Course Title: **Radiological Control Technician**
Module Title: **Respiratory Protection**
Module Number: **2.07**

Objectives:

2.07.01 Explain the purpose of respiratory protection standards and regulations.

2.07.02 Identify the OSHA, ANSI, and DOE respiratory protection program requirements.

2.07.03 Identify the standards which regulate respiratory protection.

2.07.04 Describe the advantages and disadvantages (limitations) of each of the following respirators:
a. Air purifying, particulate removing filter respirators
b. Air purifying, Chemical Cartridge and Canister respirators for Gases and Vapors
c. Full-face, supplied-air respirators
d. Self-contained breathing apparatus (SCBA)
e. Combination atmosphere supplying respirators

2.07.05 Define the term protection factor (PF).

2.07.06 State the difference between a qualitative and quantitative fit test.

2.07.07 State the recommended physical functions the subject must perform during a respirator fit test.

2.07.08 State how the term protection factor (PF) is applied to the selection of respiratory protection equipment.

2.07.09 State the general considerations and considerations for the nature of the hazard when selecting the proper respiratory protection equipment.

☞ 2.07.10 Identify the types of respiratory equipment available for use at your site.

2.07.11 Identify the quality specification breathing air must meet.

References:

1. "Basic Radiation Protection Technology", Gollnick, D., Pacific Radiation corporation, Altadena, 2nd edition.
2. "Guide to Sampling Airborne Radioactive Materials in a Nuclear Facility"
3. "Radiation Protection", General Physics Corporation, 1989.

4. "Introduction Health Physics", Second Edition, Cember, H., Pergamon Press, London, 1983.
5. "Limits for Inhalation of Radon Daughters by Workers", ICRP Publication 32.
6. "Limits for Intakes of Radionuclides by Workers", ICRP Publication 30.
7. "Operational Health Physics Training Course", Moe, H.J., et. al., Argonne National Laboratory, Argonne, 88-26.
8. "Radiation Detection and Measurement", Knoll, G., John Wiley and Sons, New York, 1979.
9. 10 CFR 835, "Occupational Radiation Protection", 1998.
10. "Practices of Respiratory Protection", ANSI Z88.2, 1992.
11. "Manual of Respiratory Protection Against Airborne Radioactive Material",NUREG-0041, 1976.
12. Respiratory Protection, Federal OSHA, 29 CFR 1910, 134.
13. OSHA 29 CFR 1910. 134
14. ANSI Z88.2-1992
15. CGA G7.1-1989

Instructional Aids:

1. Overhead projector and screen
2. Chalkboard
3. Markerboard
4. Lessons learned

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone number
3. Background
4. Emergency procedure review

B. Motivation

Internal dosimetry controls require the use of engineering controls to prevent the internal deposition of radioactive and non-radiological contaminants. However, when engineering and administrative controls are not available or feasible, respiratory protection may be necessary. The RCT should know and apply the considerations used in determining the respiratory protection equipment that is most appropriate for the job. Inappropriate use of or the use of the wrong respiratory protection equipment may result in undesirable health effects.

C. Lesson Overview

1. Requirements and regulations
2. Types of equipment
3. Protection factors
4. Fit testing
5. Selection of respirators
6. Site respiratory equipment
7. Supplied air quality testing
8. Sorbents and protection against radioiodines
9. Communications

D. Introduction of Objectives	O.H.: Objectives
II. MODULE OUTLINE	
A. REQUIREMENTS AND REGULATIONS	
1. DOE Requirements The DOE Order 440.1 mandates the requirements for a respiratory protection program contained in ANSI Z88.2 and 29 CFR 1910.134.	
2. OSHA REGULATIONS - 29 CFR 1910.134	
Purpose: Specify the minimal acceptable program which must contain or address the following:	Objective 2.07.01
a. Written procedures	
b. Respirator selection	
c. The user shall be instructed and trained in proper use of respirators	
d. Respirators shall be cleaned and disinfected after each use	
e. Respirators stored in a clean, sanitary location	
f. Respirators inspected routinely and replaced when necessary	
g. Appropriate surveillance of work area conditions and degree of employee exposure or stress	
h. Regular evaluation of program	
i. Persons should be physically able to use equipment as certified by a physician	
j. Approved respirators shall be used when they are available	
3. ANSI Z88.2 - 1992: *Further specifies the minimal acceptable program*	Objective 2.07.02 Objective 2.07.03

a. Individual exposures limited by both inhalation and skin absorption

b. Air sampling and bioassays

c. Engineering controls are primary method

d. When an individual is exposed to greater than the specified DAC or other exposure limits.

e. Respiratory protection equipment must be NIOSH/MSHA certified

f. If allowance for use of respiratory protection equipment is made,

1) Protection factor must be greater than ratio of peak exposure concentration and associated DAC

2) Average concentration inhaled must be less than associated DAC

3) If exposure is later found to be greater than estimated, corrected value shall be used.

