Appendix A
Fire Protection Devices

PERSONAL PROTECTIVE EQUIPMENT

The employer is required by 29 CFR 1910 to provide protective clothing to those employees who perform interior structural fire fighting.

Management has the responsibility of assuring that the proper protective clothing is worn by fire brigade members. Protective clothing must protect the head, body, and extremities, and consists of at least the following components:

- foot and leg protection
- hand protection
- body protection
- eye, face, and head protection

RESPIRATORY PROTECTION DEVICES

The requirements for respiratory protection devices and their use are contained in 29 CFR 1910 and are certified under 30 CFR, Mineral Resources.

Management has the responsibility of assuring that respiratory protective devices are worn by qualified fire brigade members.

Respiratory protection devices for fire brigades conducting interior fire fighting are atmosphere supplying respirators - self-contained breathing apparatus (SCBA).

NFPA 600 requires SCBAs for fire brigades except during incipient fire fighting

Air-Purifying, Particulate-Removing Filter Respirators

Description:
These are generally called “dust,” “mist,” or “fume” respirators and by a filtering action remove particulates before they can be inhaled. Single use, quarter mask, half mask, full facepiece, and air-powered hood/mask are the five types of respirators that work by the particulate removal method.

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 or sorbent canister.

In reactors, only the half face, full facepiece, and air-powered hood/mask are respirators approved for use in protection against airborne radionuclides.

Limitations:
Air-purifying respirators do not provide oxygen, so 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.

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

Description:
Vapor and gas-removing respirators use cartridges or canisters containing chemicals (that is, 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. In reactors, combination filter-canister type respirators are used with tight-fitting full facepiece respirators and are used for protection against radioiodines.

Limitations:
These respirators do not provide oxygen, so they must NEVER be worn in oxygen deficient atmospheres.

High humidity environments will shorten the life of the sorbent material.

Control of the air quality is essential to avoid introduction of hazardous respiratory agents to the wearer's breathing zone.

"Bubble suits" can aspirate air into the suit when the wearer's arms are lifted. Consequently, the protection factor (PF) suit must be tested in the exact conditions of use.

Special Considerations:
In a situation where the air-line respirator is a suit, there should be a standby rescue person equipped with self-contained breathing apparatus and communications equipment whenever supplied-air suits are used.

Requirements for use of respirators in "dangerous" atmospheres is specified in 29 CFR 1910.134(e)(3) as follows:

"(3) Written procedures shall be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or in emergencies. Personnel shall be familiar with these procedures and the available respirators.

(i) In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man should be present. Communications (visual, voice, or signal line) should be maintained between both or all individuals present. Planning shall be such that one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the other(s) in case of emergency.

(ii) When self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health, standby men must be present with suitable rescue equipment.

(iii) Persons using air line respirators in atmospheres immediately hazardous to life or health shall be equipped with safety harnesses and safety lines for lifting or removing persons from hazardous atmospheres or other equivalent provisions for the rescue of persons from hazardous atmospheres shall be used. A standby man or men with suitable self-contained breathing apparatus shall be at the nearest fresh air base for emergency rescue."

Manufacturers of airline 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.

Determining if the proper air flow rate is achieved can be complicated by the use of a breathing air manifold supplying more than one user. The following are recommendations which should be considered.

If all the hose lengths and number of hose fittings are the same, then a manifold with a single regulator and pressure gauge is appropriate for ensuring the proper pressure is used.

NOTE: If the pressure is within the manufacturer's specifications, then the delivery air flow rate should be at least 4 cubic feet per minute (cfm) for tight-fitting respirators and 6 cfm for hoods.

For situations where each user has different hose lengths, different number of connections or different air pressure requirements then a separate pressure gauge should be used as follows:

- The air flow rate should be measured at the end of the breathing tube (that is, at the delivery end).
- This air flow rate should be measured using a calibrated rotameter or equivalent air flow measuring device.

