded by a respirator and is defined as the ratio of the concentration of contaminant in the ambient atmosphere to that inside the equipment (usually inside the facepiece) under conditions of use. Respirators are to be selected so that the concentration inhaled by the wearer does not exceed the appropriate limit.

Table 6-1 lists protection factors for the various classifications of respirators. The protection factors are based on laboratory leakage studies and field experience in the use of the devices.

When using Table 6-1, it is important to keep in mind that the values given are intended for selection of respirators to protect against radionuclides in the absence of practicable engineering controls. The values are *not* intended as a device to maximize the potential exposure of workers in areas of airborne radioactivity, nor are they intended for planning the use of respirators to avoid adequate containment and other engineering controls in the designing of installations and process equipment. The indiscriminate and uncritical use of this table where it does not apply might result in undue hazards. Scrupulous attention must be paid to the limiting and qualifying notes.

The protection factors in the table may not be appropriate where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account recommendations and requirements of the National Institute for Occupational Safety and Health and the Occupational Safety and Health Administration.

Respiratory protective equipment is to be selected to provide a protection factor greater than the multiple by which peak concentrations of radioactive materials are expected to exceed the values specified in Appendix B, Table I, Column 1 of 10 CFR Part 20. The equipment selected is to be used so that the average concentration of radioactive material inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, will not exceed the values specified in Appendix B, Table I, Column 1 of 10 CFR Part 20. For the purposes of this manual the concentration of radioactive material that is inhaled when respirators are worn may be initially estimated by dividing the ambient concentration in air by the protection factor specified in Table 6-1.

TABLE 6-1
PROTECTION FACTORS FOR RESPIRATORS[a]

DESCRIPTION[b]	MODES[c]	PROTECTION FACTORS[d] PARTICULATES ONLY	PROTECTION FACTORS[d] PARTICULATES, GASES & VAPORS[e]	SELECTION OF TESTED & CERTIFIED EQUIPMENT BUREAU OF MINES/NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH APPROVALS
I. AIR-PURIFYING RESPIRATORS				
Facepiece, half-mask[f]	NP	10		30 CFR Part 11 Subpart K
Facepiece, full	NP	50		
Facepiece, half-mask, full, or hood	PP	1000		
II. ATMOSPHERE-SUPPLYING RESPIRATORS				
1. Air-line respirator				
Facepiece, half-mask	CF		1000	30 CFR Part 11 Subpart J
Facepiece, half-mask	D		10	
Facepiece, full	CF		2000	
Facepiece, full	D		50	
Facepiece, full	PD		2000	
Hood	CF		2000[g]	
Suit	CF		h	i
2. Self-contained breathing apparatus (SCBA)				
Facepiece, full	D		50	30 CFR Part 11 Subpart H
Facepiece, full	PD		10,000	
Facepiece, full	R		50	
III. COMBINATION RESPIRATOR				
Any combination of air-purifying and atmosphere-supplying respirators		Protection factor for type and mode of operation as listed above		30 CFR Part 11 § 11.63(b)

[a]For use in the selection of respiratory protective devices to be used where the contaminant has been identified and the concentration (or possible concentration) is known.

[b]Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin. (Hoods and suits are excepted.)

[c]The mode symbols are defined as follows:

- CF = continuous flow
- D = demand
- NP = negative pressure (i.e., negative phase during inhalation)
- PD = pressure demand (i.e., always positive pressure)
- PP = positive pressure
- R = demand, recirculating (closed circuit)

[d]1. The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentration inhaled by the wearer according to the following formula:

$$\text{Concentration Inhaled} = \frac{\text{Ambient Airborne Concentration}}{\text{Protection Factor}}$$

2. The protection factors apply:

(a) Only for trained individuals wearing properly fitted respirators used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters [above 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test] are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) For atmosphere-supplying respirators only when supplied with adequate respirable air.

[e]Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one half of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide; for example:

If the protection factor for a device is:	PF overall for tritium oxide is:
10	1.82
100	1.98
1,000	1.99

(Continued)

(Continued)

Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote g concerning supplied-air suits.

[f]Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentration to reach instantaneous values greater than 10 times the pertinent values in Table I, Column 1 of Appendix B to 10 CFR Part 20, "Standards for Protection Against Radiation." This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask is to be tested for fit with irritant smoke, prior to use, each time it is donned.

[g]The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-over-head. Such aspiration may be overcome if a short cape-like extention to the hood is worn under a coat or coveralls. Other limitations specified by the approval agency must be considered before using a hood in certain types of atmospheres (see footnote h). Manufacturers' recommended pressure settings for the air supply cannot always be relied on to ensure a minimum 6 cfm air flow. Equipment must be operated in a manner that ensures proper flow rates are maintained.

[h]Appropriate protection factors must be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use.

[i]No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

[j]This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure such as skin absorption must be taken into account in such circumstances.

Note 1: Protection factors for respirators, as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH) according to applicable approvals for respirators to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2: Radioactive contaminants for which the concentration values in Table I of Appendix B to 10 CFR Part 20 are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under such circumstances, limitations on occupancy may have to be governed by external dose limits.

CHAPTER 7

WEARER REQUIREMENTS AND LIMITATIONS

7.1 ACTIVITIES OF THE WEARER

An important element to be considered in the selection of respirators is the degree to which the device selected will meet the physical and physiological requirements of the work to be done without causing undue stress to the wearer or imposing restraints that lead to unsafe practices (Refs. 17, 40).

It should be recognized that the wearing of respirators usually results in some additional stress and, therefore, an additional risk to the wearer. Thus, respirators should be selected so that any specific job can be performed with a minimum of stress compatible with the job requirements and the degree of respiratory protection needed.

The work rate of the wearer determines his respiratory minute volume, peak respiratory airflow rate, and the inhalation and exhalation breathing resistance associated with the respirator. The minute volume is significant when self-contained and air-line respirators are operated from cylinders because it determines the useful duration of the air supply. The useful life of the air supply at moderate work rates may be only one-third that at sedentary use.

Peak respiratory airflow rate is of importance since to maintain a continuous-flow, air-line respirator or a positive-pressure, air-purifying respirator under positive pressure at all times, the supply rate must be

greater than the peak respiratory airflow rate. The 4 cfm air supply (minimum) recommended for tight-fitting facepieces is 115 liters per minute or approximately the peak airflow rate for a normal person working at a moderate work rate of 622 kg-m/min. Similar considerations apply to the 6 cfm air supply (minimum) recommended for hoods.

The resistance to breathing associated with air-purifying and demand-type SCBA and air-line respirators of the negative pressure (NP) type used by a person working at a moderate work rate or at higher elevations can result in worker fatigue and discomfort. This is especially true for the Type N gas mask.

Visual and communications limitations of respirators and other special problems must not be neglected (see Chapter 13). Appropriate equipment with proper visual and communications capabilities must be provided where the work to be done demands it. Otherwise, hazardous situations may arise; for example, the wearer might remove the respirator in a hazardous area in order to see (lens fogging) or to be heard.

7.2 FIT

The most significant individual requirement of the wearer is proper respirator fit. Each commercial half-mask and full-face respirator normally manufactured in the U.S. to date has been available only in one size. Since a given respirator in a single size will not fit all of the population, it is necessary that several models be available in order that each person may know which models provide him with an adequate fit. (A few individuals of

unusual facial size or contour may be encountered who cannot be fitted adequately and should therefore not be permitted to use negative pressure respirators of the facepiece type.) An adequate fit is of importance with any facepiece operating in the negative pressure mode (NP type) when a high degree of protection is required. (See Chapter 8 for fitting methods.)

7.3 ANTHROPOMETRIC CRITERION

Although there is a wide variety of facial sizes and shapes in the general population, commercial respirators are available in only one size, i.e., each manufacturer produces only one size of each of his respirator models. In addition, all masks are presently designed for men. Most women have faces that are both narrower and shorter than men's. Consequently, it is expected that the fitting of women is more difficult.

Many factors affect the fit of a mask. Even different commercial masks of the same length may accommodate different faces if there are differences in the design of sealing edge, shape, and materials of manufacture. An effective way to have the capability of fitting a large percentage of the population at the present time is to stock the products of three or four different manufacturers. Because the different brands of commercial masks differ considerably in design, the availability of different brands and the use of a fitting test is the most effective way to provide adequate protection for most of those people who wear respirators.

The 1956-1958 AEC Ad Hoc Committee on Respiratory Protection Equipment suggested that respirators be designed so that 95% of the population could

obtain an adequate fit with any specific respirator or size series of masks (Ref. 4). Table 7-1 shows the 95% limits used in determining protection factors for both half- and full-facepiece masks for men and women for face length, face width, and lip width. Persons whose facial dimensions are outside these limits should be identified since they might have more difficulty in obtaining a good seal with a respirator.

TABLE 7-1

95% LIMITS OF FACIAL MEASUREMENT (in mm)

	Men	Women
Face Length	108-133	94-119
Face Width	132-153	117-141
Lip Width	45-60	35-52

These ranges encompass $\pm$ 2.0 standard deviations of the mean values from surveys of military populations: for men, the 1967 USAF Anthropometric Survey of Flying Personnel, for women, the 1968 Anthropometric Survey of Air Force Women.

The proposed Bureau of Mines/NIOSH amendments for 30 CFR Part 11 specify that the certifying test panel be representative of 95% of the male-female working population. Thus, the protection factors given in Chapter 6 will apply *only* to 95% of the population. Therefore, it will be necessary for licensees to identify the 5% of the working population not covered by the approval tests.

7.3.1 Anthropometric Facial Measurements and Characteristics Relating to Facepiece Fit

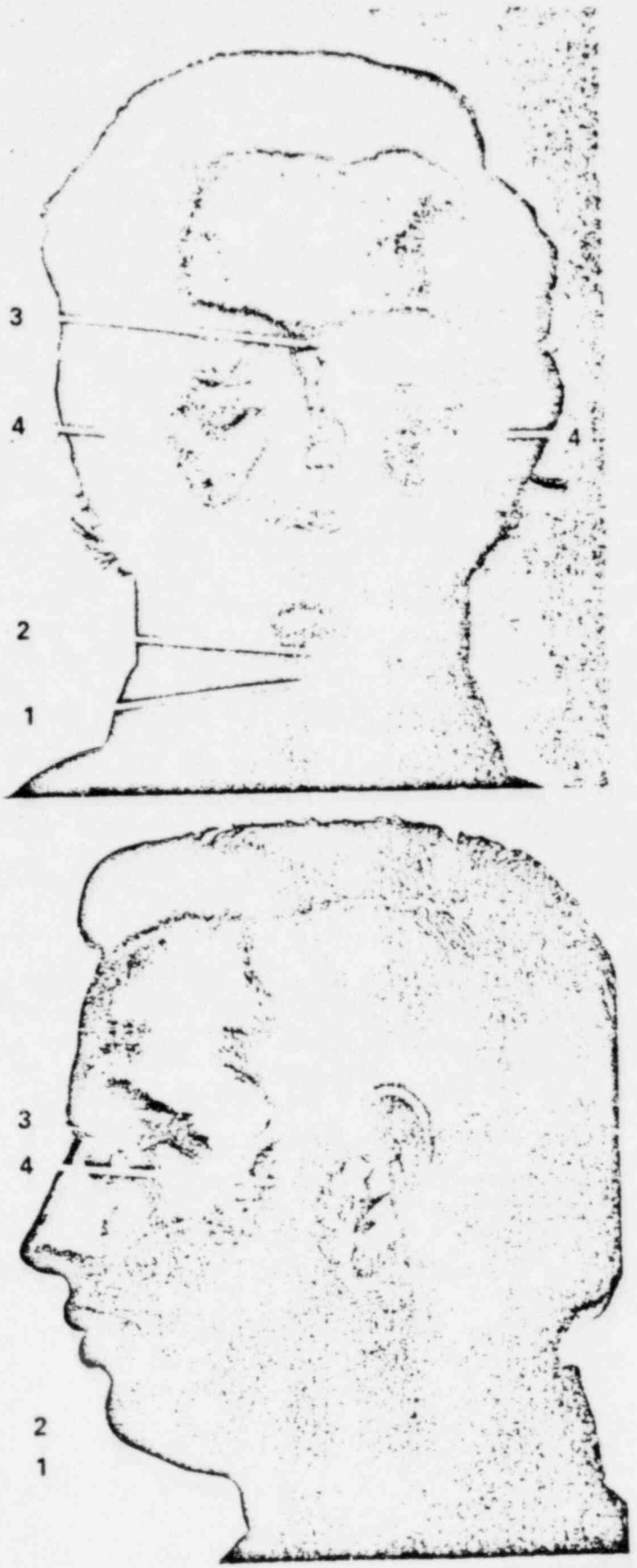
Standard anthropometric techniques consist of measuring between selected points on the face with anthropometric calipers. These points, called landmarks, refer to either visible features on the face, such as the corners of the mouth, or to points on the underlying skull. The latter must be located by palpating the skin and marking the correct location with a pencil. Then the actual measurements can be taken using the indicated landmarks. An example of a landmark located by palpation is the menton, which is the point of the chin in the center of the jaw. A few key facial dimensions of importance in respirator fitting are shown in Figure 7-1.

Face length is perhaps the most important single dimension in respirator design and fitting. Face length is measured from the menton, described above, to the nasal root depression, defined as the area of greatest indentation where the bridge of the nose meets the forehead. This distance is shown in Figure 7-2. It might be noted that although a full face mask covers the distance from under the chin to above the eyebrows, this distance is closely related to the face length.

An appropriate breadth measurement for a full-facepiece mask is face width. It is defined as the maximum horizontal breadth of the face across the zygomatic arches, where the bony arches extend horizontally along the side of the head from the cheekbone to the ear. Figure 7-3 illustrates the measurement of face width.

Figure 7-1 ANTHROPOMETRIC LANDMARKS

1. Menton- The tip at the bottom surface of the chin
2. Anterior Chin Projection- The maximum anterior projection of the fleshy chin with face viewed in profile.
3. Nasal Root Depression- With subject viewed in profile the point of maximum depression (posterior) of the nasal root.
4. Bizygomatic Breadth- The maximum horizontal breadth of the face across the most laterally projecting bones of the cheek.



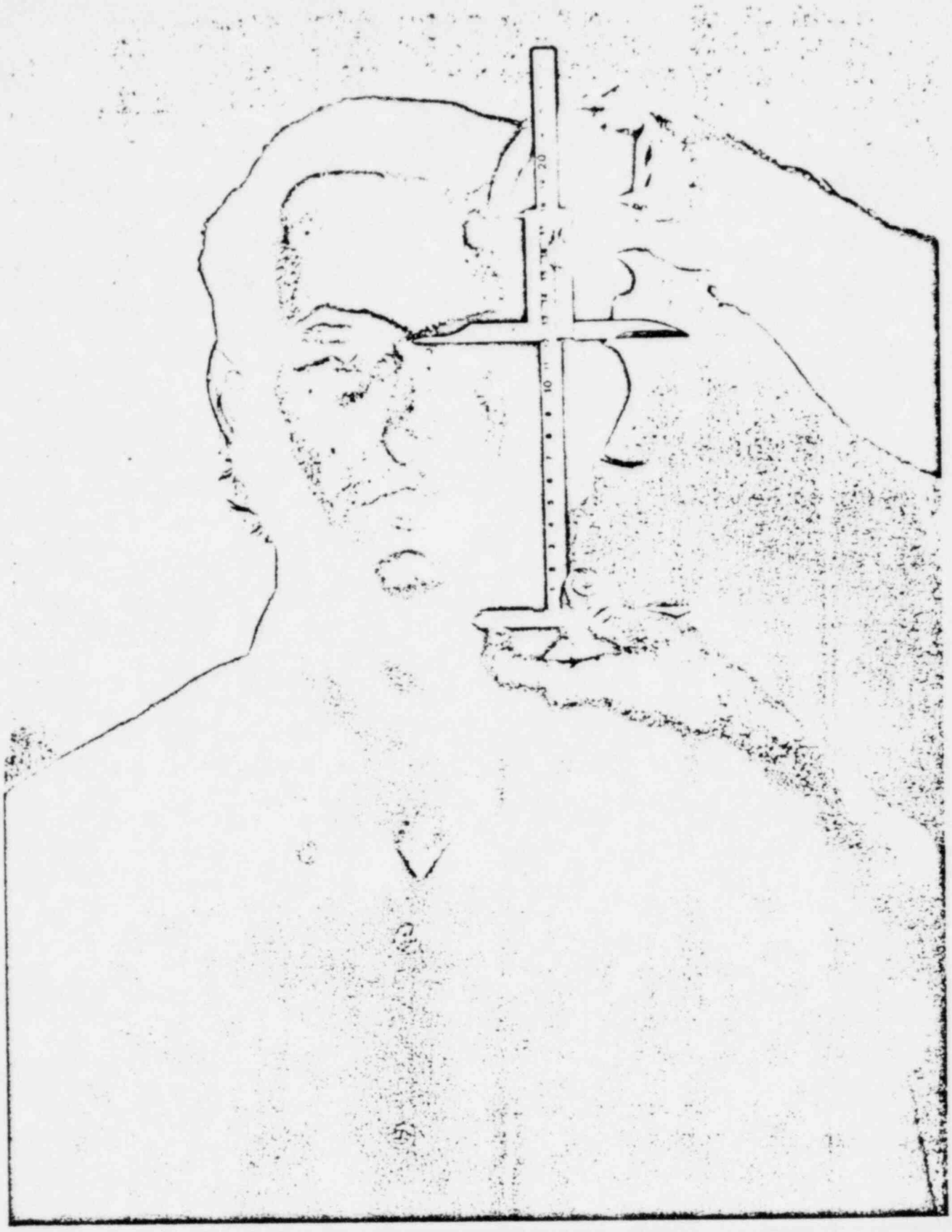


FIGURE 7-2 MEASUREMENT OF FACIAL LENGTH

FIGURE 7-3 MEASUREMENT OF FACIAL WIDTH

Other factors of possible importance in fitting a full-facepiece mask include the shape of the jaw and the width across the eyebrows.

The correlation between face length and face width is low, as it is for most facial dimensions. Therefore, subjects with a long face do not necessarily have a wide face.

For half-mask fitting, face length is important and is used, but a different width is more appropriate. Lip width, shown in Figure 7-4, is measured from one corner of the mouth to the other. This width is related to the ability of a half mask or quarter mask to seal around the mouth, although the mouth width can change while the subject is talking or moving his jaw. Other measurements may be important in evaluating the fit of a half mask, such as the width of the nasal bridge, and studies are being carried out to find what their significance may be.

Anthropologists employ standard measuring calipers which are not in general use outside the profession but are commercially available.

7.3.2 Facial Abnormalities

Many characteristics of the face can adversely affect the seal of a respirator facepiece. Some of the features that should be obvious to and carefully checked by the individual doing the respirator fitting are:

a. The effect of facial hair.

b. For half masks, the shape and size of the nose. (A nose that is skewed to one side, broken, or exceedingly broad or thin may prevent a good seal.)

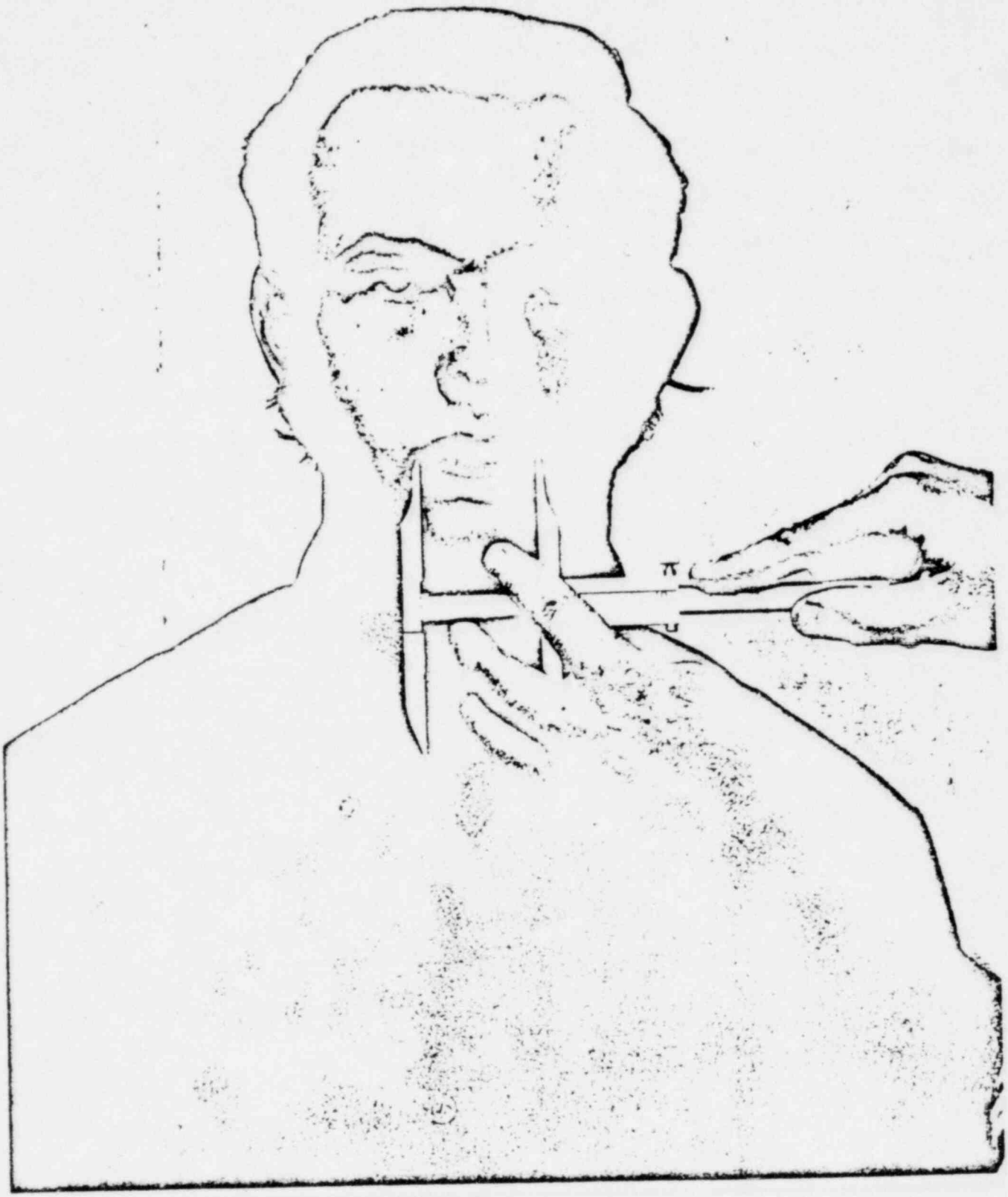


FIGURE 7-4 MEASUREMENT OF LIP WIDTH

c. A weak jaw without a clearly defined menton.

d. Hollow temples or cheeks, scars, or excessive wrinkles that may provide a channel for contaminated air to enter the breathing zone.

e. Missing dentures.

7.4 MEDICAL LIMITATIONS

Workers must be evaluated by competent medical personnel to ensure that they are physically and mentally able to wear respirators under simulated and actual working conditions. These evaluations should be an important part of the employee's periodic physical examinations routinely given in most industrial medical facilities.

Adequate medical supervision of respirator users is indispensable in determining the extent of individual stress tolerance and in preventing potential physiological derangements.

7.4.1 Physiological Factors

The "Respiratory Protective Devices Manual" (Ref. 4) devotes an entire chapter to the physiology of respiration and the effects of respiratory equipment on respiration. However, research that must still be done on the effects of stress caused by breathing against some resistance while performing various types of work includes studies of energy expenditure, pulmonary ventilation-perfusion, cardiovascular physiology, and potential for precipitating asthmatic attacks.

Because of the additional stress placed on the cardiopulmonary system, some pathological conditions (expecially those associated with hypoxemia) should preclude the use of respiratory protective devices. The presence of other cardiovascular or systemic diseases that might be aggravated also may limit the use of respiratory devices.

The following clinical conditions are among those most likely to be investigated by the examining physician in determining an individual's fitness for respirator use:

a. Chronic obstructive and restrictive lung disease: chronic bronchitis, emphysema, pneumoconioses, fibrothorax, asthma, etc;

b. Ischemic heart disease: coronary insufficiency and myocardial infarction;

c. Benign and accelerated hypertension;

d. Hemorrhagic disorders: vascular hemophilia, hypersplenism, thrombocytopenia, purpura, etc;

e. Thyroid disorders or cystic fibrosis;

f. Epilepsy: grandmal, focal, etc;

g. Diabetes mellitus;

h. Cerebrovascular accidents;

i. Facial abnormalities;

j. Kidney diseases;

k. Conductive and sensorineural hearing loss;

l. Serious defects in visual acuity;

m. Ruptured eardrum; or

n. Other disabilities.

7.4.2 Psychological Factors

It is generally very difficult to evaluate a wearer's psychological limitations by means of a routine medical examination. The examining medical doctor should investigate any mental illness thoroughly to ascertain that the wearing of respiratory protective equipment will not aggravate an existing condition. Under the best conditions, a degree of anxiety is often encountered when wearing a respirator; such anxiety may become exaggerated in emergency situations. Experienced personnel who fit and train respirator users might sometimes have the opportunity to note unusual behavior patterns.

7.4.2.1 Wearer Acceptance

Wearer acceptance of respirators can best be accomplished through proper training. Knowledge of the reason for using a device, the possible consequences of not wearing it, the capabilities of the device, and the reasons that engineering controls are not feasible may relieve any "fear of the unknown," "only sissies use them" concepts and any other preconceived notions and will improve wearer acceptance.

7.4.2.2 Claustrophobia

Some people may experience claustrophobia when wearing respirators. Claustrophobic reactions might not be detected when a device is first tried on or during the fitting phase. It usually does not appear until the wearer actually goes into an atmosphere that is either hazardous or irritating. Use of a room, chamber, or "smoke house" filled with irritating

smoke, such as that from burning wet straw, may assist greatly in identifying individuals who tend to develop claustrophobia.

7.4.2.3 Stress

Stress conditions generated in an emergency may completely incapacitate an individual, endangering him and others around him. People who may be used in an emergency, such as a standby man whose task will be to observe a worker in a tank or a rescue team member, should be trained, if possible, using simulated conditions. Because there is no way to predict how a person might react under actual stress conditions, respirator users should be conditioned physically, mentally, and psychologically for the situations they might have to deal with. Such preparation can only be accomplished by repeated and sufficient training.

7.4.3 Periodic Medical Examinations

A physical examination is required for each user before he wears any device and at least annually thereafter. A physician is to determine whether health and physical conditions are pertinent and will make necessary recommendations for each situation.

7.4.4 Medical Approval Forms

It is recommended that each licensee use a medical approval form for every individual who might use a respirator. These forms are to be completed by the examining physician for the person in charge of the respirator program. The assessment of medical restrictions facilitates the planning of training activities and the types of job assignments.

7.5 WEARER COMFORT

Comfort relates to the degree of physical distress to the respirator wearer. Everyone who wears a respirator may be expected to experience some discomfort. Distress associated with the job environment tends to be accentuated by wearing a respirator: vision is restricted; breathing is more difficult; ventilation across the face is limited; equipment may be cumbersome and restrict movement; and wearing the respirator may add to adverse effects of temperature extremes. Other factors also militate against wearer acceptance. An improperly fitted mask may create intolerable pain spots. Improperly designed or malfunctioning valves may cause uncomfortable restrictions to breathing or an irritating flicking and popping. Limitations on communications may be unpleasant and add to the hazards. All these factors contribute to the physical discomfort that affects the willingness to wear and make proper use of respirators. However, if proper attention is paid to these factors in selecting equipment, most people may be provided with respirators that do not cause undue distress and that effectively protect the wearer.

CHAPTER 8

TRAINING

8.1 QUALIFICATIONS OF TRAINING PERSONNEL

Training in the use of respiratory protective devices is to be given by a qualified and experienced instructor, such as a health physicist, industrial hygienist, or safety engineer. The instructor must have a thorough knowledge of the application and use of respiratory protective equipment and of the hazards associated with radioactive airborne contaminants. He also must have had considerable experience in the practical selection and use of respirators for protection against radioactive airborne contaminants.

8.2 EXTENT OF TRAINING

The instructor is to develop an adequate training program based on the hazards to be encountered and the types of respirators to be worn. Training must be given not only to the persons who will perform the work using the respirators but also to those individuals who will direct the work. It is important, especially in establishments where respirators are used only occasionally, that periodic retraining be performed with sufficient frequency and at appropriate times so that a high degree of proficiency will be retained when respiratory equipment is actually used.

8.3 CONTENTS OF TRAINING PROGRAM

Training in the use of any respirator must cover the following, as a minimum:

a. Discussion of the airborne contaminants against which the wearer is to be protected, including their physical properties, MPCs, physiological action, toxicity, and means of detection;

b. Discussion of the construction, operating principles, and *limitations* of the respirator and the reasons the respirator is the proper type for the particular purpose;

c. Discussion of the reasons for using the respirator and an explanation of why more positive control is not immediately feasible, including recognition that every reasonable effort is being made to reduce or eliminate the need for respirators;

d. Instruction in procedures for ensuring that the respirator is in proper working condition;

e. Instruction in fitting the respirator properly and checking for adequacy of fit;

f. Instruction in the proper use and maintenance of the respirator;

g. Discussion of the application of various cartridges and canisters available for air-purifying respirators;

h. Instruction in emergency action to be taken in the event of malfunction of the respiratory protective devices;

i. Review of radiation and contamination hazards, including the use of other protective equipment that may be used with respirators;

j. Classroom and field training to recognize and cope with emergency situations; and

k. Other special training as needed for special use.

8.4 DRILLS

Training must include the use of the respirator under simulated conditions of exposure so that the wearer will develop a sense of confidence in his ability to use the device properly. Performance in these drills is to be reviewed with the trainees by a qualified observer.

8.5 FITTING OF RESPIRATORS

Fitting of respirators can be accomplished either with quantitative man-tests or qualitative tests. In any sizable respirator program or a program that uses respirators for highly hazardous conditions or materials, quantitative tests should be used for selecting the best-performing mask for each individual during training. Qualitative field-fitting tests should be used prior to each entrance into a hazardous atmosphere to ascertain that an adequate fit has been obtained.

As a minimum, a qualitative fitting program employing a challenge atmosphere is to be used to determine which models of masks give each wearer the best protection.

8.5.1 Quantitative Man-Tests

Quantitative man-tests employ a challenge atmosphere, at a known concentration, in a chamber of some type. The wearer is first given a qualitative test while he is wearing an appropriate device for protection against the challenge atmosphere (Section 8.5.2). Once an adequate fit is obtained qualitatively, the wearer enters the chamber. A sampling tube

extends from the inside of the specially modified test respirator and is connected outside the chamber to an appropriate instrument for sampling and quantitatively measuring the atmosphere within the mask. A technician can then measure leakage into the respirator while the wearer performs various exercises.

8.5.1.1 Fitting Chambers

The following types of chambers can be used for quantitative tests:

a. Test Room. Provided there is sufficient window space in a room to allow the technician to observe the wearer in case of problems, the use of a room as a fitting chamber works well. A means of communication is also required. Although the large size of a room permits more vigorous exercise, allowing the technician to check for leakage from mask slippage due to perspiration and movement, greater volumes of the challenge atmosphere are required to achieve adequate concentrations (see Figure 8-1).

b. Test Booth. A booth may be easily converted for use as a fitting chamber. An audiometric booth or telephone-style booth could work quite well. Vigorous exercise is less practicable, however, in the smaller space than in a test room.

c. Plastic Hood. Plastic hoods work very well, particularly when used in combination with a treadmill to simulate work stress. Figure 8-2 shows a small hood, good for use with cartridge or canister masks.

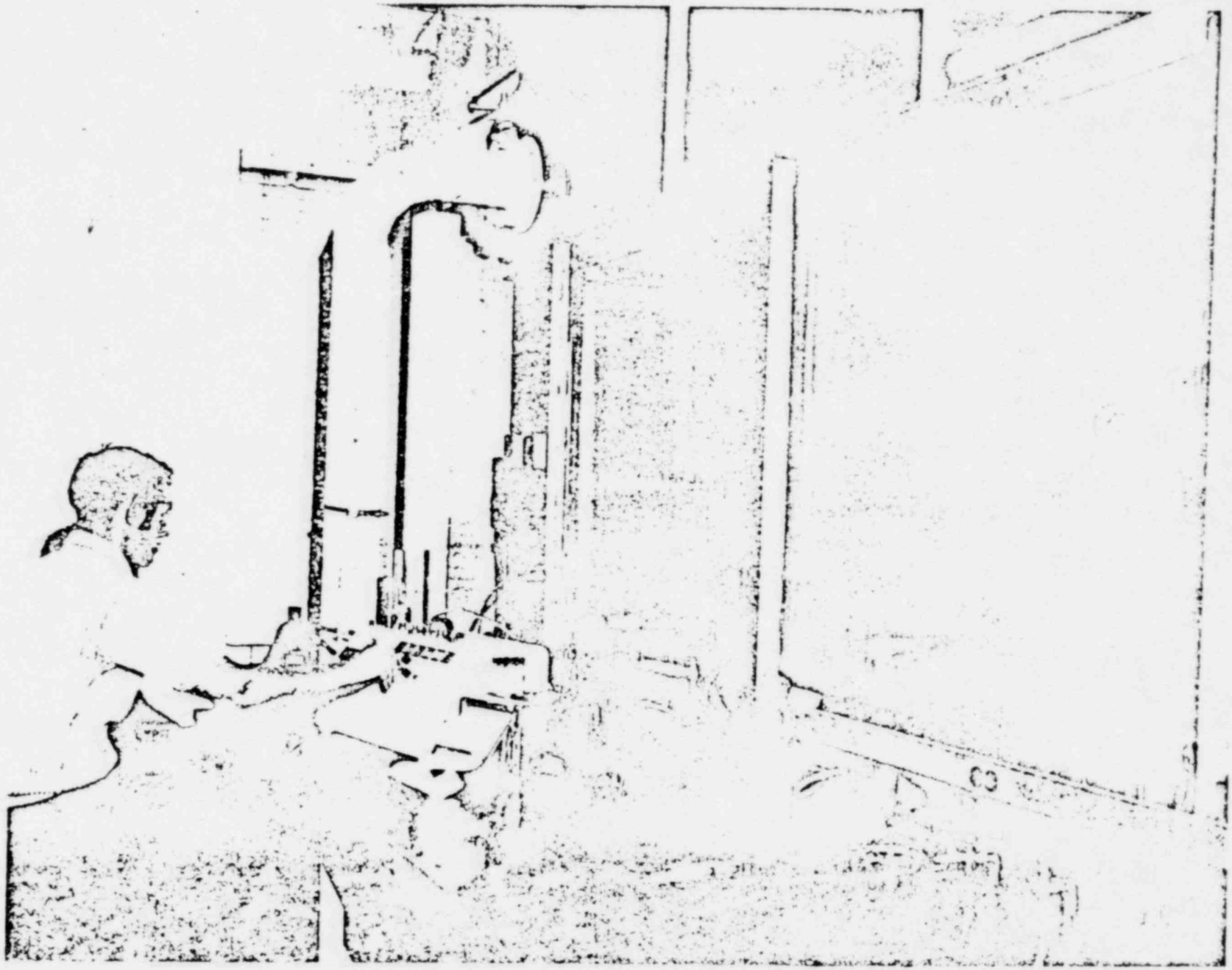


FIGURE 8-1 RESPIRATOR-FITTING TEST ROOM

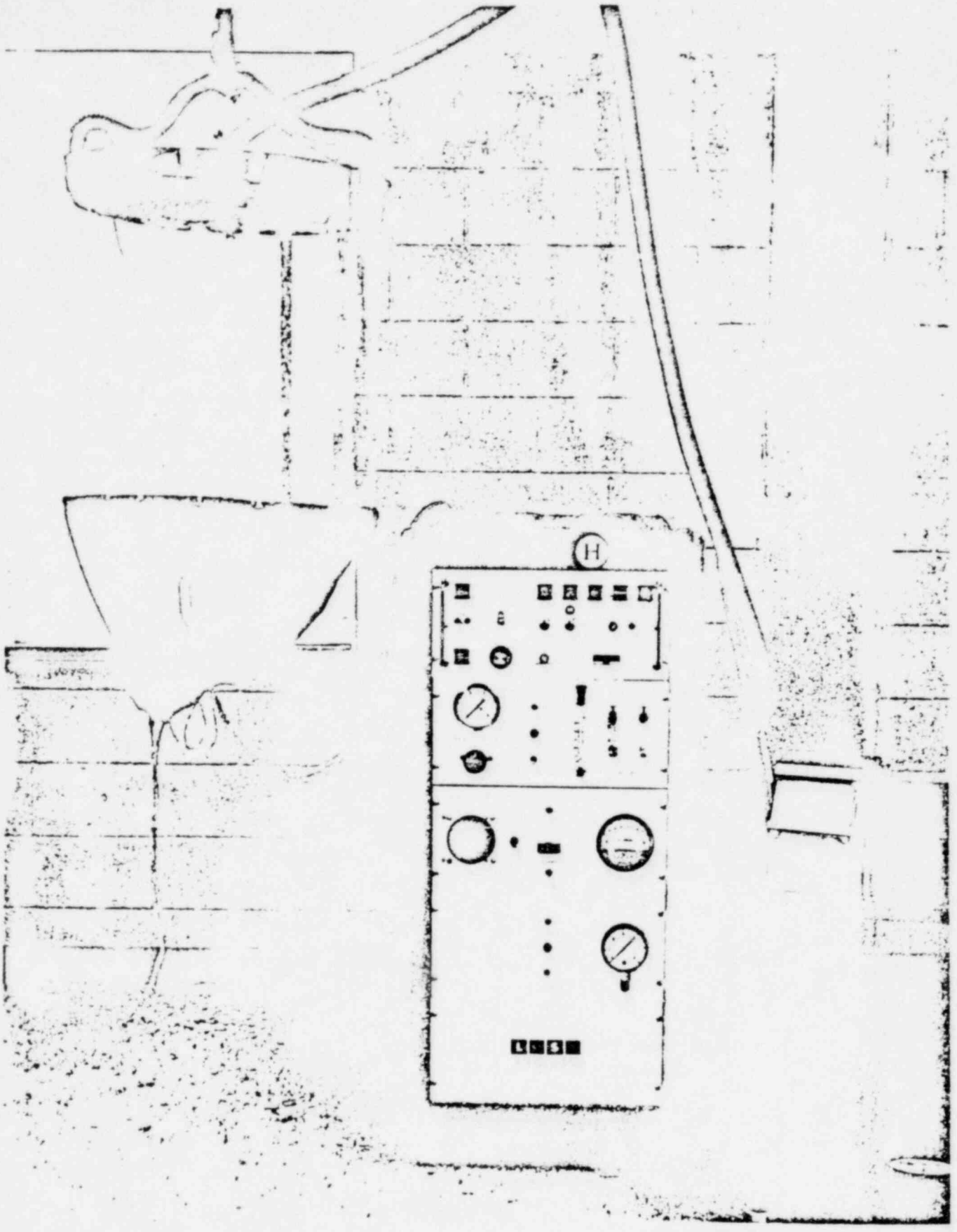


FIGURE 8-2 POLYDISPERSE DOP MAN-TEST SYSTEM WITH SMALL HOOD

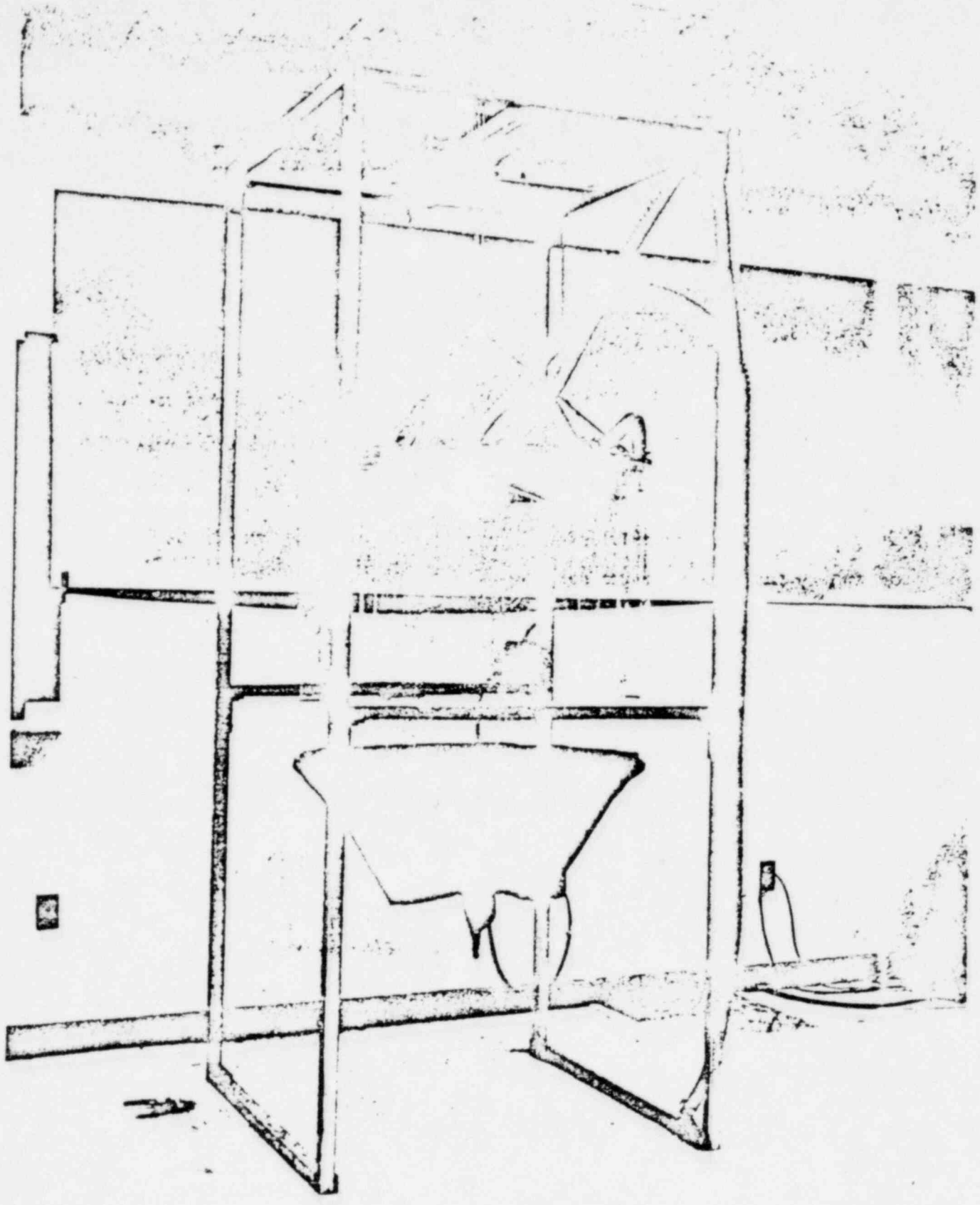


FIGURE 8-3 LARGE HOOD FOR RESPIRATOR-FITTING TESTS

Figure 8-3 shows a larger hood, which can be used even for testing a self-contained breathing apparatus. A hood can be raised or lowered with an electric motor for entering and leaving. A treadmill could be used with either hood.

8.5.1.2 Simulated Work Conditions

The more closely working conditions are simulated during fitting tests, the more useful the test results are. If a person stands perfectly still during the fitting test, those leaks that can occur from moving the head or from mask slippage due to perspiration do not show up.

The following are minimum movements that should be performed during testing of a respirator:

a. Normal breathing,

b. Deep breathing,

c. Moving head from side to side (slowly),

d. Moving head up and down (slowly),

e. Frown (for full face masks only),

f. Talking (e.g., reading a short passage aloud),

g. Running in place, and

h. Normal breathing to recheck seal after movements.

Use of a treadmill to simulate work stress may also be beneficial during fitting tests. In lieu of the treadmill, running in place or a brisk walk through an obstacle course might be used, followed immediately by another test to measure facepiece-to-face fit with hard breathing and perspiration on the face.

People who are being fitted with respirators and trained in their use should be cautioned to avoid movements of the head or face that might cause leakage at the respirator facepiece-to-face seal area. For example, extreme up-and-down or side-to-side head movements can be a source of such leaks. Extreme facial movements should also be avoided; for example, smiling is known to cause serious leakage, particularly with half-mask facepieces.

8.5.1.3 Instrumentation

8.5.1.3.1 Polydisperse DOP Man-Test System. A mobile, quantitative, polydisperse DOP respirator man-test system developed at LASL is illustrated in Figure 8-2.

The major component, the "Polydisperse DOP Aerosol System," contains an air-generated DOP aerosol system, a 5-decade, forward light-scattering photometer, air supply, and sampling vacuum system. This unit operates on 115V, 60 cycle AC current and may be moved without difficulty and operated at any location where electrical power is available.

The test chamber is a Harvard School of Public Health design that features an annular exhaust system to prevent aerosol contamination of the area outside the hood. This unit can be hung from the ceiling or from a portable frame. Flexible hose from the main unit delivers the DOP aerosol to the hood, and exhaust lines return the dynamic flow of aerosol to a high-efficiency filter. A strip chart recorder is connected to the photometer output signal for a permanent record of test results. A flow diagram of this system is shown in Figure 8-4.

FLOW DIAGRAM
COMPACT DOP MAN-TEST SYSTEM

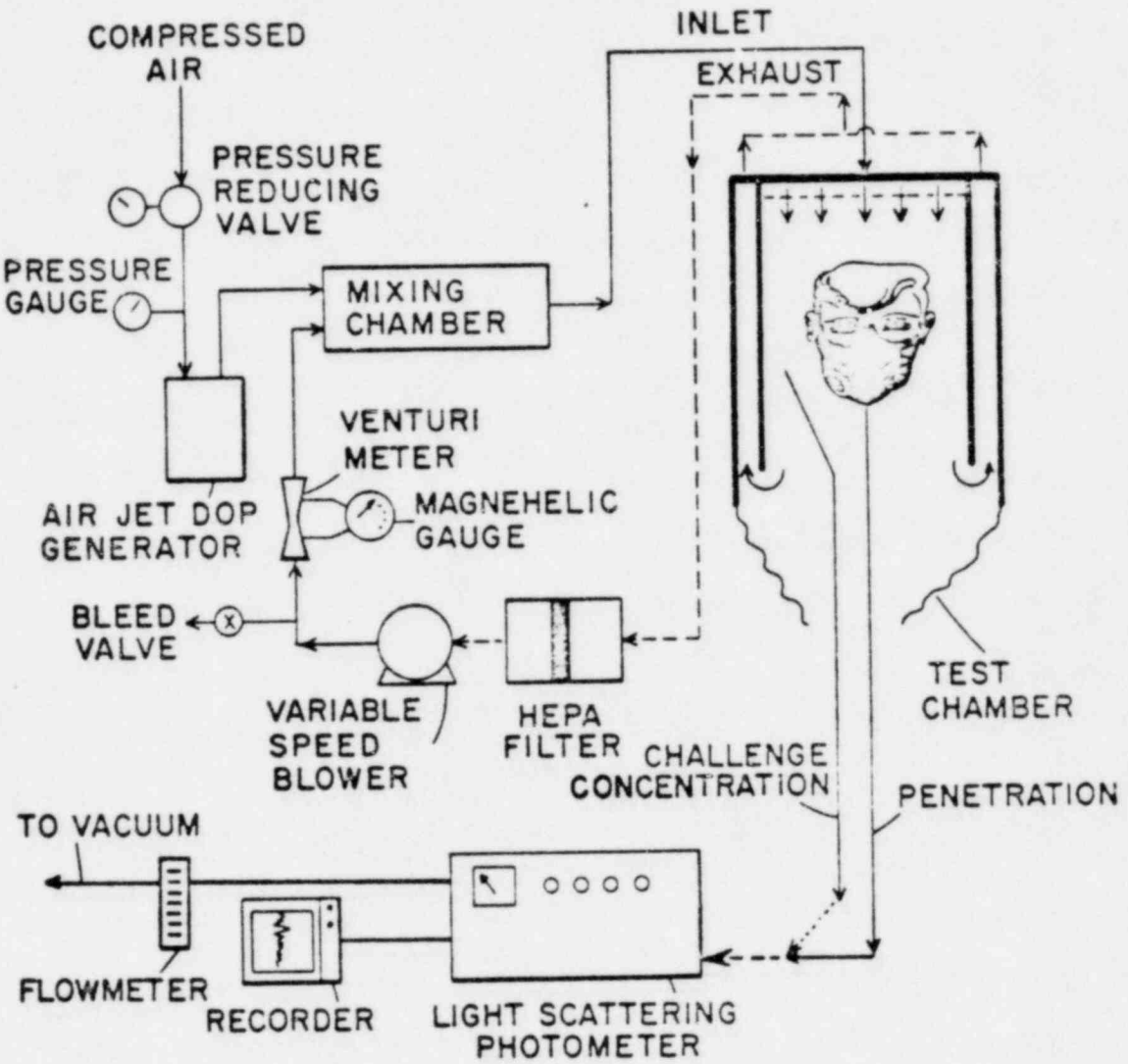


FIGURE 8-4 RESPIRATOR-FITTING TEST SYSTEM

The main advantages of this system are (a) relatively low initial cost, (b) mobility, and (c) versatility. The air-pressure-generated, polydisperse DOP aerosol is not heated[a] and therefore does not contain decomposition products of DOP. It is virtually odorless. The DOP aerosol concentration maintained in the test chamber for man-testing is 25 ± 5 mg/m^3 for air-purifying respirators and may be increased to 100 mg/m^3 for testing respiratory protective devices offering a higher degree of protection.

Air-generated, polydisperse DOP man-test systems with configurations similar to that illustrated in Figure 8-2 are commercially available from two sources.

8.5.1.3.2 Sodium Chloride Test. In the United Kingdom and Canada, sodium chloride respirator man-tests for all types of air-purifying respirators for removal of particles have been accepted as a standard procedure. In the U.S., development of an NaCl respirator man-test system has been pursued by LASL at the request of the National Institute for Occupational Safety and Health. The mobile system designed by LASL was influenced by the experience and techniques developed in the United Kingdom and Canada. The LASL-designed, polydisperse NaCl respirator man-test system is shown in Figure 8-5. Commercial models of this unit are available.

The LASL Model 1 NaCl-aerosol system is designed to generate an aerosol with reproducible particle size distribution and concentration. The NaCl-aerosol concentration is measured by the response of a photomultiplier tube to a propane flame exposed to air drawn from either the test

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[a] Monodisperse DOP is not recommended for man-tests because of the toxicity of the thermal decomposition products.

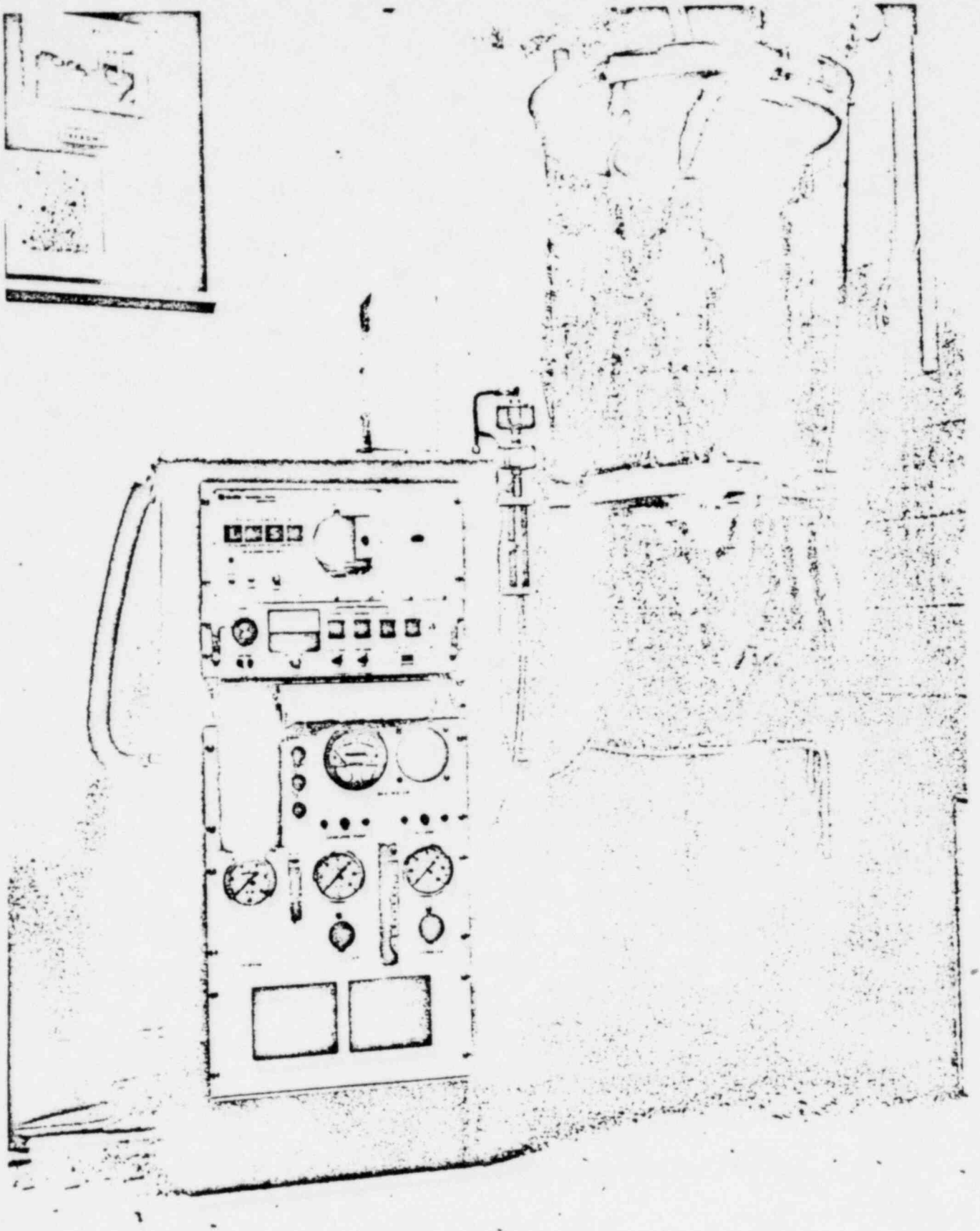

FIGURE 8-5 SODIUM CHLORIDE AEROSOL MAN- AND FILTER-TEST SYSTEM

chamber or the facepiece. The ratio of the response to the test chamber NaCl-aerosol concentration and the aerosol concentration leaking into the facepiece is monitored by a recorder built into the electronics cabinet. The test chamber is identical with that described in Section 8.5.1.3 on the polydisperse DOP man-test system. This unit can measure facepiece leakage as low as 0.02%.

The principal advantage of an NaCl respirator man-test system is the use of low concentrations (12 ± 2 mg/m^3) of a nontoxic, odor-free aerosol. The rapid response of the flame photometer to facepiece leakage is equal to that of DOP systems at much lower sampling rates (8 liters per minute for DOP to 1 liter per minute for NaCl) causing less interference with the normal functioning of the respirator. The compatible NaCl aerosol may be used for respirator man-tests with dust, fume, or high-efficiency filters without concern for overexposure of the test subject.

8.5.1.3.3 Freon-12 Test. A Freon-12 man-test system has been developed and used successfully by F. E. Adley (Ref. 16) at the Hanford Atomic Products Operation (now the Hanford Environmental Health Foundation).

Freon-12 has a TLV (Section 4.1.2.1) of 1000 ppm, is non-flammable, highly inert, and relatively nontoxic. Particle size is not a problem with a gas such as Freon-12; and it is easy to control the concentration.

For a man-test, the respirator must be equipped with pre-tested organic vapor (OV) sorbent cartridges or an external supply of clean

air. The low (~1350 cc/min) sampling rate does not interfere with the functioning of the respirator but does not provide sufficiently rapid response time for the instrument to record either the breathing cycle (inhalation-exhalation) or facepiece leakage caused by head and facial movements. The man-test data output can be recorded on a strip chart for a permanent test file and analyzed to determine an overall integrated test average.

A major difficulty with the Freon-12 respirator man-test system is in testing a respirator for facepiece fit in its Bureau of Mines approved configuration. The OV cartridges deteriorate during the test and must be tested before and after the test to determine any penetrations caused by filter deterioration or leakage (Ref. 16).

8.5.2 Qualitative Tests

When quantitative fitting test equipment is not available, some form of qualitative test is required. It is preferable to use a chamber containing a challenge atmosphere, such as isoamyl acetate, in order to perform the exercises as described in Section 8.5.2.2. If a chamber is not available, a minimum test using at least isoamyl acetate or an irritant smoke tube is required.

The major disadvantage of a qualitative test is that the wearer must determine mask leakage. The threshold of odor detection for various challenge atmospheres varies among different people. Thus, some wearers may not

detect a significant leak. Also, a wearer not properly trained to understand the reasons for wearing respirator equipment may tend to claim a leak on a less comfortable mask when no leak exists and claim no leak on a "preferred" device that is actually not sealing properly.

8.5.2.1 Fitting Chambers

As with quantitative tests, various kinds of chambers can be used. Rooms or booths are very suitable. One manufacturer makes a plastic hood and aerosol generator that fit into a suitcase for easy portability.

One of the best qualitative fitting chambers for SCBA is located in a boxcar at Lawrence Livermore Laboratory in California. The challenge atmosphere is supplied from a pot-bellied stove in which wet straw is burned to create smoke that is piped into the boxcar. The trainees, wearing SCBAs, first exercise outside the boxcar trotting and rolling barrels that are half-filled with sand. They then enter the boxcar and are asked to read various dials that display gas concentrations in the boxcar. The dials are located above platforms and under low overheads so that climbing and crawling are required. Oxygen and carbon monoxide readings are taken by each trainee so that he is aware of the gas concentrations present. Emergency conditions can be further simulated with dummy victims needing first aid.

8.5.2.2 Challenge Atmospheres

8.5.2.2.1 Isoamyl Acetate. Isoamyl acetate has been used by the Bureau of Mines/NIOSH as a qualitative means of evaluating half-face and

full-facepiece fit on air-purifying respirators. Such respirators must be fitted with appropriate organic vapor canisters or cartridges for this test. Isoamyl acetate, commonly known as banana oil, can be detected by odor in very low vapor concentrations. An air concentration of 100 parts per million (ppm) of isoamyl acetate is reccommended for testing half masks and a concentration of 1000 ppm for full-facepiece masks. (See Refs. 2 and 4 for details.) If a person wearing a respirator enters and remains in the test atmosphere while simulating work activities without detecting the odor of isoamyl acetate, the respirator is properly fitted. If he detects the odor of isoamyl acetate, he should retreat to fresh air, readjust the facepiece, and then repeat the test. If leakage is still noted, he should retreat to fresh air and recheck the respirator as previously outlined. Organic vapor cartridges must, of course, be replaced with high-efficiency filters for use against radioactive particulates.

8.5.2.2.2 Irritant Smoke. A qualitative method for checking facial fit of air-purifying respirators using high-efficiency particulate filters (Ref. 41) involves exposing the wearer to an irritating aerosol of stannic chloride (titanium tetrachloride has also been used) generated with a commercially available smoke tube. This procedure is said to provide the same sensitivity as the isoamyl acetate method.

When these smoke generators are used, the worker should be cautioned to keep his eyes closed and to breathe very shallowly at the

beginning of the test since the smoke is highly irritant. The tube should be brought no closer than 2 inches from the eyes, canister, or facepiece at any time.

This method is to be used each time a half-mask respirator is donned since it is more difficult to achieve and maintain an adequate fit with half masks than it is with other facepieces.

8.5.2.2.3 Other Challenge Atmospheres. Other challenge atmospheres, such as tear gas, have been used. However, their use is not recommended because of their toxicity and other problems associated with use of most of these materials (e.g., clinging to clothing, insensitivity or extreme sensitivity of the respirator wearer to odor, etc.).

8.5.2 Field Testing of Respirator Operation

There are many occasions where it is necessary to conduct fitting tests in the field. One of the following field-fit tests should be performed before each use of a respirator.

8.5.2.3.1 Isoamyl Acetate. For chemical cartridge respirators with organic vapor cartridges or canisters, the reliability of the face fit is checked by filling a stencil brush with isoamyl acetate or by pouring a few drops of isoamyl acetate onto a piece of cotton and waving the brush or the cotton gently near the periphery of the facepiece or cartridge (spray cans of isoamyl acetate are also available).

8.5.2.3.2 Irritant Smoke. The stannic chloride or titanium tetrachloride (smoke tube) technique can also be used in the field in a similar manner (Ref. 41).

Where it is impossible to perform the field tests using isoamyl acetate or stannic chloride, either of the following less satisfactory tests should be performed just prior to actual use of the equipment. These negative pressure and positive pressure tests should be used with considerable caution since small leakages that may be significant (e.g., around eyepieces, lens frames, speaking diaphragms, etc.) may remain undetected. Furthermore, pushing on the facepiece as described below may also close off a facepiece-to-face seal leak.

8.5.2.3.3 Negative Pressure Test. Close off the inlet opening of the canister or the breathing tube by covering it with the palm of the hand or by replacing the tape seal, gently inhale so that the facepiece collapses slightly, and hold the breath for 10 seconds. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is satisfactory.

8.5.2.3.4 Positive Pressure Test. If necessary, remove the exhalation valve cover, close off the exhalation valve with the palm of the hand, and exhale gently so that a slight positive pressure is built up in the facepiece. If no outward leakage of air is detected at the periphery of the facepiece, the face fit is satisfactory. (Note: With certain devices, removal of the exhaust valve cover is very difficult, making this test almost impossible to perform.)

CHAPTER 9

MAINTENANCE

9.1 MINIMUM ACCEPTABLE MAINTENANCE PROGRAM

The primary purpose of the maintenance program is to ensure that respiratory protective equipment is kept in a state of readiness for use. An ongoing program of continuing maintenance and inspection is imperative.

The minimum acceptable maintenance program shall include the following operations: inspection, testing, and repair; storage; inventory; issuance of devices; surveys for contamination of respirators; decontamination; cleaning and disinfection; provision of a pure, uncontaminated air or oxygen supply; and maintenance of auxiliary equipment.

9.2 INSPECTION, TESTING, AND REPAIR

An inspection, testing, and repair program must be established to ensure the operability of respiratory protective equipment. The program is to include the following elements:

a. All respirators must be inspected routinely before and after each use. Devices stored for emergency use must be inspected after each use and at least monthly to ensure that they are in satisfactory working condition. A record of inspection dates and findings is to be kept on all emergency-use devices. Routinely used and personal-issue devices are to be inspected before and after each use and at least monthly. Inspection is to include a check of the tightness of connections and the condition of the

facepiece, headbands, valves, connecting tube, and canisters. Special attention is to be given to rubber or elastomer parts to ensure that they are pliable and flexible and not deteriorating or taking a set during storage.

Self-contained breathing apparatus must be inspected at least once a month to ascertain that air and oxygen cylinders are fully charged, facepiece assemblies are totally functional and properly stored, harness assemblies are in good condition, and regulators and warning devices are functicning properly.

b. Portions of respiratory protective devices such as regulators, valves, warning devices, and cylinders, are to be tested periodically for proper function in accordance with the manufacturer's instructions or applicable standards.

c. Inspection and testing are to be carefully supervised and performed only by responsible and thoroughly trained individuals.

d. Repair of any component of a respiratory protective device may be undertaken only by persons thoroughly familiar with the device who have been instructed in the type of repair to be performed. No attempt shall be made to replace components or to make adjustments or repairs beyond the manufacturer's recommendations. No attempt shall be made to repair or adjust reducing valves or regulators. For adjustment or repair, these items are to be returned to the manufacturer or to a mechanic trained by the manufacturer.

e. Components of respiratory protective devices must be changed on a replacement schedule as required by conditions of use. In no case may replacement time exceed the time recommended by the manufacturer.

9.3 STORAGE

After cleaning, inspection, testing, and repair, the respiratory protective equipment is to be placed in storage in plastic or paper bags or storage cases. Care must be taken that the equipment is not exposed to direct sunlight, heat, extreme cold, excessive moisture, or other physicochemical environments likely to cause damage. Emergency-use devices placed at stations and work areas shall be clearly marked and shall be placed so as to be quickly accessible at all times. Devices in proper condition for re-use shall be clearly identified and separated from units needing repair. The respirators are to be packed or stored so that they are not damaged by adjacent equipment or twisted out of their normal configuration by improper storage.

9.4 INVENTORY AND CONTROL

Inventory and control procedures have to be established as a means of identifying the stock level of all respiratory protective devices and the replacement parts of any respirator. Such a procedure ensures that parts subject to deterioration can be replaced on the schedules recommended by the manufacturer. It also enables the individual supervising the respiratory protective equipment program to determine those areas where large numbers of respirators are stockpiled.

9.5 ISSUANCE OF RESPIRATORS

Procedures for issuance of respiratory protective equipment are to be established so as to ensure that only the correct respirator is obtained for a job. Proper issuance is usually accomplished by having the respirator type specified either in the work procedures or by the qualified individual supervising the respiratory protective equipment program. It is essential that the individuals issuing or supervising the use and issuance of respirators be adequately trained to ensure that the correct respiratory equipment is issued for each job and that it meets the special needs of individual workers.

Where feasible, individuals should have a permanently assigned respirator that should be durably marked indicating to whom it is assigned. This marking must not affect the respirator performance in any way.

9.6 CONTAMINATION SURVEYS/DECONTAMINATION

All respiratory protective equipment should be surveyed for radioactive contamination prior to cleaning and disinfection. Respirator facepieces or hoods may be reused by the same individual on the same working day, provided that (1) the beta-gamma contamination level on any surface of the facepiece or hood does not exceed 0.2 millirad per hour above background at contact or (2) the alpha contamination level does not exceed 100 disintegrations per minute (d/m) per 100 cm^2. The monitoring done must, of course, be appropriate for measurements of the contamination present in the area in which the respirator was used.

Respirators made available for reissuance or reuse must show no contamination (as determined by standard swipe or smear techniques) in excess of 100 d/m per 100 cm^2 fixed alpha or 1000 d/m per 100 cm^2 of beta-gamma above background at contact on any accessible surface.

9.7 CLEANING AND DISINFECTION

Respirators must be exchanged periodically for cleaning and inspection. In a large program in which respirators are used frequently, cleaning and inspection could be done daily; in small programs with only occasional use, the period might be weekly or monthly. Preferably, respirators are individually assigned; they should be durably marked to ensure that a worker receives the same device on reissuance.

Frequently used repirators are to be cleaned and disinfected as often as necessary to ensure that proper protection is provided for the user. Each worker should be briefed on the cleaning procedure and assured that he will always receive a clean and disinfected respirator. Such assurances are of greatest significance when respirators are not individually assigned to workers. Emergency devices must be cleaned after each use.

A generally accepted sound cleaning procedure is to wash the respirator with a good detergent in warm water (by hand brushing or by use of a specially adapted washing machine), rinse, and air dry in a clean place. Care should be taken not to damage the respirator by excessive heating or by agitation in the washing solution. This procedure need not be followed by disinfection for respirators issued on an individual basis.

The following procedure may be followed in cleaning air-purifying respirators:

a. Remove the filters, cartridges, or canister.

b. Wash the respirator in cleaner-sanitizer solution at 120-140°F (see the following paragraph).

c. Rinse completely in clean, warm or hot water (140°F maximum).

d. Air dry in a clean area.

e. Inspect valves, headbands, and other parts; replace with new parts, if defective.

f. Insert new or retested filters and cartridges; make sure the seal is tight.

g. Place in a plastic bag for storage.

Cleaner-sanitizer solutions that effectively clean the respirator and contain a bactericidal agent are available. The bactericidal agent is generally a quaternary ammonium compound. The respirator may be immersed in the cleaner-sanitizer solution (120-140°F), rinsed well in clean, warm water (140°F maximum) to remove all sanitizer solution, and air or machine dried.

It is good practice to disinfect respirators in addition to washing them before they are reissued, especially if a respirator will be used by different individuals. In addition to commercial cleaner-sanitizers, other compounds considered reliable for disinfecting respirators are (1) a hypochlorite solution (50 ppm of chlorine; 2 minutes immersion)

or (2) an aqueous solution of iodine (50 ppm iodine; 2 minutes immersion). A concentration of 200 ppm of quaternary ammonium compounds in water with less than 500 ppm total hardness is generally an effective disinfecting solution. The disadvantages of the quaternary ammonium compounds are (1) for waters of different compositions, different concentrations of salts are required to achieve a disinfecting solution and (2) the possibility of dermatitis of the respirator user if the quaternary ammonium salts are not completely rinsed from the respirator.

Cleaning and disinfecting agents or solvents that can damage parts of a respiratory protective device shall not be used.

9.8 MAINTENANCE OF AIR OR OXYGEN SUPPLIES

Procedures for the maintenance of a supply of respirable air or oxygen are to be included as part of the respiratory protective equipment program. Both compressed gas cylinder supplies and compressor supplies shall be maintained and used in accord with appropriate standards and recommendations. The compressed-air and oxygen-cylinder supply shall be inventoried periodically to ensure that an adequate supply is available.

All fittings and components shall be standardized so that the introduction of gases other than pure breathing air or pure breathing oxygen into a respirator system is impossible. Every compressed-gas cylinder shall have a *label* indicating that it contains pure breathing air or pure breathing oxygen, as appropriate. When a compressor is used, it must be properly monitored and attended to ensure that the air intake remains in

an uncontaminated atmosphere. A separate breathing air supply and distribution system shall be used. The ordinary plant supply of compressed air in any building shall not be used for breathing purposes (due to possible presence of carbon monoxide, oil vapor, and other contaminants) unless it has been specially modified and properly adapted for such use and specifically approved for this purpose by the qualified person supervising the respiratory protective equipment program. The maintenance of a breathing air or oxygen supply shall be performed by capable, thoroughly trained individuals. Adequate numbers of personnel must be assigned to attend and monitor air supplies, hoses, and communication lines and to keep workers using the respiratory equipment under precautionary surveillance by signal, verbal, or line-of-sight communication.

CHAPTER 10

QUALITY ASSURANCE

The purpose of a quality assurance (QA) program is to prevent the use of defective or faulty devices. A proper and complete QA program must encompass inspection and testing of both new and used devices. Written procedures must be established to maintain uniformity of the program.

10.1 NEW EQUIPMENT

Quality assurance inspection and testing of new equipment is not intended to dispute the design but to find any instances of human error in the manufacture and assembly of the devices. Manufacturers of Bureau of Mines/NIOSH-approved devices maintain rigid quality assurance programs for testing of newly manufactured devices and parts, but human error in testing may permit distribution of defective equipment. Thus, a QA program covering new equipment is needed.

10.1.1 Air-Purifying Devices

The air-purifying device, which is the least complex of respiratory protective devices, should not be slighted in inspection and testing because of its simplicity.

10.1.1.1 Facepieces

Half-mask facepieces should be inspected to ascertain the following:

a. Four-point strap suspension is to be specified on the order. Only 4-point suspension is acceptable.

b. Rubber or elastic strap material. Elastic straps are recommended and should be specified on the order.

c. Single or dual cartridge facepiece should be specified on the order.

d. Integrity of valves and seats.

e. Presence and integrity of cartridge gasket or gaskets (as required).

f. Integrity of facepiece (absence of tears, mold defects, etc.).

Full facepieces require more attention than the half-mask facepieces owing to the intricacy of the valves and speaking diaphragm assembly available on most. Inspection of full facepieces should include the following:

a. Straps and suspension.

b. Facepiece material (i.e., neoprene, silicone, etc.) should be specified on the order.

c. Integrity of facepiece (absence of tears, mold defects, etc.).

d. Canister or cartridge mounts (cheek, chin, etc.) should be specified on the order.

e. Canister or cartridge gaskets (where applicable).

f. Integrity of inhalation and exhalation valves and seals.

g. Speaking diaphragm assembly (Mylar diaphragm, diaphragm gasket, assembly tightness). A simple vacuum test on the assembly is quite effective.

h. Lens (absence of scratches, cracks, blemishes).

i. All clamps and connections (check for tightness).

Where leak-test equipment is available, it is advisable to test the complete facepiece assembly for leaks.

10.1.1.2 Cartridges, Canisters, and Filters

Cartridges, canisters, and filters should be visually inspected for damage created by handling and shipping. The presence of proper labels should be checked and the protection afforded checked against the label on the storage container. (Note: High-efficiency particulate filters, by definition, must be at least 99.97% efficient as determined by the manufacturer by testing with a monodisperse 0.3μm dioctyl phthalate (DOP) aerosol.) If possible, arrangements should be made to check some portion of each filter shipment for efficiency. (It should be noted that a fraction of the high-efficiency filters from each manufacturer has been found defective.)

For air-purifying respirators with chest- or back-mounted canisters, the canister harness assembly and corrugated breathing tube or tubes should be inspected for possible defects.

10.1.1.3 Powered Air-Purifying Units

A powered air-purifying respirator consists of a battery-operated blower fitted with an air-purifying filter connected to a facepiece by means of a corrugated breathing tube. The facepieces on the units must be inspected and tested, the blower must be checked for adequate airflow, and the tubing must be inspected for cracks or other defects and for tightness of connections.

10.1.2 Air-line Respirators

10.1.2.1 Facepieces, Hoods, and Suits

Facepieces of supplied air devices should be inspected and tested as outlined in Section 10.1.1. An additional step must be added: checking of the corrugated breathing tube for holes or defects in the rubber and for tightness of the connections at each end.

Hoods and suits should be checked for tears and defects in fabrication material, presence of zippers and snaps as required, and integrity of air distribution and exhaust systems.

10.1.2.2 Regulators

Supplied-air regulators shall be visually inspected for damage, attached to an appropriate air supply, and tested for proper function.

If a factory-trained repair technician and factory-approved test equipment are available, it is advisable to test the regulator function. Otherwise, the regulator is to be returned to the factory at least every 3 years for repair and inspection.

10.1.2.3 Compressors

Compressors used to provide air for atmosphere-supplying respirators should be inspected and tested to ascertain the following:

a. Proper and adequate intake filters.

b. Presence of moisture trap.

c. Sufficient reserve air storage (where required).

d. Carbon monoxide alarm presence and proper function (for oil-type compressors).

e. Adequate air output and presence of proper connectors for equipment to be used.

f. Heat alarm function (for oil-type compressors).

Oil-type compressors may only be used if fitted with either a continuous carbon monoxide monitor or high-temperature alarm. Diaphragm and water-seal pumps are recommended since they do not create an air supply contaminated with oil mist or carbon monoxide.

10.1.2.4 Air-Line Hose

Air-line hose should be inspected for the following:

a. Contaminants (mold powder, ground rubber, etc.) inside the hose.

b. Proper fittings and connections (i.e., not compatible with other gas systems).

c. Cuts, breaks, or weak spots in hose.

10.1.3 Self-Contained Breathing Apparatus

The self-contained breathing apparatus (SCBA), the most complicated of respiratory protective devices, requires more extensive inspection and testing than other types of devices. Owing to the intricacy of the parts of the SCBA, simple visual inspection is not sufficient to identify defective units. Inspection and testing of a SCBA must be done by individuals totally familiar with the particular device.

10.1.3.1 Facepiece Assemblies

Facepiece assemblies should be inspected as outlined in Section 10.1.1; and the corrugated breathing tube and the facepiece-to-regulator connector should also be inspected. Special attention should be given to the exhalation valves of those devices having a pressure-demand mode of operation.

10.1.3.2 Regulators and Alarms

Regulators and alarms of SCBA are to be visually inspected and a simple test performed to ascertain proper regulator function and integrity of the regulatory diaphragm. The alarm should be activated to ascertain that it functions properly.

A method for testing regulator function and disphragm integrity is as follows:

a. Demand-Only Units

(1) Open the cylinder valve.

(2) Suck on the regulator outlet (air should flow).

(3) Blow gently on outlet (no air should pass through).

b. Combined Demand/Pressure-Demand Units.

(1) Select the demand mode of operation.

(2) Follow steps (1), (2), and (3) of a, above.

(3) Cover the outlet of the regulator with a hand.

(4) Select the pressure-demand mode of operation (no air should flow).

(5) Remove hand from outlet (air should flow freely).

c. Pressure-Demand-Only Units.

(1) Blow gently on the outlet (no air should pass through).

(2) Open the cylinder valve.

(3) Cover the regulator outlet with a hand.

(4) Open the main line valve on the regulator (no air should flow).

(5) Remove the hand from the outlet (air should flow freely).

10.1.3.3 Other Associated Equipment

The following other parts of SCBA must be checked:

a. Cylinder - check the pressure; check the cylinder valve for leaks; and inspect the cylinder valve lock for presence and function.

b. Backpack and harness assembly - Inspect the integrity of straps, buckles, and fasteners; and check the backpack cylinder lock assembly for function.

10.1.3.4 Recirculating Devices (Closed-Circuit Apparatus)

The following parts of recirculating devices must be checked:

a. Breathing Bags - Visually inspect for tears and defects; then inflate and check for leaks.

b. CO_2 Sorbent - Make certain that used sorbent is removed from the unit before storage. (Do not refill with sorbent until immediately prior to use of unit.) Ensure that seals on sorbent containers are in place.

c. O_2-Generating Canister - Never store an oxygen-generating unit with the O_2-generating canister in place. Place the canister in the unit immediately prior to use. Make certain that canisters are properly sealed.

d. Check the rubber canister seals on the unit.

It is virtually impossible to inspect and test self-contained breathing apparatus properly without actually donning the unit. When factory-approved test equipment and factory-trained personnel are available, it is strongly advised that new units be tested before they are placed in use.

Although complete test and inspection procedures for each device available cannot be given in this guide, such tests and inspections should be made. Complete instructions for inspection procedures are packed with most devices or are available from the manufacturer.

10.2 INSPECTION AND TESTS AFTER CLEANING AND MAINTENANCE

The procedures for inspecting and testing cleaned and repaired devices are the same as those outlined in the preceding new equipment section except that a leak test shall be performed on all cleaned or repaired devices. This leak check may vary from a simple field test of the device (a test using irritant smoke or isoamyl acetate to check the device prior to its use) to a very sophisticated leak check employing test heads on which the device is mounted and probe tested using a specially generated aerosol or gas with the appropriate readout equipment. The following are examples of this aerosol-generating and readout equipment:

a. Dicctyl phthalate aerosol with light-scattering photometric readout equipment.

b. Sodium chloride aerosol with flame photometer readout.

All of the above equipment is commercially available.

Maintenance and repair of respiratory protective devices shall be performed only by qualified individuals who are totally familiar with the function of each part of the device in question. Only factory-trained individuals shall repair or adjust regulators, timers, alarms, or other such parts of respiratory protective devices.

10.3 PERIODIC CHECKS OF ITEMS IN STORAGE

Periodic checks of items in storage should be performed to ensure that the facepiece rubber is not taking a set, that rubber parts are not hardening or deteriorating, that sorbent canisters have not exceeded their shelf life, and that breathing-air or oxygen cylinders contain sufficient pressure. Other checks relevant to the equipment in storage should be made as necessary.

These checks should be designed to ensure that if the devices in storage are needed, they will be ready for immediate use.

CHAPTER 11

BIOASSAY PROGRAMS

Bioassay programs are used to evaluate the amounts of radioactive materials in the body as a result of inhalation, ingestion, absorption, or injection. From such a program, the intake of the material may be estimated. A bioassay program performed by a laboratory that provides accurate analyses is essential to verify the effectiveness of respiratory protection programs.

11.1 BIOASSAY TECHNIQUES

Details on techniques for bioassay and subsequent determination of the intake by the body constitute a separate field of study and are not included in this manual. A brief summary of the techniques is given below.

11.1.1 Sampling

11.1.1.1 Urine

Urine samples are collected according to the metabolite identity and mode of metabolism. Materials metabolized and excreted in the urine at analytically significant levels may, when determined, be an index to uncontrolled exposure.

11.1.1.2 Fecal

Materials that are insoluble or known not to be absorbed, either from inhalation or ingestion, are best estimated by analysis of fecal samples.

Although the presence and amounts of radionuclides may be determined, interpretation of the data to estimate lung burden and time of exposure may be difficult.

11.1.1.3 Breath

Materials excreted via the lungs may often be determined by breath analysis. The breath sample may serve as an index to exposure shortly after cessation of exposure. Collection of a series of samples in an atmosphere free of contaminating material simplifies the interpretation of exposure.

11.1.1.4 Nasal and Throat Swabs or Washings

Nasal and throat swabs or washings may serve as indicators of particulate exposures. These samples serve as a qualitative exposure index for radionuclides. From baseline data, the radionuclides may be determined simply and may be semiquantitatively related to exposure.

11.1.1.5 External Wholebody Counting (X-ray or γ-ray) and Individual Organ Scanning

Employees exposed to radionuclides may be examined by various external X-ray or gamma-ray counting techniques. Where analytically significant results can be determined, the exposure or intake may be easily evaluated.

11.1.1.6 Hair

Analysis of hair samples is not normally employed to verify the effectiveness of a respiratory protection program. However, properly

selected and prepared samples may serve as an indicator of past performance of the program for a number of metals or compounds. The hair strand or bundles can be cut into sections and analyzed for the metabolite or metal. Correlations of the analyzed sections with growth rate can be an exposure profile for the effectiveness of the respiratory protection program.

11.1.1.7 Summary

The choice of monitoring techniques to be used for an adequate bioassay program depends mainly on the characteristics of the material to which personnel might be exposed. The frequency of respiratory protection usage and duration of exposure also dictates the bioassay program. Table 11-1 indicates the types of samples that should be assayed in relation to the type of material to which employees might have been exposed in order to evaluate the effectiveness of a respiratory protection program.

11.1.2 Analysis

All analyses must be performed by a qualified laboratory. The limits of the analytical technique must be known and the mechanism of detoxification or excretion must be thoroughly understood.

11.2 BIOASSAY SAMPLING

It is desirable to obtain baseline measurements on each individual prior to work assignment in potentially contaminated atmospheres. Subsequent sampling must be frequent enough to account for all potential hazards; i.e., sample collection following exposure must be appropriately timed to permit accurate evaluation of the total intake and the resultant dose.

Additional bioassay should be performed if, on the basis of air sampling data, accident, equipment failure, etc., there is reason to believe that an individual might have taken into his body an appreciable quantity of material.

Processing of bioassay samples and evaluation of bioassay data must be performed by or under the direct supervision of persons qualified in such techniques.

TABLE 11-1

SELECTION OF TYPES OF BIOASSAY SAMPLES FOR EVALUATION OF RESPIRATORY PROTECTION PROGRAMS

Type of Material to Which Exposure is Possible	Urine	Fecal	Breath	Nose or Throat Swab	Whole Body Counting	Hair Sections
Actinides	C	C		I	I-C	C
Fission Products	C	C		I	I-C	
Acid Gases[a]			I			
Most Metals	C	C		C		C
Inert Organic Gases			I			
Metabolizable Organic Compounds	C		I			C (few)
Biohazards[b]				C		
Radium	C	C	I(Rn)	I		C

[a] Special: CO, HCN, NO_2, other (Blood Metabolite)

[b] Special: Biohazards (Blood Culture)

Code (The individual compound dictates the sampling selection; these are generalities):

I = Immediate evaluation of single exposure or delayed multiple exposures.

C = Continuous evaluation or reconstruction of exposure.

CHAPTER 12

ADMINISTRATION

An effective respirator program must be based on well-conceived administrative and supervisory practices and guides. Although detailed formats for such practices and guides vary from one installation to another, certain important broad administrative areas, briefly discussed below, should be included.

12.1 QUALIFICATIONS OF RESPONSIBLE PERSON IN CHARGE

Responsiblity for the respirator program is to be vested in one individual. The respirator program may be under the direction of a health physicist, industrial hygienist, safety engineer, or other person similarly qualified. Regardless of his organizational position, the responsible individual in charge of the respirator program must have the ability, training, and experience to (1) evaluate the total hazard and the job, (2) recommend engineering controls if appropriate, (3) specify respiratory protection if control cannot be otherwise obtained, and (4) forbid the use of respirators if conditions warrant. The responsible person should have, in addition to his other qualifications, at least 1 year's field experience in the use of respirators.

12.2 PROCEDURES AND STANDARDS

Procedures are to be prepared in writing regarding all phases of the respirator program, including: descriptions of equipment; information regarding issuance, maintenance, selection, use, and return of equipment;

and training techniques. Information regarding air-sampling and bioassay programs is to be included or referenced.

12.3 EVALUATION OF PROGRAM EFFECTIVENESS

Continuous feedback of a respirator program's effectiveness is necessary in order to evaluate its value. The following are suggested methods to obtain such feedback:

12.3.1 Wearer Acceptance

Comfort, ability to breathe without objectionable effort, adequate visibility, ability to communicate, ability to perform all tasks without undue interference, and confidence in the facepiece fit (Ref. 2), all contribute to acceptance of the devices by the wearers. Discussions with users at plant safety committee meetings, on inspections, on tours through the plant, and at training sessions can bring to light complaints that should be investigated.

12.3.2 Evaluation of Protection

Bioassay results, correlated with air-sampling results, are an effective means of program evaluation. Any evidence of a rise in exposure levels that could be linked to inhalation should be investigated immediately, even if within permissible exposure limits.

Any positive facepiece interior smear results should be investigated. The investigation should include immediate bioassay sampling of the worker who used the facepiece.

12.4 RECORDS

Records systems are to be established for the four main purposes described in the following sections:

12.4.1 Analysis of Adequacy of Respirator Program

The adequacy of a respirator program can only be determined by periodic review of respirator usage, including identification of the hazard, specification and use of the respirators, and analysis of the results of bioassay and air-sampling programs. These latter programs should include records of accurate and continuous monitoring of spaces whenever work is performed as well as records of the internal exposures of individual workers.

12.4.2 Procurement Information

Periodic review of respirator usage is needed to provide information for reordering canisters and other replacement parts and to establish a replacement table for respirator components.

12.4.3 Maintenance Information

Maintenance records are needed to provide knowledge of the out-of-service time for respirators, common failure modes of particular respirator types, and personnel complaints on respirator design.

12.4.4 Training and Fitting Records

Training and fitting records are necessary for all workers who might use respiratory protective equipment as a basis for scheduling refresher courses and refitting and to have a record of what makes of masks each person can wear. In addition, it is desirable that each person be issued a wallet-sized card listing those devices that adequately fit

him. The wallet cards can save time in the field, particularly in the event of an emergency, by making it unnecessary to check files for issuance of acceptable masks.

12.5 METHODS OF STAYING ABREAST OF NEW DEVELOPMENTS IN THE FIELD

Since rapid advancements are occurring in the respirator field in both equipment and regulations, it is essential for the program administrator to stay up to date. Some sources of current information are:

a. The *Federal Register* prints all changes in Federal regulations. Various periodic health and safety newsletters and abstracting services report on the changes directly affecting industrial health and safety regulations (Ref. 42).

b. Health and safety professional societies, such as the American Industrial Hygiene Association, Health Physics Society, National Fire Protection Association, American Society of Safety Engineers and others, notify their members in newsletters and journals of new developments. Membership in one or more of these societies is recommended to those in charge of the respirator programs.

c. The NRC, Bureau of Mines, NIOSH, and OSHA frequently publish documents on aspects of respirators. For example, every criteria document published by NIOSH has a section on recommended respiratory protective devices for the substance about which the document was written.

CHAPTER 13

SPECIAL PROBLEMS

In addition to the normal problems associated with properly fitting a group of workers with respiratory protection, there are some specific hazards that can be avoided by following a few basic guidelines. Among the topics of particular interest are facial hair, dentures, prescription glasses, the wearing of other types of protective headgear such as surgeon's caps, bumpcaps, hardhats, goggles, and faceshields, and the use of respirators in extreme temperatures.

13.1 COMMUNICATIONS

Although conventional respirators distort the human voice to some extent, adequate communications can be maintained in relatively quiet areas. In noisy areas, modifications and special attachments for facepieces are available to improve the quality of the communications. A description of the various options is available in ANSI Standard Z88.2-1969, Section 9.5 (Ref. 2).

13.2 PRESCRIPTION GLASSES

Prescription or safety glasses may be worn with half-mask respirators although there is likely to be some interference with the mask at the bridge of the nose. This interference can be minimized by careful choice of mask and proper fitting and training.

Glasses with standard temple bars shall not be worn with full-facepiece respirators since extension of the temple bars through the

sealing surface of the facepiece causes leakage. If prescription glasses must be worn, it is required that all Bureau of Mines/NIOSH-approved full facepieces be provided with means for optional use of corrective spectacles or lenses without temple bars that break the facepiece-to-face seal and that shall not otherwise reduce the respiratory protective qualities of the facepiece.

Contact lenses shall not be worn with full-facepiece respirators. These devices present a distinct hazard to the individual owing to the possibility of the lenses slipping because of pressure on the outside corners of the eyes from a full face mask or a speck of dirt getting under them while the respirator is being worn. Corrective action would entail removing the respirator, which would mean that the individual would either have to leave the contaminated atmosphere or run the risk of exposure if he removed the respirator in the contaminated area.

13.3 FACIAL HAIR

Persons using tight-fitting (facepiece) respirators shall not have any facial hair that interferes with the sealing surface of the respirator. Any intrusion of facial hair into the sealing surface of the respirator results in an increase in leakage (Ref. 43). Problem areas, in addition to full facial hair, are beards and moustaches if half-mask facepieces are used, and long, wide sideburns if full facepieces are used.

Close supervision must be maintained of individuals who do have facial hair styles that might interfere with the sealing surface of a respirator. Over a short period of time (7 days), the facial hair

can extend into the critical seal area. *Any worker who has facial hair that intrudes into the area where the respirator seals against the face shall not be fitted with a respirator. Additionally, any worker who is not clean-shaven shall not be allowed to wear a respirator, even though he has previously obtained a satisfactory fit with the particular device.* These proscriptions do not apply to loose-fitting enclosures such as hoods, blouses, or suits.

The above precautions do *not* mean that all facial hair must be forbidden when respirators are worn, since a moustache or sideburn may be permitted if it does not interfere with the sealing surface of the respirator. Each case must be considered individually, but it is incumbent upon the supervisor to ensure that the respirator is sealing properly while, at the same time, having regard for the personal feelings of the individual wherever possible. Good relations can be maintained if time is taken to carefully explain the danger of increased facepiece leakage due to facial hair. If a means is available for quantitatively assessing the amount of leakage, it should be used. A demonstration of this type can be quite convincing.

13.4 DENTURES

Dentures, either partial or full, can be worn with respirators subject to certain restrictions. Full dentures generally present few problems other than some possible discomfort to the individual when wearing half-mask or full-facepiece respirators. In fact, full dentures

should not be removed because the jaw becomes distorted without them. This causes leakage in the chin area.

Partial dentures may or may not be worn with a respirator, depending upon the configuration. If there is a possibility that the partial dentures could be swallowed, they should be removed. The wearing of dentures with hoods, suits, and blouses is not a problem.

13.5 PROTECTIVE HEADGEAR

Use of other types of protective headgear is permitted with respirators, but certain precautions shall be observed. *There shall be no interference between the additional headgear and the normal method of wearing the respirator.* This means that the respirator head straps or headharness should lie next to the head in their normal position, and any other protective headgear should go over them. Surgeon's caps used for protection against contamination may be worn under the head straps or harness, but care must be exercised to ensure that the front of the cap does not intrude under the sealing surface of a full facepiece in the forehead area.

Goggles may be worn with half masks only if they do not interfere with the normal sealing of the mask in the nasal bridge area. *Goggles shall never be worn with full-facepiece respirators* because the strap holding the goggles to the face would of necessity pass under the sealing edge in the temple area and cause leakage. In any case, only full facepieces that have an impact-resistant, shatterproof lens or eyepieces are granted a Bureau of Mines/NIOSH approval.

Faceshields can be worn with half-mask or full-facepiece respirators, depending on the individual design. The shield must not interfere with the normal position of the respirator on the face.

13.6 USE IN EXTREMES OF TEMPERATURES

The use of respirators at temperatures below 32°F can result in freezing of exhalation valves and fogging of the lenses in full facepieces. Use at high temperatures causes added stress on the individual.

ANSI Standard Z88.2-1969, Section 9.3, describes steps that can be taken to minimize the effect of both low and high temperatures on respirators. These steps include:

a. Antifog compounds to coat the inside of the lens.

b. Nose cups to direct exhaled air directly through the exhalation valve.

c. Use of dry breathing air with SCBA or air-line equipment. (The dew point of the breathing air shall be appropriate to the ambient temperature.)

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APPENDIX D. RADIATION DETECTION INSTRUMENTATION INFORMATION

1. Ion Chamber, Eberline RO-2
2. Micro R Meter, Eberline PRM-7
3. Geiger Counter, Eberline PRM-6/HP-210
4. Alpha Counter, Eberline PAC-4G
5. Geiger Counter, Beta-Gamma, Eberline E-530/HP-570
6. Geiger Counter, Eberline PRM-4A/HP-230
7. Ion Chamber, Victoreen 470A
8. Alpha Scintillation Counter, Eberline PAC-4S

APPENDIX D. RADIATION DETECTION INSTRUMENTATION INFORMATION

D.1. ION CHAMBER, EBERLINE RO-2

The Model RO-2 is a portable air ion chamber instrument used to detect beta, gamma, and x-ray radiation. It has four linear ranges of operation from 5 to 5000 mR/hour full scale. The chamber is vented to atmospheric pressure and is specifically designed to have a flat energy response from 12 keV to more than 1.3 MeV. A sliding shield of approximately 400 mg/cm^2, on the bottom of the case, serves as a beta shield. The side wall beta response for Sr-90-Y-90 is about 8% of the true surface dose rate.

The chamber is electronically insulated and normally electrostatic charges and low RF fields will have minimal effects. Magnetic switching is used internally so there is the possibility of strong magnetic fields causing switching action within the meter.

See the operating manual and the section on measuring radiation for additional information.

D.2. MICRO R METER, EBERLINE PRM-7

The PRM-7 is a portable, ruggedized instrument for use in field monitoring of fine variations of gamma radiation. An internally mounted 1 inch x 1 inch NaI(Tl) scintillator, coupled to a photomultiplier tube, offers optimum performance in counting low level radiation fields from typical natural background (10 micro R/hr) up to 5 mR/hr (Cs-137 equivalent). The Micro R Meter operates over four linear ranges. An internally mounted speaker provides a clear, audible signal to facilitate low level counting. The response time is continuously variable from about 10 to 2 seconds.

The PRM-7 is energy dependent. It is factory calibrated to Cs-137.

Additional information will be found in the operating manual.

D.5. BETA-GAMMA GEIGER COUNTER, EBERLINE E-530/HP-270

The Model E-530 Geiger Counter is designed to monitor beta-gamma and x-ray radiation or energies above 40 keV. A rotary switch combines the functions of power switch, battery check and selection of one of the four sensitivity ranges, X.01, X0.1, X1.0, X10, yielding scales of 0.2-200 mR/hr and corresponding cpm scales.

The Model HP-270 Energy Compensated Beta-Gamma Hand Probe utilizes a thin wall G-M tube with a compensating shield to limit the characteristic over-response of G-M tubes in the region of lower photon energies. It has a beta window which may be opened by sliding the compensating shield forward. The response is $\pm$20% from 40 keV to 1.25 MeV, with a gamma sensitivity of about 1200 counts per minute per mR/hr for Cs-137.

Additional information will be found in the operating manuals.

D.6. GEIGER COUNTER, EBERLINE PRM-4A/HP-230

The Model PRM-4A Portable Lin-Log Rate Meter gives a continuous linear meter reading from 0 to 200,000 counts per minute without range switching. The continucusly variable high voltage is matched to the detector. A variable discrimator can be used to optimize detector operation.

The HP-230A is a thin window alpha-beta-gamma GM detector. It operates at a high voltage of 900 volts. The thin window (1.5-2 mg/cm^2) allows monitoring for low enegry beta and higher energy alpha particles.

Additional information will be found in the operating manuals.

D.7. IONIZATION CHAMBER, VICTOREEN 470A

The 470A "Panaramic" Survey Meter offers wide dynamic range and energy response. The dose measurements are obtained from an air ionization chamber with a removable equilibrium sleeve and cap. The instrument, with rate and integrate capability, has a gamma energy response from 10 keV to 2 MeV. Dose rate capability is from 1 mR/hr to 1000 R/hr.

Further information and specifications are included in the operating manual.

D.3. GEIGER COUNTER, EBERLINE PRM-6/HP-210

The PRM-6, a general purpose survey meter, operated with the HP-210 probe, provides a small lightweight instrument for surveying surfaces for contamination.

The switch on the PRM-6 has seven positions: off; battery check; high voltage, 875-925 volts for the HP-210; and four scale multipliers, X1, X10, X100, X1K. The meter range is 0-500 cpm. The maximum usable count rate with the HP-210 probe is about 200,000 cpm.

The HP-210 probe with the high density tungsten shield is especially suitable for monitoring surface contamination. It should not be used for measuring dose rates. The probe has a thin (1.4-2 mg/cm^2) mica window with an effective area of 15 cm^2. The 2π Beta counting efficiency for a 1" diameter Sr-90, Y-90 source is approximately 45% with the protective screen in place. This will yield about 34 cpm above background for a contamination level of 1000 dpm/100 cm^2.

For additional information on this instrument see the operating manual.

D.4. ALPHA COUNTER, EBERLINE PAC-4G

The PAC-4G Portable Gas Proportional Alpha Counter is designed to detect and measure alpha radiation in the presence of high humidity, volatile solvent vapors, inert or other atmospheres, and other types of radiation. The Lin-Log meter gives a continuous linear reading from 0-500,000 counts per minute. The high voltage applied to the gas proportional alpha probe may be readily adjusted to optimize its position on the plateau of the probe. Discriminator adjustment may further optimize detector operation and with proper discriminator setting and calibration, alpha surveys may be performed in gamma/radiation levels up to 50 R/hr.

The detector, Model AC-21 Gas Proportional Alpha Probe, has 50 cm^2 of active area with a 0.85 mg/cm^2 Mylar window. It has an efficiency of approximately 50% of 2π geometry from a 50 cm^2 distributed Pu-239 source.

The gas system, utilizing Model AC-2G Gas Cylinder, containing 75% propane gas, provides a nominal twenty five hours of operation per cylinder.

Consult the operating manual for additional information.

D.8. ALPHA SCINTILLATION COUNTER, EBERLINE PAC-4S

The PAC-4S is a portable pulse rate meter used as an alpha survey meter. It is equipped with the AC-3-7 alpha scintillation probe.

The count rate on the PAC-4S is read out by the Eberline Lin-Log (R) presentation. This eliminates scale switching and multiplying factors, but retains the linear presentation within each range. Two meter movements and electronic range changing present four linear decades of information on the meter face. Full scale readings on the ranges are 2000, 20,000, 200,000 and 2,000,000 cpm respectively.

The AC-3-7 probe is used for measuring alpha surface contamination directly. The probe face must be placed very near the surface to be monitored, about 1/8 inch, but it should not touch the surface. If it is determined that surface contamination is very low, then the probe may touch the surface. The detector is a thin layer of zinc sulfide protected by a very thin aluminized mylar window. This window must not be contaminated or punctured. The window should be kept covered with the protective cover when not in use.

Sensitivity of the probe is determined by taking three measurements using a calibrated source: one measurement in the middle and one at each end of the detector face.

Additional information may be found in the operating manual for the instrument.

APPENDIX E

THORIUM-232 URANIUM-238

DECAY CHAINS

Thorium Series (4n)*

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities†		
			α	β	γ
$^{232}_{90}Th$	Thorium	1.41×10^{10}y	3.95 (24%) 4.01 (76%)	---	---
$^{228}_{88}Ra$	Mesothorium I	6.7y	---	0.055 (100%)	---
$^{228}_{89}Ac$	Mesothorium II	6.13h	---	1.18 (35%) 1.75 (12%) 2.09 (12%)	0.34c‡ (15%) 0.908 (25%) 0.96c (20%)
$^{228}_{90}Th$	Radiothorium	1.910y	5.34 (28%) 5.43 (71%)	---	0.084 (1.6%) 0.214 (0.3%)
$^{224}_{88}Ra$	Thorium X	3.64d	5.45 (6%) 5.68 (94%)	---	0.241 (3.7%)
$^{220}_{86}Rn$	Emanation Thoron (Tn)	55s	6.29 (100%)	---	0.55 (0.07%)
$^{216}_{84}Po$	Thorium A	0.15s	6.78 (100%)	---	---
$^{212}_{82}Pb$	Thorium B	10.64h	---	0.346 (81%) 0.586 (14%)	0.239 (47%) 0.300 (3.2%)
$^{212}_{83}Bi$	Thorium C	60.6m	6.05 (25%) 6.09 (10%)	1.55 (5%) 2.26 (55%)	0.040 (2%) 0.727 (7%) 1.620 (1.8%)
64.0% / 36.0%					
$^{212}_{84}Po$	Thorium C'	304ns	8.78 (100%)	---	---
$^{208}_{81}Tl$	Thorium C"	3.10m	---	1.28 (25%) 1.52 (21%) 1.80 (50%)	0.511 (23%) 0.583 (86%) 0.860 (12%) 2.614 (100%)
$^{208}_{82}Pb$	Thorium D	Stable	---	---	---

*This expression describes the mass number of any member in this series, where n is an integer.
Example: $^{232}_{90}Th$ (4n).....4(58) = 232

†Intensities refer to percentage of disintegrations of the nuclide itself, not to original parent of series.

‡Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

Data taken from: Lederer, C. M., Hollander, J. M., and Perlman, I., Table of Isotopes (6th ed.; New York: John Wiley & Sons, Inc., 1967) and Hogan, O. H., Zigman, P. E., and Mackin, J. L., Beta Spectra (USNRDL-TR-802 [Washington, D.C.: U.S. Atomic Energy Commission, 1964]).

Uranium Series (4n + 2)*

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities†		
			α	β	γ
$^{238}_{92}U$	Uranium I	4.51×10^{9}y	4.15 (25%) 4.20 (75%)	---	---
$^{234}_{90}Th$	Uranium X_1	24.1d	---	0.103 (21%) 0.193 (79%)	0.063c‡ (3.5%) 0.093c (4%)
$^{234m}_{91}Pa$	Uranium X_2	1.17m	---	2.29 (98%)	0.765 (0.30%) 1.001 (0.60%)
99.87% | 0.13%					
$^{234}_{91}Pa$	Uranium Z	6.75h	---	0.53 (66%) 1.13 (13%)	0.100 (50%) 0.70 (24%) 0.90 (70%)
$^{234}_{92}U$	Uranium II	2.47×10^{5}y	4.72 (28%) 4.77 (72%)	---	0.053 (0.2%)
$^{230}_{90}Th$	Ionium	8.0×10^{4}y	4.62 (24%) 4.68 (76%)	---	0.068 (0.6%) 0.142 (0.07%)
$^{226}_{88}Ra$	Radium	1602y	4.60 (6%) 4.78 (95%)	---	0.186 (4%)
$^{222}_{86}Rn$	Emanation Radon (Rn)	3.823d	5.49 (100%)	---	0.510 (0.07%)
$^{218}_{84}Po$	Radium A	3.05m	6.00 (~100%)	0.33 (~0.019%)	---
99.98% | 0.02%					
$^{214}_{82}Pb$	Radium B	26.8m	---	0.65 (50%) 0.71 (40%) 0.98 (6%)	0.295 (19%) 0.352 (36%)
$^{218}_{85}At$	Astatine	~2s	6.65 (6%) 6.70 (94%)	? (~0.1%)	---
$^{214}_{83}Bi$	Radium C	19.7m	5.45 (0.012%) 5.51 (0.008%)	1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
99.98% | 0.02%					
$^{214}_{84}Po$	Radium C'	164μs	7.69 (100%)	---	0.799 (0.014%)
$^{210}_{81}Tl$	Radium C''	1.3m	---	1.3 (25%) 1.9 (56%) 2.3 (19%)	0.296 (80%) 0.795 (100%) 1.31 (21%)
$^{210}_{82}Pb$	Radium D	21y	3.72 (.000002%)	0.016 (85%) 0.061 (15%)	0.047 (4%)
$^{210}_{83}Bi$	Radium E	5.01d	4.65 (.00007%) 4.69 (.00005%)	1.161 (~100%)	---
~100% | .00013%					
$^{210}_{84}Po$	Radium F	138.4d	5.305 (100%)	---	0.803 (0.0011%)
$^{206}_{81}Tl$	Radium E''	4.19m	---	1.571 (100%)	---
$^{206}_{82}Pb$	Radium G	Stable	---	---	---

*This expression describes the mass number of any member in this series, where x is an integer.
Example: $^{206}_{82}Pb$ (4n + 2).....4(51) + 2 = 206

†Intensities refer to percentage of disintegrations of the nuclide itself, not to original parent of series.

‡Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

Data taken from: Table of Isotopes and DNFRDL-TR-802.

APPENDIX F

KERR-McGEE CORPORATION STANDARD NO. 9

EXPOSURE TO GAMMA RADIATION DURING PREGNANCY

9-16-80

STANDARD

KERR-McGEE CORPORATION

RADIATION HEALTH AND SAFETY

DATE 9-16-80 NO. 9

SUBJECT EXPOSURE TO GAMMA RADIATION DURING PREGNANCY

INTRODUCTION

It is the responsibility of Kerr-McGee Corporation Managers to ensure that instructions on established radiation protection standards, procedures and exposure limits are provided to all employees and other persons potentially subject to such exposure at company operations. Such instruction should include the extent to which they will be exposed to low-level gamma radiation and the possible effect such exposure may have on their health, as well as the health of any unborn child.

The maximum radiation exposure limits established by governmental agencies are less restrictive for employees who are occupationally exposed to low-level gamma radiation than for members of the general public. There has been established a basic whole body exposure limit for all occupationally exposed adults of 5 rems per year. The maximum exposure limit to a non-occupationally exposed individual (including all individuals under 18 years of age) is 0.5 rem per year, in addition to background radiation and medical and dental exposures.

The National Council on Radiation Protection and Measurements (NCRP) has recommended in its Report No. 39 that because unborn children may be more sensitive to radiation than adults, their radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem during the entire gestation period. The International Commission on Radiation Protection (ICRP) has also stressed the need to keep radiation doses to unborn children as low as is reasonably achievable and recommends the same limit of 0.5 rem during pregnancy.

In view of the Company's obligation to provide as safe a working environment as practicable and the Company's obligation not to discriminate against females on account of pregnancy, the following standard is established pertaining to radiation exposure of pregnant females in the work force.

SCOPE

In keeping with the recommendation of the National Council on Radiation Protection and Measurements (NCRP) it shall be the policy of Kerr-McGee Corporation to take action to limit the occupational gamma radiation exposure of every pregnant employee (and unborn child) to no more than 0.5 rem during the period of pregnancy. To this effect, the Company will take all practicable steps to keep radiation doses to the employee as low as is reasonably achievable. When the accumulated dose approaches 0.5 rem, transfer will be mandatory.

Employment of Pregnant Applicants

Due to the possible lack of previous radiation exposure history, pregnant applicants will only be considered for positions in areas known to have little or no occupational exposure to radiation.

New Employee Indoctrination and Safety Training

During the period of employee indoctrination and safety training, all new employees shall receive instruction in the health protection problems associated with exposure to radioactive materials or radiation. In providing this instruction, female employees will be given specific instruction about prenatal exposure risks to the unborn child. The instruction should ensure that those employees understand what the NCRP has recommended and the reasons for this recommendation. It will also include the information provided in the Appendix to the NRC's Regulatory Guide 8.13, and will be presented both orally and in written form. Each employee will be given an opportunity to ask questions, and will be required to acknowledge in writing that the instruction has been received and understood.

Supervisor Training

Specific instructions about prenatal exposure risks to the unborn child will be included as a part of the regular supervisory training program.

Employee Notification of Pregnancy

As soon as the employee knows or thinks she is pregnant, she is required to notify her immediate supervisor (or the radiation health and safety officer) about her condition. The employee's supervisor will initiate action pursuant to the provisions of the Corporate Radiation Health and Safety Procedure on "Exposure to Gamma Radiation During Pregnancy."

Mandatory Transfer

In the event that during continued employment, the pregnant employee's accumulated occupational exposure approaches a total of 0.5 rem, transfer to a location where there is little or no occupational exposure to gamma radiation is mandatory until the period of pregnancy is terminated.

At such time as the employee's physician determines she is physically not able to perform her assigned tasks she will be placed on leave of absence in accordance with Kerr-McGee Corporation's Corporate Policy No. 57 (Sick Leave) or the applicable sick leave provisions of the controlling collective bargaining agreement when the employee is a member of a bargaining unit.

PROCEDURE

KERR-McGEE CORPORATION

RADIATION HEALTH AND SAFETY

DATE 9-16-80 NO. 9

SUBJECT EXPOSURE TO GAMMA RADIATION DURING PREGNANCY

GENERAL

The following procedure applies to all facilities with a potential employee annual gamma radiation exposure level of as much as 0.5 rem, and describes the necessary steps to be taken when an employee becomes aware she is pregnant.

Responsibility	PROCEDURE
Employee	1. Notifies her immediate supervisor that she is pregnant.
Supervisor	2. Immediately upon being advised of an employee's pregnancy, requires the employee to furnish a Physician's Statement including an estimated delivery date and a statement of whether or not the employee is physically able to continue working in her regular job.
	3. Notifies the radiation health and safety officer of employee's condition.
	4A. When the Physician's Statement indicates the employee's physical condition renders her unable to perform her regular job, arranges for the employee to commence sick leave in accordance with Corporate Policy No. 47 or collective bargaining agreement when the employee is covered by such an agreement.
	4B. When continued employment is possible, arranges for the employee to receive refresher instructions about prenatal exposure risks to the unborn child, ensuring that the employee understands what the NCRP has recommended, the reasons for this recommendation and the company's position in this regard.

NOTE: The information provided in the NRC's Regulatory Guide 8.13 should be presented both orally and in writing.

Supervisor and Radiation Health and Safety Officer

5. Review the employee's radiation exposure records and calculate the amount of exposure the employee has received during the estimated period of pregnancy.

6. Advise the employee of her current gamma radiation exposure history and the estimated future exposure she could expect to receive during pregnancy if she remains in her present job.

Employee

7. Reviews the provided information, and asks questions to ensure that the material is thoroughly understood, and acknowledges in writing that the instruction has been received and understood.

8. Chooses to either continue working at her present job assignment or to request a leave of absence without pay.

Supervisor

9A. When the employee elects to continue working, promptly reviews employee's work assignment and location to ensure exposure to radiation during the term of the pregnancy is minimized.

9B. When the employee requests a leave of absence without pay, places the employee on leave of absence in accordance with Kerr-McGee Corporation's Corporate Policy No. 59 or collective bargaining agreement when the employee is covered by such an agreement.

Supervisor and Radiation Health and Safety Officer	10. Initiate a program to more closely monitor and measure the pregnant employee's future exposure to gamma radiation and keep the employee fully informed on the readings.
	11. In the event the pregnant employee's accumulated dosimeter readings total 0.3 rem within six months or less, critically review employee's work assignments.
	12. In the event the pregnant employee's accumulated readings approach a total of 0.5 rem, immediately inform the employee that based on her accumulated readings a temporary change in her work location is mandatory until the period of pregnancy is terminated, and reassign the employee to a work location where there is little or no occupational exposure to gamma radiation.

APPENDIX G

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

U. S. Nuclear Regulatory Commission
Division of Fuel Cycle
and Material Safety
Washington, D. C. 20555

November 1976

The instructions in this guide in conjunction with Table 1.1 specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table I.1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.
2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table I.1 prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.
3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.
4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but

Table I-1. Acceptable surface contamination levels

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm²	15,000 dpm α/100 cm²	1,000 dpm α/100 cm²
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm²	300 dpm/100 cm²	20 dpm/100 cm²
Th-nat, Th-232, Sr-90 Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm²	3,000 dpm/100 cm²	200 dpm/100 cm²
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and other noted above.	5,000 dpm βγ/100 cm²	15,000 dpm βγ/100 cm²	1,000 dpm βγ/100 cm²

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm².

[e] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

would not be limited to, special circumstances such as razing of buildings, transfer or premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table I.1. A copy of the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.