If less than estimated, the corrected value may be used

4) Surveys and bioassays conducted as appropriate to evaluate actual exposures.

5) Written procedures must be established.

6) Determination by a qualified health care professional of a user's physical capability

7) A written policy statement must be issued

a) Engineering controls

b) Routine, non-routine and emergency use

c) Periods of use

8) Each user must be advised upon failure of equipment, physical stress or deterioration of operating conditions.

9) Equipment is appropriate for environment and special equipment, such as communication devices issued when needed.

10) Emergency use equipment must be specifically certified as such by NIOSH/MSHA.

Objective 2.07.04

B. TYPES OF EQUIPMENT

1. Air purifying, particulate-removing filter respirators

a. Description

"dust," "mist" or "fume" respirators

1) Filtering action removes particulate

2) Operate in negative pressure (NP) mode

3) Exception is a special type of powered air purifying respirator that is designed to never be negative pressure.

b. Limitations

1) Do not provide oxygen

NEVER to be worn in oxygen-deficient atmospheres

2) No protection against gases or vapors

3) Should not be used for abrasive blasting operations

4) Battery operated respirators are limited by battery life.

5) High humidity may increase breathing resistance as paper elements become water saturated.

6) Not to be used in IDLH atmospheres

2. Air Purifying, Chemical Cartridge and Canister Respirators for Gases and Vapors

a. Description - use cartridges or canisters containing chemicals to remove specific vapors and gases.

The difference between a cartridge and a canister is the volume of the sorbent. Canisters have longer capacity and are used in gas masks.

b. Limitations

1) Do not provide oxygen

NEVER to be worn in oxygen deficient atmospheres

2) Unless approved by DOE, no credit for protection against radioactive gases and vapors

3) High humidity shortens life of the sorbent material and increases breathing resistance.

4) Not to be used in IDLH atmospheres

3. Atmosphere Supplying Respirators - Supplied Air

a. Description

1) Use central source of breathing air delivered to wearer through a line or hose.

2) Either tight-fitting facepiece or loose-fitting hood/suit

3) Demand device - during inhalation there may be negative pressure in the mask.

4) Pressure demand device - positive air pressure inside mask is maintained at all times.

5) Continuous-flow air line - is designed to create positive pressure in facepiece.

b. Limitations

1) Not used in IDLH atmospheres

(not for emergency escape or rescue)

2) Trailing air supply hose severely limits mobility.

3) Length of hose, number of potential users and pressure of the supply system are interdependent. No more than five sections of hose with a maximum length of 250 feet.

4) Control of air quality is essential.

5) "Bubble suits" must be tested for exact conditions of use.

c. Special considerations

1) Where air line respirator is a suit, requires a standby rescue person with SCBA

2) Follow all manufacturers instruction and written facility/site procedures

3) If all hoses and fittings are same then a single pressure gauge is appropriate.

4) For situations where each user has different hose lengths, different number of connection or different air pressure requirements then a separate pressure gauge should be used.

4. Atmosphere Supplying Respirators - Self-Contained Breathing Apparatus (SCBA)

a. Description

1) Allows the user to carry a respirable breathing supply

Air supply may last 3 minutes to four hours

2) There are two groups of SCBAs closed circuit and open circuit

a) Closed circuit SCBAs - "rebreathing" device

Designed primarily for 1-4 hours use in toxic atmospheres

b) Open circuit SCBA exhausts the exhaled air to the atmosphere

Service life is shorter

c) Two types of open circuit SCBA are available, "demand" or "pressure demand."

- Demand SCBA - air flows into facepiece only on demand of the wearer.

When the person inhales note: demand-type SCBA does not provide any higher degree of protection against airborne contaminants than air-purifying respirator with same facepiece, but it does provide protection against oxygen deficiency.

- Pressure demand - maintains positive pressure in facepiece at all times regardless of "demand" of user.

Recommended for emergency use, escape and rescue.

b. Combination atmosphere supplying respirators

1) Combination Pressure Demand Breathing Apparatus provides respiratory protection for personnel who must work in atmospheres that are IDLH.

Equipped with small air cylinder in case primary air supply (hose line) is interrupted.

2) Dual-purpose Breathing Apparatus combines all capabilities of SCBA and a supplied air respirator in one unit.

c. Limitations of the pressure and demand SCBA

1) Air supply is limited

2) Bulky and heavy

3) Demand type not for fire fighting

10CFR20 Appendix R Section H

d. Special considerations of the pressure demand SCBA

1) Only pressure-demand type SCBA should be selected for emergency use, rescue and reentry into contaminated area.

Section 5.5 of NUREG 0041

2) Performance of SCBAs in high temperature environments, such as fires may lead to rapid deterioration of components.

B. PROTECTION FACTORS

Objective 2.07.05

1. Overall protection afforded by a given respirator design is defined in terms of its protection factor (PF).

2. An assigned PF is defined as the level of protection that would be expected from a class or type of respirator to a properly fitted and trained user.

3. Application of PFs

4. Z88.2 Protection Factors
Table 1 - "Assigned Protection Factors"

C. FIT TESTING

Objective 2.07.06

1. Definitions

a. Qualitative fit test:

Test to determine if there is any mask leakage, usually using irritant smoke.

b. Quantitative fit test:

Test to determine quantity of mask leakage and assign a "fit factor," an oil or dust particles are the typical challenge atmospheres used.

2. Qualitative fit tests are sometimes performed in lieu of quantitative fit tests.

a. Can use challenge atmospheres such as Isoamyl Acetate (banana oil) or irritant smoke (e.g. stannic chloride or titanium tetrachloride).

b. A qualitative fit test uses the same series of exercises as quantitative fit testing.	Irritant smoke tests are most effective
c. An abbreviated qualitative "fit check" may be used prior to entry into a contaminated area.	
3. At least a qualitative test must be formed - a negative pressure type is typical.	
4. Additional factors to be considered	
a. Use of communication devices	
b. Sorbent canisters with respirators	
5. Respirator face pieces and cartridges must be periodically tested.	
a. Test a portion of particulate cartridges upon procurement.	Minimum requirement - each site may be more restrictive
b. Test all particulate cartridges prior to re-use.	
c. Respirator facepieces are tested annually using:	
1) Test head mannequin	Penetration value of less than or equal to 0.003% is acceptable
2) Challenge atmosphere with a light scattering photometer	
6. Fit testing of individual is normally quantitative	Objective 2.07.07
a. Involves measurement of a challenge atmosphere both inside and outside respiratory facepiece	
b. A "fit factor" is determined by dividing concentration of challenge atmosphere outside respirator by concentration inside facepiece.	Note: DOP has been discontinued as a challenge atmosphere since it is a potential carcinogen

c. An oil mist may be used as a challenge atmosphere.

d. Apparatus uses photometry as system for measuring challenge and breathing zone atmospheres.

e. Subject generally performs the following functions during fit testing:

Highlight significance of functions as related to job performance

1) Normal breathing

2) Deep breathing

3) Moving head from side to side

4) Moving head up and down

5) Frown

6) Talking

7) Running in place

8) Normal breathing

D. SELECTION OF RESPIRATORS

1. Most critical factor: the protection factor for respirator device to be used needs to be greater than ratio of work area concentration to associated DAC.

Objective 2.07.08
10 CFR 835

2. Only approved respirators shall be selected.

ANSI Z88.2, 1980

3. General considerations. The selection of a proper respirator for any given situation shall require consideration of the following factors:

Objective 2.07.09

a. The nature of the hazard

b. The characteristics of the hazardous operation or process

c. The location of the hazardous area with respect to a safe area having respirable air.

d. The period of time for which respirator protection may be provided

e. The activity of workers in the hazardous area

f. The physical characteristics, functional capabilities, and limitations of respirators of various types.