To utilize the (PF) of 2,000 assigned to air-supplied hoods, a delivery flow rate of at least 6 cfm but not greater than 15 cfm must be obtained. The individual user's air flow valves should not be altered to maintain a minimum delivery flow rate of 6 cfm, because this violates the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) approval. If through improper worker training, motivation, or supervision or if operation of the device at the maximum flow rate causes discomfort or unacceptable degradation of hearing or ability to communicate when other workplace factors are considered, the respirator should be operated at lower flow rates and a protection factor of only 1,000 assigned to its use. Taping or otherwise securing the airflow valves in the fully open position does not void the NIOSH/MSHA approval provided the valve is not permanently altered or made so that it would be impossible to increase or decrease the air flow by the user.

Atmosphere Supplying Respirators-Self-Contained Breathing Apparatus

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

There are two groups of SCBAs—the closed circuit and the open circuit:

1. Another name for closed circuit SCBAs is "rebreathing" device. The air is rebreathed after the exhaled carbon dioxide has been removed and the oxygen content restored by a compressed oxygen source or an oxygen-generating solid. These devices are designed primarily for one to four hours use in toxic atmospheres.

2. 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 there is no recirculation of air, the service life of the open circuit SCBA is shorter than the closed circuit system. Two types of open circuit SCBA are available, "demand" or "pressure demand."

In a demand SCBA, air flows into the facepiece only on demand of the wearer; that is, when the person inhales. During inhalation, there is a negative pressure in the mask so if there is leakage, contaminated air can enter the mask and be breathed by the user. It is important to note that 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. These types of respirators should not be used for emergency use or for escaping from dangerous environments according to existing guidance (NUREG 0041). The pressure demand open circuit SCBA has a regulator and a valve design which 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.

Atmosphere Supplying Respirators - Supplied Air

Description:
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 face or full) or loose-fitting hood/suit. There are essentially two major groups of supplied air respirators: (1) the air-line device and (2) the hose mask with or without a blower. Hose masks are not used in reactors.

In a demand device, the air enters the facepiece only on “demand” of the wearer; that is, when the person inhales. During inhalation, there is a negative pressure in the mask, so if there is leakage, contaminated air may enter the mask and be inhaled by the wearer. The pressure demand device has a regulator and valve design such that there is a continuous 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 outward. The continuous-flow air-line respirator maintains a constant airflow at all times and does not use a regulator, but uses an airflow control valve or orifice which regulates the flow of air. The continuous-flow device creates a positive pressure in the facepiece. At reactors, virtually all supplied air operations use the continuous-flow mode.

Limitations:
Since the air-line respirator provides no protection if the air supply fails, they should 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 so 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.

Battery operated air-powered respirators are limited by battery life, which may be unknowingly shortened due to a memory build-up on the rechargeable nickel cadmium (NiCd) batteries.

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

Combination Atmosphere Supplying Respirators - Combination Pressure Demand Breathing Apparatus

Description:
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, which enables the wearer to escape from dangerous atmospheres in case the primary air supply is interrupted.

The apparatus serves as a long duration work device and as an escape device as well. It is approved for respiratory protection for entry into, for extended periods of work in, and for escape from IDLH atmospheres. If 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 five-minute escape device. The pressure demand air-line respirator phase 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 for any reason, the worker can switch to the egress cylinder by turning a valve, and then escape to a safe atmosphere. The worker then can leave, connected to the primary air source, or can open the egress cylinder valve and have approximately five minutes respiratory protection. When breathing from the air cylinder, the user can remain connected to the primary air supply and exit, or can disconnect from the air source for easier escape.

Combination Atmosphere Supplying Respirators - Dual-Purpose Breathing Apparatus

Description:

The dual-purpose breathing apparatus combines all of the capabilities of a self-contained breathing apparatus and a supplied-air respirator in 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. 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.
- The wearer to work within the area for a limited time using the cylinder air.
- The wearer to work within the area for an extended time using air from a supply line.

Thus, the dual-purpose breathing apparatus has all the advantages of both air and work masks. Note particularly that 20% of the cylinder air may be used for entry and that the apparatus is not limited to escape. Of course, if the air from the supply line should fail, the wearer can escape the area using the cylinder air.

The dual-purpose breathing apparatus is available in both demand and pressure demand models. In the demand model, air is supplied on demand at ambient atmospheric pressure. In the pressure demand model, a slight positive pressure is maintained within the facepiece during both inhalation and exhalation. The slight positive pressure prevents a toxic atmosphere from leaking into the facepiece; this type of leakage can occur with a demand apparatus due to the negative pressure developed in the facepiece. A pressure demand apparatus should therefore be used where the potential toxicity of the atmosphere is such that no back leakage can be tolerated.

The regulator on the dual purpose breathing apparatus reduces the high pressure from the apparatus' compressed air cylinder to a breathable pressure. In pressure demand models, it also automatically monitors the flow of air into the facepiece so as to maintain a slight positive pressure within the facepiece. The regulator has two inlet ports — one for the cylinder and another for the supply line. A Foster connector allows the air supply to be semiautomatically switched from the cylinder to the air line. With no supply line connected to the regulator, the wearer receives air from the cylinder. When an air line is connected to the regulator through the Foster fitting, the wearer automatically receives air from the supply line. If the air supply from this line should be interrupted, the wearer must disengage the supply line in order to automatically receive air from the cylinder.

Limitations of the Pressure 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 a negative pressure mode and, therefore, cannot be used for firefighting (10 CFR 50, Domestic Licensing of Production and Utilization Facilities).
Special Considerations of the Pressure and Demand SCBA
As specified in Section 5.5 of NUREG 0041, "Manual of Respiratory Protection Against Airborne Radioactive Materials," 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 performance of SCBAs in high temperature environments such as fires may lead to rapid deterioration of components.

RESPIRATOR 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.

Protection factors 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. For example, 50% of the intake from exposure to tritiated oxide is through skin absorption. The use of atmosphere supplying respirators will only provide a PF of 2.

Application of PFs is relatively straight-forward. The work area airborne radioactivity concentration is divided by the PF to estimate the inhaled concentration.

SELECTION OF RESPIRATORS

Equipment selected must be certified by NIOSH/MSHA or specifically authorized by facility specialist. Approvals for respiratory devices are authorized in accordance with 30 CFR and the device, type, and certification number are listed in NIOSH Publication No. 76-45.

Consideration for Situation

Selection of the proper respirator for any given situation should require consideration of 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
- The respirator protection factors and respirator fit

Consideration of the Hazard

The following factors concerning the nature of the hazard requiring the use of respirators should be considered in respirator selection:

- The type of hazard
  - Oxygen deficiency
  - Contaminant
- The physical and chemical properties
- The physiological effects on the body
- The peak and average concentrations of toxic material or airborne radioactivity level
- The established permissible time-weighted average or peak concentration of toxic material, or both, or established maximum permissible airborne radioactivity level for radioactive substances
- Whether the hazard is an IDLH concentration of toxic material
- Warning properties

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

- Identification of the type of respiratory hazard
  - Oxygen deficiency
  - Specific contaminants

- Nature of contaminants
  - Particulate matter
  - Vapors or Gases

- Concentration of respiratory hazard

Consideration of Hazardous Operation or Process

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

- Operation, process, and work-area characteristics

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

- Worker activities (Modification in the operation or process should be taken into account, since this may change the hazard and, therefore, require the selection of a different respirator.)

Selection of air-line respirators includes not only the PF but also the air supply pressure, the air flow to the user, and hose length. Each manufacturer's approval sheet lists the approved criteria. For use of 15 to 50 feet of hose at 16 to 20 pounds per square inch, an airflow of greater than 4 cfm to a facepiece, 6 cfm to a hood, and less than 15 cfm to either must be obtained. As discussed, air flow rate delivery should be evaluated for multiple personnel use of breathing air manifolds.

SORBENTS AND PROTECTION AGAINST RADIOIODINES

The regulations specifically prohibit the use of PFs for canister sorbents as protection against radioiodine atmospheres. However, the charcoal canisters provided by most manufacturers do provide a measure of protection against radioiodine atmospheres. The efficiency of the charcoal canister is dependent upon the chemical form of the radioiodine, humidity of the atmosphere, and breathing rate of the user. Approval can be obtained from the NRC to use PFs for sorbent cartridges. The 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*.

A brief summary of test conditions and acceptance criteria follows in the table below.

Test Conditions and Acceptance Criteria

Test Parameter	Criteria
Vapor	CH3I
Concentration	1 PPM
Temperature	30 + 1 C

Total Airflow	64 L/min
Equilibration	All as received
(6H at 64 L/min)	3 at 50% RH 3 at 75% RH
Maximum Penetration	.01 PPM
Minimum Service Life	30 min at 100% RH (extrapolated); 60 min at 75% RH

Limiting Conditions of Use:
Total challenge in the workplace (radioactive iodine, nonradioactive iodine, or the halogenated compounds) may not exceed 1 ppm.

Temperature in the work area may not exceed 100°F. Temperature is to be measured on each shift or in conjunction with operations that produce heat in the work area.

Service life is eight hours maximum. This is calculated from the time the canister is unsealed and includes periods of non-use. Once the screw cap on the canister threads or the tape seal over the inlet port on the bottom are removed, the 8-hour use duration begins whether used or not by an individual.

Canisters will not be used in the presence of organic solvents, vapors, or chemicals (such as decontamination compounds, lubricants, volatilized paint, alcohol, freon) that could cause aging, poisoning, or desorption of the adsorbed radioiodines. Nonexposure to these organic agents must be demonstrated by usage restrictions and by air sampling.

Canisters must be stored in sealed humidity-barrier packaging in a cool, dry environment (QA Class "A" storage).

Respirator Communications

Although conventional respirators distort the human voice to some extent, adequate communication can be maintained in relatively quiet areas. For reactors, those areas requiring the greatest use of respiratory protection are often the noisiest due to the numerous pumps, motors, and fans. Consequently, special attachments, or modifications to the respiratory device are often needed to ensure adequate communication.

A mechanical speech-transmission device, called a speaking diaphragm, is an integral part of the facepiece in some respirators. It usually consists of a resonant cavity and diaphragm that 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 leakage of an air contaminant into the respirator. Various methods of electronically transmitting and amplifying speech through the respirator are available. These utilize a microphone connected to a speaker, telephone, or radio transmitter. Usually, the microphone is mounted inside the respiratory-inlet covering, while the amplifier, power pack, and speaker or transmitter are attached to the exterior of the respiratory-inlet covering, carried on the body, or remotely located. Respirators with electronic speech-transmission devices having a battery power supply should be used with caution in explosive atmospheres. Sealed power sources should be checked for integrity of the seals. Connecting cables from the microphones inside the respiratory inlet covering should have gas-tight seals where they pass through the covering. When the speaker diaphragm is part of the barrier between the respirator wearer and the ambient atmosphere, it should be adequately protected from puncture or rupture. A microphone mounted on the respirator wearer's throat or head, or a microphone/speaker worn in the respirator wearer's ear, does not require penetration of a respirator facepiece by a cable.

Any communication device that is an integral part of the respirator or is attached to the exterior, such as a sound transducer on the face plate, must be part of the NIOSH/MSHA approval for the respiratory device. One system with a NIOSH/MSHA approval extension for use with negative pressure air-purifying respirators is the ClearComV. The ClearComV is a battery-operated device with the microphone inserted as an integral part of the facepiece and a plug.

Summary of Respiratory Protection Devices

All respiratory protection devices share a common limitation for protection against hazardous substances that injure the skin or eyes (except SCBAs) or are absorbed through the skin. When selecting any protective device, the chemical form of the hazardous substance should be ascertained to determine if skin protection is required and if the eye protection afforded by the respirator is adequate.

MANUFACTURE, STORAGE, AND USE OF EXPLOSIVE MATERIALS

The term “explosive” includes any material determined to be within the scope of Title 18, United States Code, Chapter 40 (18 USC 40), Importance, Manufacture, Distribution, and Storage of Explosive Materials. It also includes any material classified as an explosive by the Department of Transportation (DOT) Hazardous Material Regulations. This section provides operational requirements and responsibilities for the manufacture, storage, and use of explosive materials in compliance with the following standards as applicable:

- NFPA 495, *Explosives Material Code*
- NFPA 498, *Standard for Explosives Motor Vehicle Terminals*
- 49 CFR 100-199, *Transportation*

Management should ensure that the following are accomplished:

1. The manufacture, storage, and use of explosive materials are prohibited unless they can be done in a safe manner.

2. The safety of the explosives workers, general public, and environment in the vicinity of the explosive materials are the primary importance of the operations.

3. Smoking and flame-producing equipment are not permitted in the vicinity where explosive materials are produced, handled, stored, or used.

4. All explosive materials that are not in the process of manufacture, being transported, or in use are kept in a storage magazine.

5. Storage magazines are of the proper construction and are properly located for the type and amount of explosive being stored.

6. The area around storage magazines is kept clear of brush, dry grass, leaves, or similar combustibles for a minimum distance of 25 feet.

7. Combustible materials are not stored within 50 feet of explosive magazines.

8. All electrical equipment used near explosive material complies with NFPA 70, National Electrical Code, for classified hazardous areas.

9. Precautions are taken to prevent accidental detonation of explosives from currents induced by radar and radio transmitters, lightning, adjacent power lines, dust and snow storms, or other sources of extraneous electricity. These precautions should include the following:

   a. Post signs warning against the use of mobile radio transmitters on all roads within 350 feet of explosive operations, as required.

   b. Construct tools used in the handling of explosives of nonsparking materials.

   c. Discontinue all handling of explosive materials during the approach and progress of an electrical storm. Move all personnel to a safe location.

   d. Provide bonding and grounding straps for all equipment where explosive materials are processed and handled.

   e. Ensure floorings are of nonsparking materials.

FILTER PLENUM FIRE PROTECTION

All HEPA filters used in nuclear ventilation exhaust systems should be listed in UL 586, Test Performance of High Efficiency, Particulate, Air Filter Units.

All nuclear duct entrance filters and prefilters located upstream or made part of final HEPA filter exhaust plenums should be listed as a Class 1 air filter unit as tested in accordance with UL 900, *Test Performance of Air Filter Units*.

A filter framing system may be constructed of combustible material provided that the material has a flame-spread rating of 25 or less and a smoke-developed rating of 50 or less.

When nuclear HEPA filters serve as the final means of effluent cleaning, a minimum of two stages of HEPA filters should be arranged in series in the final filter plenum. In existing HEPA installations, one of the two stages of final HEPA filters may be located upstream from the final filter plenum.

Filter plenums located inside process buildings and other buildings should be separated from all parts of the building and be enclosed by 2-hour fire-rated construction. Buildings should be provided with fire protection (that is, smoke detectors and sprinkler systems) for the appropriate particular hazards within the building.

Filter plenums located in separate buildings should be of minimum 2-hour fire-rated construction when located less than 5 feet (1.5 meters) from an adjacent building.

Filter plenum housing should be a minimum of 1-hour fire-rated construction when located more than 5 feet (1.5 meters), but not more than 20 feet (6.1 meters) from an adjacent building.

Filter plenums housed greater than 20 feet (6.1 meters) from an adjacent noncombustible building may be of unprotected noncombustible construction provided that no unprotected openings occur in the exposed adjacent building.

Filter plenum housing need not be rated or located away from an adjacent building at a minimum distance if the adjacent building's exposed wall has a minimum 2-hour fire-rated construction and no unprotected openings.

Filter plenums located near combustible or flammable liquid storage buildings or tanks should be located not less than 50 feet away from the storage or tanks and be housed in minimum 2-hour fire-rated construction.

Small filter plenums that serve as a final filter and have a leading surface area of 16 square feet (1.4 square meters) or less need not be separated by fire-rated construction from other parts of a building or be located in a separate fire-rated enclosure if the filter plenum is located in a building provided with an automatic fire sprinkler system, designed and installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, and the filter plenum is provided with an automatic water spray system described herein.

Plenums that have already been built and are in service before issuance of this criteria do not require a rated enclosure or minimum separation distance unless there is a significant hazard that endangers building occupants, the public, or the environment, as determined by a Fire Hazard Analysis.

Protection of Openings in Fire-Rated Construction

Door openings into 2-hour rated filter plenum housings should be 1 1/2-hour fire-rated minimum.

Door openings into 1-hour rated filter plenum housings should be 3/4-hour fire-rated minimum.

Fire Damper Rating

Listed 1 1/2-hour fire-rated dampers should be installed where ventilation ducts, not required to continuously function as part of a confinement system, penetrate 2-hour fire-rated construction.

Fire dampers are not required when ducting penetrates 1-hour fire-rated construction. The duct should pass through the wall and extend into the area to be considered ducted. The area should be protected by automatic sprinklers in order to eliminate the dampers. Transfer grills and other similar openings should be provided with an approved damper.

Fire dampers in duct work should not be utilized when penetrating the fire-rated construction where the ducting is an integral part of the nuclear air filter system equipment that is required to continuously function as part of the confinement system. Such duct material penetrating fire-rated construction without fire dampers should:

- be made part of that fire-rated construction by either wrapping, spraying, or enclosing the duct with an approved material, or by other means of separating the duct material from other parts of the building with equivalent required fire rated construction; or

- be qualified by an engineering analysis for a 2-hour fire-rated exposure to the duct at the penetration location where the duct maintains integrity at the duct penetration with no flame penetration through the fire wall after a 2-hour fire exposure.

Other types of dampers in the air cleaning system for the purpose of controlling pressure, direction, or volume of air flow and for isolation of filters during change out or inspection are permitted in the ventilation system.

Other Penetrations and Openings in Fire-Rated Enclosures

All mechanical and electrical penetrations made into fire-rated plenum enclosures should be fire-stopped by listed materials meeting requirements of ASTM E814, Fire Tests of Through Penetration Fire Stops, with a fire rating not less than the rated enclosure.

Materials and Special Hazards Inside Plenums

Filter plenum enclosures should only be used for ventilation control equipment. The storage and accumulation of combustible materials as well as combustible and flammable liquids in any quantity should not be permitted. In addition, the storage of spare filters inside the filter plenum is not permitted.

All electrical equipment located in the filter plenum should comply with NFPA 70, National Electrical Code, and all electrical wiring located in the filter enclosure should be in metal conduit.

Processes Subjecting Final Filter Plenum to Flammable and Combustible Vapors

When operations or processes involve flammable or combustible liquids that produce vapors, the concentration of the gases or vapors inside the final filter plenum should not exceed 25 percent of their lower flammable limit inside the filter enclosure.

Fixed combustible gas analyzers should be provided in the final filter enclosure when the process involves these gases or vapor with analyzer alarms set to sound an alarm at 25 percent of the lower flammable limit. These alarms should be transmitted to a continuously manned location.

Processes Subjecting Final Filter Plenum to Pyrophoric Dust Particles

When operations or processes involve pyrophoric materials that may subject the final filter plenum to the pyrophoric dust particles, a method to remove the dust particles before reaching the final filter enclosure, such as a prefilter, should be required.

Process Subjecting Final Filter Plenum to High Dust Loading, High Moisture Air, Acid, or Solvent Environments

Operations sometimes may involve processes that may subject the final filters to airstreams made of high moisture content, high dust loading, acids, and solvents that may rapidly degrade, plug or disintegrate the final filter medium or separators. When operations involve these sorts of airstreams, methods should be utilized to stop the degradation impact on the final filters. Methods can include, but are not limited to, more frequent filter change outs, prefilters, scrubbers or traps, filters rated for the particular environment, and the use of alternative chemicals. When chemical degraders to HEPAs are utilized, including hydrogen fluoride (HF), nitric acid (HNO3), and perchloric acid (HCLO4), processes should include scrubbers, traps, or other methods to remove the chemical before the final HEPA filters.

Prefilters and Duct Entrance Filters

Protection of the final filter plenum from dust and particulate loading should be accomplished by using duct entrance filters or prefilters or a combination of both as follows:

All gloveboxes, hot cells, and fume hoods connected to containment ventilation systems should be provided with at least moderately efficient (30 to 45 percent atmospheric dust spot efficiency based on ASHRAE 52.1, Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter) duct entrance filters.

High efficiency (at least 80 percent atmospheric dust spot efficiency based on ASHRAE 52.1 test method) prefilters should be provided in the ventilation system to protect the final HEPA filters from: (1) particles with diameters larger than 1 or 2 micrometers; (2) lint; and (3) dust concentrations greater than 10 grains per 1,000 cubic feet (30 cubic meters). High efficiency prefilters not only provide a degree of fire protection to the final HEPA filters, but they can also extend the operational life of the HEPA filters.

Prefilters that should be located in final filter plenums enclosures should be high efficiency prefilters (at least 80 percent ASHRAE atmospheric dust spot efficiency). These prefilters should be located at least 36 inches (91 centimeters) upstream and away from the final HEPA filters.

Where airborne materials are known to be flammable (such as metal powders), replaceable prefilters should be located as near the source as possible. However, prefilters should not be located where there is an unacceptable radioactive hazard to personnel to changing the prefilters.

Fire Screens for Filter Plenums

Fire screens are metal mesh spark arresters that should be located upstream from the prefilters and final filter plenums. Their purpose is to stop burning embers from reaching the final exhaust filters while not allowing enough accumulation of material to stop ventilation air flow.

Fire screens with metal meshes from 8 to 16 openings per inch should be provided and located at least 4 to 5 feet (1.2 to 1.5 meters) upstream from all prefilters and at least 20 feet (6.1 meters) upstream from all final filter plenum enclosures.

Where prefilters are located in final filter enclosures, fire screens should be located at least 20 feet (6.1 meters) upstream from the prefilters.

Duct entrance filters may not require fire screens unless a significant amount of combustible materials are present before the system duct entrance.

Detection Systems

Automatic fire detectors should conform to NFPA 72, National Fire Alarm Code.

Detectors should be rate compensated type heat detectors.

Detectors should be listed for the use of their intended purpose.

Detectors should be of the 190°F (89°C) temperature range unless operations require higher temperature air flows.

Detector Location

Heat detectors or pilot sprinkler heads should be provided in ducting prior to final filter enclosures. Airflow should be considered when determining detector or pilot head location.

Heat detectors or pilot sprinkler heads should also be provided in the final filter enclosures.

System Arrangement

The detection system or pilot system should be arranged to detect a rise in air flow temperatures, actuate automatic fire suppression systems, when required, and transmit an alarm to the responding fire department or constantly attended proprietary station. The fire alarm system should be installed per NFPA 72.

Detection system installations should conform to NFPA 72. Control units and signaling alarm systems connected to the heat detectors should be listed for their intended purpose.

Detection Testing Capability

Detector installations should be engineered and installed so that they can be tested during the life of the detector. Remote testing should be provided for detectors that are not accessible due to unacceptable hazards. One method of providing remote testing is to provide detectors with heating strips or coils that can be energized by a separate control unit. Detectors should be tested at the appropriate frequency required by NFPA 72. If a linear heat detection system is used, a heat testing pad should be provided outside the plenum for operability testing of the system.

Where high contamination levels do not exist, detectors may be installed so that the detector can be removed from the plenum enclosure and tested externally.

Deluge Spray Suppression Systems

Where Deluge Spray Systems are Required

1. Automatic and manual water deluge spray systems should be provided inside all final filter plenums for protection of the filters where plenums filters have a leading filter surface area greater than 16 square feet (1.4 square meters).

2. Automatic water deluge spray systems should be provided inside all final filter plenums having a leading surface area of 16 square feet (1.4 square meters) or less when the filter plenum is not separated by fire-rated construction.

3. Plenums that have already been built and are in service before issuance of this criteria do not require automatic or manual water deluge spray systems unless there is a significant hazard that endangers building occupants, the public, or the environment, as determined by a Fire Hazard Analysis.

4. The design of water deluge spray systems should reflect the potential for filter failure mechanisms, such as excessive differential pressures during water discharge. Such failure mechanisms can be significantly mitigated by altering ventilation flow rates by throttling back fan controls or by providing redundant filters.

Demister Requirements

1. Where automatic deluge spray systems are installed in filter plenum enclosures that do not contain prefilters, metal demisters should be installed downstream of the automatic deluge spray sprinkler heads and upstream of the first series HEPA filter.

2. Demisters should have a nearly 100 weight (wt) percent efficiency for water drops 50 micrometers and larger and should have an efficiency greater than 99 wt percent for 1 to 10 micrometers with air flow velocities of 500 to 600 feet (153 to 183 meters) per minute or at operated air flow velocities with operated water flow deluge spray delivery rate.

3. