LA-UR-17-27205
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Title:	RCT: Module 2.07, Respiratory Protection, Course 8773
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Intended for:	Training
Issued:	2017-08-10

RCT: Module 2.07, Respiratory Protection

Course 8773

April 2017

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EST. 1943
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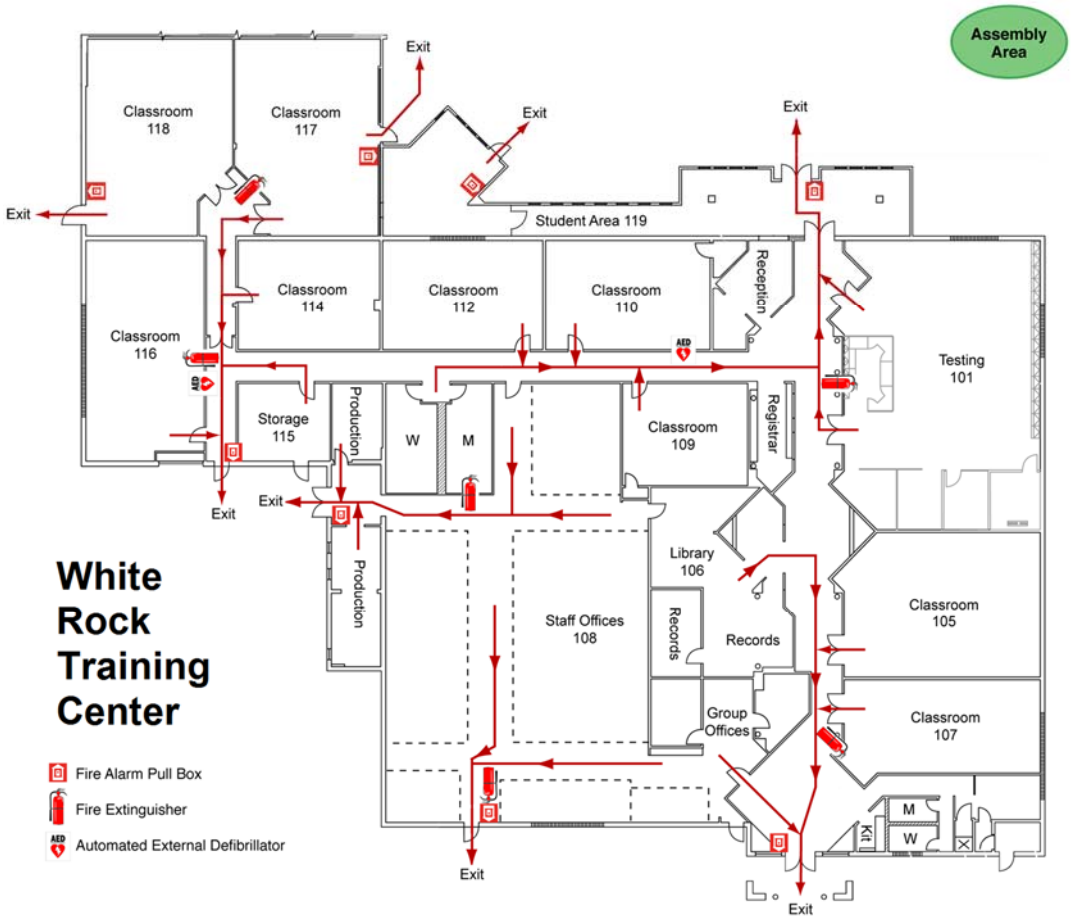

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Course Number: 8773
April 2017
LA-UR-17-XXXX
Controlled Document Number: RCT_2.07_Respir-Prot_SM_8773,R2.0

Contents

Introduction

Course Overview

Internal dosimetry controls require the use of engineering controls to prevent the internal deposition of radioactive and nonradiological contaminants. However, when engineering and administrative controls are not available or feasible, respiratory protection may be necessary.

The radiation control technician (RCT) should know and apply the considerations used in determining the respiratory protection equipment that is most appropriate for the job. The inappropriate use of or the use of the wrong respiratory protection equipment may result in undesirable health effects.

This course will prepare the student with the skills necessary for RCT qualification by passing quizzes, tests, and the RCT Comprehensive Phase 1, Unit 2 Examination (TEST 27566) and will provide in-the-field skills.

Course 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 LANL.

2.07.11 Identify the quality specification breathing air must meet.

Target Audience

This course is designed for LANL new-hire RCT employees with no operational experience.

Acronyms

ANSI	American National Standards Institute
APF	assigned protection factor
APR	air-purifying respirator
DAC	derived air concentration
DOE	Department of Energy
IDLH	immediately dangerous to life or health
IHS-CS	Industrial Hygiene and Safety-Central Services
IHS-IH	Industrial Hygiene and Safety Division
LANL	Los Alamos National Laboratory
MSHA	Mine Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
NP	negative pressure
OSHA	Occupational Safety and Health Administration
OSH-ISH	Occupational Safety and Health, Industrial Safety and Hygiene Group
PAPR	powered air-purifying respirator
PF	protection factor
PPE	personal protective equipment
RCT	radiation control technician
SAR	supplied-air respirator
SCBA	self-contained breathing apparatus
RCT	radiological control technician
RP	radiation protection

Purpose of Respiratory Protection Standards and Regulations

2.07.01 Explain the purpose of respiratory protection standards and regulations.

Respiratory protection standards provide information and guidance on the proper selection, use, and maintenance of respirators, which will help safeguard the life and health of respirator wearers.

Regulations establish the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing workers with a safe and healthful workplace.

Notes. . . .

Respiratory Protection Standards

2.07.03 Identify the standards which regulate respiratory protection.

Standards regulating respiratory protection are

- The Occupational Safety and Health Standard, 29 CFR, Part 1910.134, *Respiratory Protection* and
- ANSI Standard Z88.2-1992, *Practices for Respiratory Protection.*

Notes. . . .