g. The respirator-protection factors and respirator fit

h. Requirement of facility/site written procedures

4. Nature of Hazard. The following factors concerning the nature of the hazard requiring the use of respirators shall be considered in respirator selection:

   a. Type of hazard

      - Oxygen deficiency
      - Contaminant

   b. Physical properties

   c. Chemical properties

   d. Physiological effects on the body

   e. Actual concentration of a toxic material or airborne radioactivity level both average and peak

   f. Whether the hazard is an immediately-dangerous-to-life-or-health (IDLH) concentration

   g. Warning properties

5. Recognition and evaluation of the respiratory hazard (oxygen deficiency or contaminant(s)) shall be an essential part of selecting a respirator except in emergency or rescue operations. Initial monitoring of the respiratory hazard shall be carried out to obtain data needed for the selection of proper respiratory protection. The data should include:

   a. Identification of the type of respiratory hazard

1) Oxygen deficiency

2) Specific contaminant(s)

b. Nature of contaminant(s)

1) Particulate matter

2) Vapor(s) or gas(es)

c. Concentration of respiratory hazard

6. The following factors concerning the hazardous operation or process shall be taken into account in selecting the proper respirator:

a. Operation or process characteristics both as-built and modified

b. Work-area characteristics

c. Materials, including raw materials, end products, and byproducts (actual and potential)

d. Worker activities

E. SITE RESPIRATORY EQUIPMENT — Objective 2.07.10

(Insert site specific material here)

F. SUPPLIED AIR QUALITY TESTING

1. Referenced in 29 CFR 1910.134 — Objective 2.07.11

a. Compressed breathing air shall meet at least quality specification for Grade D breathing air.

b. Breathing air specifications are listed in Compressed Gas Association G 7.1-1989.

2. No explicit limit for water vapor but is contaminant

3. Acceptable analytical procedures for measuring the respirable air components

4. Frequency of performing air quality tests is recommended by ANSI Z88.2-1992

   a. For bottled air systems received from a supplier that does not fill cylinders with any other gasses, the tests should check 10% of the cylinders from each lot for ppm CO and odor. In addition, if the supplier fills cylinders with gas other than air, analyze **all** cylinders for percent oxygen.

   b. For facilities which generate respirable air, the sampling should be performed:

      1) Prior to each lot fill

      2) Once during the lot fill

      3) Once upon completion of the lot fill

   c. For compressed air supply systems sampling frequency is best performed prior to each use of a specific manifold system.

   In cases of heavy usage then a daily check of the system may be more appropriate.

5. Separate breathing air supply and distribution system is the ideal source or worker-supplied air

G. SORBENTS AND PROTECTION AGAINST RADIOIODINES

1. The regulations specifically prohibit the use of PFs for canister sorbents as protection against radioiodine atmospheres
   The efficiency of the charcoal canister is dependent upon:

   a. chemical form of the radioiodine,

   b. humidity of the atmosphere,

   c. and breathing rate of the user.

2. Approval may be obtained to use PF's for sorbent cartridges.

3. Examples of limiting conditions of use (user must follow manufactures instructions and DOE approval criteria):

    a. Total challenge in the work place (radioactive iodine, non-radioactive iodine or the halogenated compounds) may not exceed 1 ppm.

    b. Temperature in the work area may not exceed 100 °F.

    c. Respirator wearers must have demonstrated a fit factor greater than 100 for half mask, 1000 for full face piece.

    d. Service life is 8 hours maximum. This is calculated from the time the canister is unsealed and includes periods of non-use.

    e. Canisters will not be used in the presence of organic solvents, vapors, or chemicals.

    f. Canisters must be stored in sealed humidity-barrier packaging in a cool, dry environment.

H. COMMUNICATIONS

1. Conventional respirators distort the human voice to some extent.

2. Special attachments are often needed to ensure adequate communications

    a. Speaking diaphragm

    b. Various methods of electronically transmitting and amplifying speech through the respirator.

    c. Any communication device that is an integral part of respirator must be part of NIOSH/MSHA approval.

III. SUMMARY

A. Review major topics

1. Requirements and regulations
2. Types of equipment
3. Protection factors
4. Fit testing
5. Selection of respirators
6. Site respiratory equipment
7. Supplied air quality testing
8. Sorbents and protection against radioiodines
9. Communications

2. Review learning objectives

IV. EVALUATION

Evaluation should consist of a written examination comprised of multiple choice, fill-in the blank, matching and/or short answer questions. 80% should be the minimum passing criteria for examinations.

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