Respiratory Protection Program Requirements

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

Occupational Safety and Health Standard, 29 CFR, Part 1910.134

The Occupational Safety and Health Standard, 29 CFR, Part 1910.134, specifies that the minimal acceptable respiratory protection program must contain or address the following:

- Written standard operating procedures governing the selection and use of respirators shall be established.
- Respirators shall be selected on the basis of hazards to which the worker is exposed.
- The user shall be instructed and trained in the proper use of respirators and their limitations.
- Respirators shall be regularly cleaned and disinfected. Those issued for the exclusive use of one worker should be cleaned after each day's use, or more often if necessary.
- Respirators shall be stored in a convenient, clean, and sanitary location.
- Respirators used routinely shall be inspected during cleaning. Worn or deteriorated parts shall be replaced. Respirators used for emergency use, such as self-contained devices, shall be thoroughly inspected at least once a month and after each use.
- Appropriate surveillance of worker area conditions and the degree of employee exposure or stress shall be maintained by appropriate workplace surveys and monitoring.
- Regular inspections and evaluations shall determine the continued effectiveness of the program.
- Persons should not be assigned to tasks requiring the use of respirators, unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (e.g., annually).

- Approved or accepted respirators shall be used when they are available. The respirator furnished shall provide adequate respiratory protection against the particular hazard for which it is designed, in accordance with standards established by competent authorities.

ANSI Z88.2-1991, Respiratory Protection Requirements

ANSI Z88.2-1992 further specifies the minimal acceptable program for industries involved in the use of radioactive material and addresses the following:

- individual exposures limited by both inhalation and skin absorption,
- air sampling and bioassays,
- engineering controls as the primary method,
- individuals exposed to greater than the specified derived air concentration (DAC) or other exposure limits, and
- respiratory protection equipment certifications [National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA)].

If allowance for the use of respiratory protection equipment in estimating exposures is made (based on the assigned protection factor, or APF), then the following must be observed:

- The protection factor (PF) for the device selected must be greater than the ratio of the peak exposure concentration and the associated DAC or other exposure limit.
- The average concentration inhaled on any one day must be less than the associated DAC.
- If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is less than estimated, the corrected value may be used.
- Written procedures for selection, fitting, maintenance, records, issuance and pre-use operability checks of respirators, and supervision and training of personnel using respirators must be established.
- Before a respirator’s initial use and annually thereafter, a qualified health care professional must determine a user's physical capability to wear a respirator.
- A written policy statement on the use of engineering controls instead of respirators; routine, nonroutine, and emergency use of respirators; and periods of respirator use and relief from respirator use must be issued.
- Surveys and bioassays shall be conducted as appropriate to evaluate actual exposures.

- Each user must be advised that he/she can leave the work area upon failure of equipment, physical distress, or deterioration of operating conditions.
- Equipment is to be used for the appropriate environment; special equipment, such as visual or communication devices, is to be issued when needed.
- Emergency use equipment must be specifically certified as such by NIOSH/MSHA.

Notes. . . .

Respirators (Advantages and Disadvantages/ Limitations)

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

Air-Purifying, Particulate-Removing Filter Respirators

These respirators are often called “dust,” “mist,” or “fume” respirators; they remove particulates using a filtering action before particulates can be inhaled.

The five types of respirators that work by particulate removal are the single use, quarter-mask, half-mask, full facepiece, and air-powered hood/mask.

Air-purifying respirators generally operate in the negative pressure (NP) mode; that is, an NP is created in the facepiece during inhalation.

An exception is a special type of powered air-purifying respirator that operates by using a motor-driven blower to drive the contaminated air through an air-purifying filter or sorbent canister.

These respirators have the following limitations:

- Air-purifying respirators do not provide oxygen; therefore, they must NEVER be worn in oxygen-deficient atmospheres.
- Particulate-removing, air-purifying respirators offer no protection against atmospheres containing contaminant gases or vapors.
- Except for pressurized air-purifier respirators, these respirator types should not be used for abrasive blasting operations.
- Battery-operated, air-powered respirators are limited by their battery life, which may be unknowingly shortened because of a memory buildup on the rechargeable NiCd batteries.
- High humidity may increase breathing resistance as paper elements become water saturated.

Air-Purifying, Chemical Cartridge, and Canister Respirators for Gases and Vapors

Vapor and gas-removing respirators use cartridges or canisters containing chemicals (i.e., sorbents) to trap or react with specific vapors and gases and remove them from the air breathed. The basic difference between a cartridge and a canister is the volume of the sorbent.

These respirators have the following limitations:

- They do not provide oxygen; therefore, they must NEVER be worn in oxygen-deficient atmospheres.
- Unless specifically approved by the Department of Energy (DOE), no credit may be taken for the use of sorbent cartridges or canisters for protection against radioactive gases and vapors.
- High-humidity environments may shorten the life of the sorbent material.

Full-Face, Supplied-Air Respirators

Supplied-air respirators use a central source of breathing air that is delivered to the wearer through an air supply line or hose. The respirator type is either a tight-fitting facepiece (half- or full-face) or a loose-fitting hood/suit.

Supplied-air respirator with escape bottle.

The pressure-demand device has a regulator and valve design such that there is a flow (until a fixed static pressure is attained) of air into the facepiece at all times, regardless of the "demand" of the user. The airflow into the mask creates a positive pressure.

The continuous-flow, air-line respirator maintains a constant airflow at all times and does not use a regulator; however, it uses an airflow control valve or orifice, which regulates the flow of air. The continuous-flow device does not guarantee a positive pressure in the facepiece.

- These respirators have the following limitations:
  - Because the air-line respirator provides no protection if the air supply fails, it shall not be used in immediately dangerous-to-life-or-health (IDLH) atmospheres or for emergency escape or rescue.
  - The trailing air supply hose severely limits mobility; therefore, it may be unsuitable if frequent movement among separated work stations is required.
  - The length of hose, number of potential users, and pressure of the supply system can reduce the number of allowable users.
  - Control of the air quality is essential to avoid the introduction of hazardous respiratory agents to the wearer's breathing zone.
  - "Bubble suits" can aspirate air into the suit when wearers lift their arms. Consequently, the suit must be tested for the exact conditions of use.

These respirators have the following special considerations:

- In a situation where the air-line respirator is a suit, there shall be a standby rescue person equipped with a self-contained breathing apparatus (SCBA) and communications equipment whenever supplied-air suits are used.
- Requirements for the use of respirators in IDLH atmospheres are specified in 29 CFR 1910.134(g)(3).
- Manufacturers of air-line respirators include instructions specifying a range of air required to produce at least the minimum required flow rates. These specifications are based on hose lengths and the number of sections connected together.

Self-Contained Breathing Apparatus (SCBA)

SCBA allows the user to carry a respirable breathing supply. SCBA does not need a stationary air source, such as a compressor, to provide breathable air. The air supply may last from 3 minutes to 4 hours, depending on the nature of the device.

The two groups of SCBAs are the closed circuit and the open circuit. Closed-circuit SCBA is a “rebreathing” device. The air is rebreathed after the exhaled carbon dioxide has been removed and the oxygen content has been restored by a compressed oxygen source or an oxygen-generating solid.

An open-circuit SCBA exhausts the exhaled air to the atmosphere instead of recirculating it. A tank of compressed air carried on the back supplies air via a regulator to the facepiece. Because air is not recirculated, the service life of the open-circuit SCBA is shorter than the closed-circuit system. The only type of open-circuit SCBA available for use is “pressure demand.”

The pressure-demand, open-circuit SCBA has a regulator and a valve design that maintains a positive pressure in the facepiece at all times, regardless of the “demand” of the user.

Because of the high degree of protection provided by the pressure-demand SCBA, this type of unit is recommended for emergency, escape, and rescue use. Combination atmosphere-supplying respirators also use supplied air and a SCBA.

Pressure-demand and demand-SCBA respirators have the following limitations:

- The air supply is limited to the amount in the cylinder; therefore, the respirator cannot be used for extended periods without recharging or replacing cylinders.
- Because these respirators are bulky and heavy, they are often unsuitable for strenuous work or use in confined spaces.
- The demand-type SCBA works in an NP mode and is considered obsolete.

Combination Atmosphere-Supplying Respirators

The combination pressure-demand breathing apparatus provides respiratory protection for personnel who must work in atmospheres that are IDLH. When connected to a respirable air source, the device permits the wearer to work and move about freely, within the limits of the approved hose length. The combination pressure-demand breathing apparatus is equipped with a small air cylinder that enables the wearer to escape from dangerous atmospheres if the primary air supply is interrupted. The apparatus serves as a long-duration work device, as well as an escape device; it is approved for respiratory protection for entry into, for extended periods of work in, and for escape from IDLH atmospheres. If the apparatus is used for entry into IDLH atmospheres, the air line must be connected before entry.

The self-contained air supply is approved for escape only. Operation of the combination pressure-demand breathing apparatus is manual; it is an approved, rated, 5-minute escape device.

The pressure-demand, air-line respirator is connected by an approved air-supply hose to a primary respirable air source; the worker breathes from this source with the valve of the egress (exit) cylinder of the device turned off until the user is ready to leave the working area. If the primary air-supply source should fail, the worker can switch to the egress cylinder by turning a valve and escaping to a safe atmosphere.

The dual-purpose breathing apparatus combines all of the capabilities of a SCBA and a supplied-air respirator into one unit. The apparatus is approved by the National Institute for Occupational Safety and Health (NIOSH) and Mine Safety and Health Administration (MSHA) for use in oxygen-deficient atmospheres or where dangerous concentrations of toxic gases or vapors are present.

The NIOSH/MSHA approval allows the wearer of the apparatus to

- enter or exit a dangerous area using only the cylinder air in applications such as emergency rescue,
- work within the area for a limited time using the cylinder air, and
- work within the area for an extended time using air from a supply line.

The combination atmosphere supplying respirator provides a

- limited range due to the length of the hose and
- limited time to egress due to limited amount of air in the escape bottle.

Notes. . . .

Protection Factors

2.07.05 Define the term protection factor (PF).

The overall protection afforded by a given respirator design is defined in terms of its PF. The PF is defined as the ratio of the concentration of contaminant in the atmosphere to the concentration inside the facepiece or hood under conditions of use.

PFs may not be appropriate where chemical or other respiratory hazards exist in addition to radioactive hazards or where the mode of entry is through the skin and not through inhalation.

The application of PFs is relatively straight forward. The work area's airborne radioactivity concentration is divided by the PF to estimate the inhaled concentration. For example, a worker performing steam generator eddy current testing with a full-facepiece, continuous-air-flow, air-line respirator (PF = 1000) in an atmosphere of 1×10^{-6} µCi/cm^3 Co-60 would be estimated to inhale a concentration of 1×10^{-9} µCi/ cm^3 Co-60.

Notes. . . .

Qualitative vs Quantitative Fit Test

2.07.06 State the difference between qualitative and quantitative fit test.

The qualitative fit test determines any mask leakage, usually using irritant smoke ("go/no-go" test, but no measured value is assigned).

The quantitative fit test determines the quantity of mask leakage and assigns a "fit factor"; oil or dust particles are the typical challenge atmosphere used (the test measures the concentration in the mask due to leakage against the concentration in the atmosphere).

Notes. . . .

Respirator Fit Testing

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

It is impractical to perform a quantitative fit test before each entry requiring respiratory protection. Therefore, qualitative tests are performed to ensure an adequate fit for the user. Qualitative tests can use challenge atmospheres, such as isoamyl acetate (banana oil), irritant smoke, or a negative or positive pressure test.

Subjects perform at least the following functions during fit testing:

- normal breathing,
- deep breathing,
- moving their head from side to side,
- moving their head up and down,
- frowning,
- talking,
- running in place, and
- normal breathing.

Notes. . . .

Protection Factor and Selection of Respiratory Protection Equipment

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

In protecting against radiological airborne contaminants, the most critical factor is in meeting the provisions of ANSI Z88.2, which requires the PF for the respirator device used to be greater than the ratio of the work area's airborne concentration.

Equipment selected must be certified by NIOSH/MSHA or specifically authorized by DOE. Approvals for respiratory devices are authorized in accordance with 42 CFR 84, and the device, type, and certification number are listed in NIOSH publication *Certified Equipment List*.

Notes. . . .

Considerations for 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.

Selecting the proper respirator for any given situation must consider the following:

- the nature of the hazard;
- the characteristics of the hazardous operation or process;
- the location of the hazardous area with respect to a safe area having respirable air;
- the period of time for which respiratory protection may be provided;
- the activity of the workers in the hazardous area;
- the physical characteristics, functional capabilities, and limitations of respirators of various types; and
- the respirator PFs and respirator fit.

The following factors concerning the nature of the hazard that require the use of respirators shall be considered in selecting a respirator:

- The type of hazard:
  - oxygen deficiency or
  - contaminant;
- the physical and chemical properties;
- the physiological effects on the body;
- the peak and average concentrations of toxic material or the airborne radioactivity level;
- the established permissible time-weighted average or peak concentration of the toxic material, or both, or the established maximum permissible airborne radioactivity level for radioactive substances;
- whether the hazard has an IDLH concentration of toxic material; and
- warning properties.

Recognition and evaluation of the respiratory hazard 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 the data needed for the selection of proper respiratory protection. The data should include the

- identification of the type of respiratory hazard
  - oxygen deficiency or
  - specific contaminants,
- nature of contaminants
  - particulate matter or
  - vapors or gases, and
- concentration of the respiratory hazard

The following factors concerning the hazardous operation or process shall be considered in selecting the proper respirator:

- the operation, process, and work-area characteristics;
- the materials, including raw materials, end products, and byproducts (actual and potential); and
- worker activities.

Respiratory Equipment at LANL

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

P121, Chapter 10, *Personal Protective Equipment (PPE)*, Part 3, *Respiratory Protection* contains requirements for respiratory protection.

RP-1-DP-32, *Respiratory Protection* states the types and uses of radiological respiratory protection and describes radiation protection (RP) personnel's role in the Los Alamos National Laboratory (LANL) respiratory protection program. It does not address nonradiological respiratory protection requirements.

All respirators and breathing air used at LANL must be approved by Occupational Safety and Health, Industrial Safety and Hygiene Group (OSH-IHS).

Respiratory protective equipment used at LANL includes

- air-purifying respirators (APRs) that are equipped with cartridges or canisters that remove particulates, gases, vapors, or a combination of the three;
- powered air-purifying respirators (PAPRs);
- supplied-air respirators (SARs) that are pressure demand or continuous flow; and
- SCBA.

Dust masks or half-face respirators are not used at LANL for RP.

The use of respiratory protection should be reduced to the minimum practical by implementing engineering controls and work practices to contain radioactivity at the source.

Respiratory protective equipment must be used when

- the concentration of airborne radioactivity exceeds, or is likely to exceed, 1 derived air concentration (DAC) or
- an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-h in a week.

Criteria for Selecting Respiratory Protection is found in Table 1 from RP-1-DP-32.

Table 1 from RP-1-DP-32

Type	Air-Purifying Respirator (APR)	Powered Air-Purifying Respirator (PAPR)	Supplied-Air Respirator (SAR) or Air-Line	Self-Contained Breathing Apparatus (SCBA)	Supplied-Air Suits
Configuration	Full facepiece	Full facepiece	Full-Facepiece Pressure demand	Pressure demand	
Airborne radioactivity concentration	≤ 50 DAC	≤ 25[4] ≤1000 DAC[3]	≤ 1000 DAC	≤ 10,000 DAC	> 100 DAC [5]
IDLH	No	No	Yes	Yes	Yes
Skin absorption hazard is present due to an airborne contaminant, such as tritium. [1]	No	No	No	No	Yes
Additional considerations	Cartridge is available for both the radiological and non-radiological airborne contaminant. Worker comfort and efficiency may be reduced by its use Potential for heat stress may be increased by its use Appropriate training	Cartridge is available for both the radiological and non-radiological airborne contaminant. PAPR issuer must have process in place for battery maintenance and RPE Storage. Battery charging time and permissible time of use between charges must be closely tracked and documented. Appropriate training	Use to increase worker comfort and efficiency and to reduce the potential for heat stress. When SARs are used in an IDLH or unknown atmosphere, an auxiliary self-contained air supply must be provided by the RPPA and used by the SAR user. Appropriate training	Appropriate training	Use to increase worker comfort and efficiency and to reduce the potential for heat stress. Must be used in accordance with plans developed and approved by facility management, IHS-CS, and RP-1 supervision. The RP-1 Team Leader must authorize the RWP covering this planned entry into high concentrations. Appropriate training
Air Supply	Not applicable	Not applicable	Air compressors or breathing-air tube Trailers [2]	Compressed air cylinders	Breathing-Air Tube Trailers[2]

Notes

(1) Noble gases, tritium water vapor, and tritium gas cannot be removed with cartridges.

(2) Refer to Industrial Hygiene and Safety-Central Services (IHS-CS) for guidance on operating the air-supply equipment for these respiratory protective devices.

(3) A PF of 1000 can be used only when evidence is provided by the manufacturer or as approved by IHS-CS. Otherwise, a PF of 25 is used.

(4) For a loose-fitting (i.e., hood-type) PAPR that has not been tested and approved for a higher PF.

(5) Consult with the Industrial Hygiene and Safety Division (IHS-IH) Respiratory Protection Team on the selection of supplied air suits and the level of protection required.

Air Quality Specifications

2.07.11 Identify the quality specification breathing air must meet.

Air Quality Testing

An air quality testing program for all sources of respirable air is required.

Compressed breathing air shall meet at least the quality specification for Grade D breathing air as described in Compressed Gas Association Commodity Specification G-7.1-1989.

Sorbents and Protection against Radioiodines

The regulations specifically prohibit the use of PFs for canister sorbents as protection against radioiodine atmospheres.

The efficiency of the charcoal canister is dependent on the chemical form of the radioiodine, the humidity of the atmosphere, and the breathing rate of the user. Criteria for testing and certifying the charcoal cartridges are contained in NUREG/CR-3403, “Criteria and Test Methods for Certifying Air-Purifying Respirator Cartridges and Canisters against Radioiodine.” Approval can be obtained from DOE to use PFs for sorbent cartridges.

Communication

Although conventional respirators distort the human voice to some extent, adequate communication can be maintained in relatively quiet areas.

A mechanical speech-transmission device, called a speaking diaphragm, is an integral part of the facepiece in some respirators. This device usually consists of a resonant cavity and diaphragm, which transmit sound. The diaphragm also acts as a barrier to the ambient atmosphere and thus should be handled carefully to prevent possible puncture, which would permit an air contaminant to leak into the respirator.

RCT: Module 2.07, RESPIRATORY PROTECTION

Course 8773

April 2017

Overview of Lesson

Internal dosimetry controls require the use of engineering controls to prevent the internal deposition of radioactive and nonradiological 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. The inappropriate use of or the use of the wrong respiratory protection equipment may result in undesirable health effects.

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.

Enabling Objectives

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

Objectives

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.

Objectives

2.07.10 – Identify the types of respiratory equipment available for use at LANL.

2.07.11 – Identify the quality specification breathing air must meet.

2.07.01 – Purpose of Respiratory Protection Standards and Regulations

Respiratory protection standards provide information and guidance on the proper selection, use, and maintenance of respirators, which will help safeguard the life and health of respirator wearers.

Regulations establish the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing workers with a safe and healthful workplace.

2.07.03 – Respiratory Protection Standards

Standards regulating respiratory protection are:

- The Occupational Safety and Health Standard, 29 CFR, Part 1910.134, *Respiratory Protection*.
- ANSI Standard Z88.2-1992, *Practices for Respiratory Protection*

DOE Order 440.1B mandates the requirements for a respiratory protection program contained in 29 CFR 1910.134 and ANSI Z88.2.

2.07.02 – Respiratory Protection Program Requirements

Occupational Safety and Health Standard, 29 CFR, Part 1910.134

- The Occupational Safety and Health Standard, 29 CFR, Part 1910.134, specifies that the minimal acceptable respiratory protection program must contain or address:
  - Written standard operating procedures governing the selection and use of respirators shall be established.
  - Respirators shall be selected on the basis of hazards to which the worker is exposed.
  - The user shall be instructed and trained in the proper use of respirators and their limitations.

2.07.02 – Respiratory Protection Program Requirements

Occupational Safety and Health Standard, 29 CFR, Part 1910.134 *(continued)*

- Respirators shall be regularly cleaned and disinfected. Those issued for the exclusive use of one worker should be cleaned after each day's use or more often if necessary.
- Respirators shall be stored in a convenient, clean, and sanitary location
- Respirators used routinely shall be inspected during cleaning. Worn or deteriorated parts shall be replaced. Respirators used for emergency use, such as self-contained devices, shall be thoroughly inspected at least once a month and after each use.

2.07.02 – Respiratory Protection Program Requirements

Occupational Safety and Health Standard, 29 CFR, Part 1910.134 *(continued)*

- Appropriate surveillance of worker area conditions and the degree of employee exposure or stress shall be maintained.
- Regular inspections and evaluations shall determine the continued effectiveness of the program.
- Persons should not be assigned to tasks requiring the use of respirators, unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (e.g., annually).

2.07.02 – Respiratory Protection Program Requirements

Occupational Safety and Health Standard, 29 CFR, Part 1910.134 *(continued)*

- Approved or accepted respirators shall be used when they are available. The respirator furnished shall provide adequate respiratory protection against the particular hazard for which it is designed in accordance with standards established by competent authorities.

2.07.02 – Respiratory Protection Program Requirements

ANSI Z88.2-1991, *Respiratory Protection Requirements*

- ANSI Z88.2-1992 further specifies the minimal acceptable program for industries involved in the use of radioactive material, and addresses the following:
  - Individual exposures limited by both inhalation and skin absorption
  - Air sampling and bioassays
  - Engineering controls as the primary method
  - Individuals exposed to greater than the specified DAC or other exposure limits
  - Respiratory protection equipment certifications (NIOSH/MSHA)

2.07.02 – Respiratory Protection Program Requirements

ANSI Z88.2-1991, *Respiratory Protection Requirements (continued)*

- If allowance for the use of respiratory protection equipment in estimating exposures is made, then the following must be observed:
  - The protection factor (PF) for the device selected must be greater than the ratio of the peak exposure concentration and the associated DAC or other exposure limit.
  - The average concentration inhaled on any one day must be less than the associated DAC.
  - If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is less than estimated, the corrected value may be used.

2.07.02 – Respiratory Protection Program Requirements

ANSI Z88.2-1991, *Respiratory Protection Requirements (continued)*

- Written procedures for selection, fitting, maintenance, records, issuance and pre-use operability checks of respirators, and supervision and training of personnel using respirators must be established.
- Before a respirator's initial use and annually thereafter, a qualified health care professional must determine a user's physical capability to wear a respirator must be performed.
- A written policy statement on the use of engineering controls instead of respirators; routine, nonroutine, and emergency use of respirators; and periods of respirator use and relief from respirator use must be issued.

2.07.02 – Respiratory Protection Program Requirements

ANSI Z88.2-1991, *Respiratory Protection Requirements (continued)*

- Surveys and bioassays shall be conducted as appropriate to evaluate actual exposures.
- Each user must be advised that he/she can leave the work area upon failure of equipment, physical distress, or deterioration of operating conditions.
- Equipment is to be used for the appropriate environment; special equipment, such as visual or communication devices, is to be issued when needed.
- Emergency use equipment must be specifically certified as such by NIOSH/MSHA.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Air-purifying, particulate-removing filter respirators

- Often called "dust," "mist," or "fume" respirators.
- Remove particulates using a filtering action before they can be inhaled.
- The five types of respirators that work by particulate removal are the single use, quarter-mask, half-mask, full facepiece, and air-powered hood/mask.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Air-purifying, particulate-removing filter respirators *(continued)*

- Air-purifying respirators generally operate in the negative pressure (NP) mode; that is, an NP is created in the facepiece during inhalation.
- An exception is a special type of powered air-purifying respirator that operates by using a motor-driven blower to drive the contaminated air through an air purifying filter or sorbent canister.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Air-purifying, particulate-removing filter respirators *(continued)*

- Limitations:
  - Air purifying respirators do not provide oxygen; therefore, they must NEVER be worn in oxygen-deficient atmospheres.
  - Particulate-removing, air-purifying respirators offer no protection against atmospheres containing contaminant gases or vapors.
  - Except for pressurized air-purifier respirators, these respirator types should not be used for abrasive blasting operations.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Air purifying, particulate removing filter respirators *(continued)*

- Battery-operated, air-powered respirators are limited by their battery life, which may be unknowingly shortened because of a memory buildup on the rechargeable NiCd batteries.
- High humidity may increase breathing resistance as paper elements become water saturated.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Air-Purifying, Chemical Cartridge, and Canister Respirators for Gases and Vapors

- Vapor and gas-removing respirators use cartridges or canisters containing chemicals (i.e., sorbents) to trap or react with specific vapors and gases and remove them from the air breathed.
- The basic difference between a cartridge and a canister is the volume of the sorbent.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Air-Purifying, Chemical Cartridge, and Canister Respirators for Gases and Vapors *(continued)*

- Limitations:
  - These respirators do not provide oxygen; therefore, they must NEVER be worn in oxygen-deficient atmospheres.
  - Unless specifically approved by DOE, no credit may be taken for the use of sorbent cartridges or canisters for protection against radioactive gases and vapors.
  - High-humidity environments may shorten the life of the sorbent material.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Full-face, supplied-air respirators

- Supplied-air respirators use a central source of breathing air that is delivered to the wearer through an air supply line or hose.
- The respirator type is either a tight-fitting facepiece (half- or full-face) or a loose-fitting hood/suit.

Supplied-air respirator with escape bottle.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Full-face, supplied-air respirators *(continued)*

- The pressure-demand device has a regulator and valve design such that there is a flow (until a fixed static pressure is attained) of air into the facepiece at all times, regardless of the "demand" of the user.
- The airflow into the mask creates a positive pressure.
- The continuous-flow air-line respirator maintains a constant airflow at all times and does not use a regulator; however, it uses an airflow control valve or orifice, which regulates the flow of air.
- The continuous-flow device does not guarantee a positive pressure in the facepiece.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Full-face, supplied-air respirators *(continued)*

- Limitations:
  - Because the air-line respirator provides no protection if the air supply fails, it shall not be used in immediately dangerous-to-life-or-health (IDLH) atmospheres or for emergency escape or rescue.
  - The trailing air supply hose severely limits mobility; therefore, it may be unsuitable if frequent movement among separated work stations is required.
  - The length of hose, number of potential users, and pressure of the supply system can reduce the number of allowable users.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Full-face, supplied-air respirators *(continued)*

- Control of the air quality is essential to avoid the introduction of hazardous respiratory agents to the wearers breathing zone.
- "Bubble suits" can aspirate air into the suit when wearers lift their arms. Consequently, the suit must be tested for the exact conditions of use.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Full-face, supplied-air respirators *(continued)*

- Special Considerations:
  - In a situation where the air-line respirator is a suit, a standby rescue person shall be equipped with self-contained breathing apparatus (SCBA) and communications equipment whenever supplied-air suits are used.
  - Requirements for use of respirators in “IDLH" atmospheres is specified in 29 CFR 1910.134(g)(3).
  - Manufacturers of air-line respirators include instructions specifying a range of air required to produce at least the minimum required flow rates. These specifications are based on hose lengths and the number of sections connected together.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Self-contained breathing apparatus (SCBA)

- SCBA allows the user to carry a respirable breathing supply
- SCBA does not need a stationary air source, such as a compressor, to provide breathable air.
- The air supply may last from 3 minutes to 4 hours, depending on the nature of the device.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Self-contained breathing apparatus (SCBA) *(continued)*

- The two groups of SCBAs are the closed circuit and the open circuit.
- Closed-circuit SCBA is a "rebreathing" device. The air is rebreathed after the exhaled carbon dioxide has been removed and the oxygen content has been restored by a compressed oxygen source or an oxygen-generating solid.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Self-contained breathing apparatus (SCBA) *(continued)*

- An open-circuit SCBA exhausts the exhaled air to the atmosphere instead of recirculating it. A tank of compressed air carried on the back supplies air via a regulator to the facepiece. Because air is not recirculated, the service life of the open-circuit SCBA is shorter than the closed-circuit system. The only type of open-circuit SCBA available for use is “pressure demand.”

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Self-contained breathing apparatus (SCBA) *(continued)*

- The pressure-demand, open-circuit SCBA has a regulator and a valve design that maintains a positive pressure in the facepiece at all times, regardless of the "demand" of the user.
- Because of the high degree of protection provided by the pressure-demand SCBA, this type of unit is recommended for emergency, escape, and rescue use.
- Combination atmosphere-supplying respirators also use supplied air and a SCBA.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Self-contained breathing apparatus (SCBA) *(continued)*

- Limitations of the Pressure Demand and Demand SCBA:
  - The air supply is limited to the amount in the cylinder; therefore, the respirator cannot be used for extended periods without recharging or replacing cylinders.
  - Because these respirators are bulky and heavy, they are often unsuitable for strenuous work or use in confined spaces.
  - The demand-type SCBA works in an NP mode and is considered obsolete.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Combination atmosphere-supplying respirators

- The combination pressure-demand breathing apparatus provides respiratory protection for personnel who must work in atmospheres that are IDLH. When connected to a respirable air source, the device permits the wearer to work and move about freely, within the limits of the approved hose length.
- The combination pressure-demand breathing apparatus is equipped with a small air cylinder that enables the wearer to escape from dangerous atmospheres if the primary air supply is interrupted.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Combination atmosphere supplying respirators *(continued)*

- The apparatus serves as a long-duration work device, as well as an escape device.
- It is approved for respiratory protection for entry into, for extended periods of work in, and for escape from IDLH atmospheres.
- If the apparatus is used for entry into IDLH atmospheres, the air line must be connected before entry.
- The self-contained air supply is approved for escape only.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Combination atmosphere-supplying respirators *(continued)*

- Operation of the combination pressure-demand breathing apparatus is manual. It is an approved, rated, 5-minute escape device.
- The pressure-demand, air-line respirator is connected by an approved air-supply hose to a primary respirable air source; the worker breathes from this source with the valve of the egress (exit) cylinder of the device turned off until the user is ready to leave the working area.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Combination atmosphere supplying respirators *(continued)*

- If the primary air supply source should fail, the worker can switch to the egress cylinder by turning a valve and escaping to a safe atmosphere.
- The dual-purpose breathing apparatus combines all of the capabilities of a SCBA and a supplied-air respirator into one unit. The apparatus is approved by the NIOSH and MSHA for use in oxygen-deficient atmospheres or where dangerous concentrations of toxic gases or vapors are present.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Combination atmosphere supplying respirators *(continued)*

- The NIOSH/MSHA approval allows the wearer to
  - enter or exit a dangerous area using only the cylinder air in applications such as emergency rescue.
  - work within the area for a limited time using the cylinder air.
  - work within the area for an extended time using air from a supply line.

2.07.04 – Respirators (Advantages and Disadvantages/Limitations)

Combination atmosphere-supplying respirators *(continued)*

- Limitations of the combination atmosphere supplying respirator:
  - Limited range due to length of hose.
  - Limited time to egress because of the limited amount of air in the escape bottle.

2.07.05 – Protection Factors

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

The PF is defined as the ratio of the concentration of contaminant in the atmosphere to the concentration inside the facepiece or hood under conditions of use.

PFs may not be appropriate where chemical or other respiratory hazards exist in addition to radioactive hazards or where the mode of entry is through the skin and not through inhalation.

2.07.05 – Protection Factors

The application of PFs is relatively straight forward.

The work area's airborne radioactivity concentration is divided by the PF to estimate the inhaled concentration.

For example, a worker performing steam generator eddy current testing with a full-facepiece, continuous-air-flow, air-line respirator (PF = 1000) in an atmosphere of 1×10^{-6} $\mu Ci/cm^3$ Co-60 would be estimated to inhale a concentration of 1×10^{-9} $\mu Ci/cm^3$ Co-60.

2.07.06 – Qualitative vs Quantitative Fit Test

Qualitative fit test:

- Determines any mask leakage, usually using irritant smoke (“go/no-go" test, but no measured value is assigned).

Quantitative fit test:

- Determines the quantity of mask leakage and assigns a "fit factor”; oil or dust particles are the typical challenge atmosphere used (the test measures the concentration in the mask due to leakage against the concentration in the atmosphere).

2.07.07 – Respirator Fit Testing

It is impractical to perform a quantitative fit test before each entry requiring respiratory protection.

Therefore, qualitative tests are performed to ensure an adequate fit for the user.

Qualitative tests can use challenge atmospheres such as isoamyl acetate (banana oil), irritant smoke, or a negative or positive pressure test.

2.07.12 – Respirator Fit Testing

Subjects perform at least the following functions during fit testing:

- Normal breathing
- Deep breathing
- Moving their head from side to side
- Moving their head up and down
- Frowning
- Talking
- Running in place
- Normal breathing

2.07.08 – Protection Factor and Selection of Respiratory Protection Equipment

In protecting against radiological airborne contaminants, the most critical factor is in meeting the provisions of ANSI Z88.2, which requires the PF for the respirator device used to be greater than the ratio of the work area's airborne concentration.

Equipment selected must be certified by NIOSH/MSHA or specifically authorized by DOE.

Approvals for respiratory devices are authorized in accordance with 42 CFR 84 and the device, type, and certification number are listed in NIOSH publication *Certified Equipment List*.

2.07.09 – Considerations for Selection of Respiratory Protection Equipment

Selecting the proper respirator for any given situation must consider the following:

- The nature of the hazard.
- The characteristics of the hazardous operation or process.
- The location of the hazardous area with respect to a safe area having respirable air.
- The period of time for which respiratory protection may be provided.

2.07.09 – Considerations for Selection of Respiratory Protection Equipment

- The activity of the workers in the hazardous area
- The physical characteristics, functional capabilities, and limitations of respirators of various types
- The respirator PFs and respirator fit

2.07.09 – Considerations for Selection of Respiratory Protection Equipment

The following factors concerning the nature of the hazard that require the use of respirators shall be considered in selecting a respirator:

- The type of hazard
  - oxygen deficiency or
  - contaminant
- The physical and chemical properties.
- The physiological effects on the body.
- The peak and average concentrations of toxic material or the airborne radioactivity level.

2.07.09 – Considerations for Selection of Respiratory Protection Equipment

- The established permissible time-weighted average or peak concentration of the toxic material, or both, or the established maximum permissible airborne radioactivity level for radioactive substances
- Whether the hazard has an IDLH concentration of toxic material
- Warning properties

Recognition and evaluation of the respiratory hazard shall be an essential part of selecting a respirator, except in emergency or rescue operations.

2.07.09 – Considerations for Selection of Respiratory Protection Equipment

Initial monitoring of the respiratory hazard shall be carried out to obtain the data needed for the selection of proper respiratory protection. The data should include:

- Identification of the type of respiratory hazard
  - oxygen deficiency or
  - specific contaminants
- Nature of contaminants
  - particulate matter or
  - vapors or gases
- Concentration of the respiratory hazard

2.07.09 – Considerations for Selection of Respiratory Protection Equipment

The following factors concerning the hazardous operation or process shall be considered in selecting the proper respirator:

- Operation, process, and work-area characteristics
- Materials, including raw materials, end products, and byproducts (actual and potential)
- Worker activities

2.07.10 – Respiratory Equipment at LANL

P121, Chapter 10, *Personal Protective Equipment (PPE)*, Part 3, *Respiratory Protection* contains requirements for respiratory protection.

RP-1-DP-32, *Respiratory Protection* states the types and uses of radiological respiratory protection and describes RP personnel's role in the LANL respiratory protection program. It does not address nonradiological respiratory protection requirements.

All respirators and breathing air used at LANL must be approved by Occupational Safety and Health, Industrial Safety and Hygiene Group (OSH-IHS).

2.07.10 – Respiratory Equipment at LANL

Respiratory protective equipment used at LANL includes:

- Air-purifying respirators (APRs) that are equipped with cartridges or canisters that remove particulates, gases, vapors, or a combination of the three
- Powered air-purifying respirators (PAPRs)
- Supplied-air respirators (SARs) that are pressure demand or continuous flow
- SCBA

Dust masks or half-face respirators are not used at LANL for RP.

2.07.10 – Respiratory Equipment at LANL

The use of respiratory protection should be reduced to the minimum practical by implementing engineering controls and work practices to contain radioactivity at the source.

Respiratory protective equipment must be used when:

- the concentration of airborne radioactivity exceeds, or is likely to exceed, 1 DAC or
- an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-h in a week.

2.07.10 – Respiratory Equipment at LANL

Criteria for Selecting Respiratory Protection

Type	Air-Purifying Respirator (APR)	Powered Air-Purifying Respirator (PAPR)	Supplied-Air Respirator (SAR) or Air-Line	Self-Contained Breathing Apparatus (SCBA)	Supplied-Air Suits
Configuration	Full facepiece	Full facepiece	Full-Facepiece Pressure demand	Pressure demand	
Airborne radioactivity concentration	≤ 50 DAC	≤ 25 [4] ≤1000 DAC [3]	≤ 1000 DAC	≤ 10,000 DAC	> 100 DAC [5]
IDLH	No	No	Yes	Yes	Yes
Skin absorption hazard is present due to an airborne contaminant, such as tritium. [1]	No	No	No	No	Yes
Additional considerations	Cartridge is available for both the radiological and non-radiological airborne contaminant. Worker comfort and efficiency may be reduced by its use Potential for heat stress may be increased by its use Appropriate training	Cartridge is available for both the radiological and non-radiological airborne contaminant. PAPR issuer must have process in place for battery maintenance and RPE Storage. Battery charging time and permissible time of use between charges must be closely tracked and documented. Appropriate training	Use to increase worker comfort and efficiency and to reduce the potential for heat stress. When SARs are used in an IDLH or unknown atmosphere, an auxiliary self-contained air supply must be provided by the RPPA and used by the SAR user. Appropriate training	Appropriate training	Use to increase worker comfort and efficiency and to reduce the potential for heat stress. Must be used in accordance with plans developed and approved by facility management, IHS-CS, and RP-1 supervision. The RP-1 Team Leader must authorize the RWP covering this planned entry into high concentrations. Appropriate training
Air Supply	Not applicable	Not applicable	Air compressors or breathing-air tube Trailers [2]	Compressed air cylinders	Breathing-Air Tube Trailers [2]

Table 1 from RP-1-DP-32

2.07.10 – Respiratory Equipment at LANL

Criteria for Selecting Respiratory Protection (Notes)

(1) Noble gases, tritium water vapor, and tritium gas cannot be removed with cartridges.

(2) Refer to IHS-CS for guidance on operating the air supply equipment for these respiratory protective devices.

(3) A PF of 1000 can be used only when evidence is provided by the manufacturer or as approved by IHS-CS. Otherwise, a PF of 25 is used.

(4) For a loose-fitting (i.e., hood-type) PAPR that has not been tested and approved for a higher PF.

(5) Consult with the HIS-IH Respiratory Protection Team on the selection of supplied air suits and the level of protection required.

2.07.11 – Air Quality Specifications

Air Quality Testing

- An air quality testing program for all sources of respirable air is required.
- Compressed breathing air shall meet at least the quality specification for Grade D breathing air as described in Compressed Gas Association Commodity Specification G-7.1-1989.

2.07.11 – Air Quality Specifications

Sorbents and Protection against Radioiodines

- The regulations specifically prohibit the use of PFs for canister sorbents as protection against radioiodine atmospheres.
- The efficiency of the charcoal canister is dependent on the chemical form of the radioiodine, the humidity of the atmosphere, and the breathing rate of the user.
- Approval can be obtained from DOE to use PFs for sorbent cartridges.

2.07.11 – Air Quality Specifications

Sorbents and Protection Against Radioiodines *(continued)*

- Criteria for testing and certifying the charcoal cartridges is contained in NUREG/CR-3403, "Criteria and Test Methods for Certifying Air-Purifying Respirator Cartridges and Canisters Against Radioiodine."

2.07.11 – Air Quality Specifications

Communication

- Although conventional respirators distort the human voice to some extent, adequate communication can be maintained in relatively quiet areas.
- A mechanical speech-transmission device, called a speaking diaphragm, is an integral part of the facepiece in some respirators.
- This device usually consists of a resonant cavity and diaphragm, which transmit sound.
- The diaphragm also acts as a barrier to the ambient atmosphere and thus should be handled carefully to prevent possible puncture, which would allow an air contaminant to leak into the respirator.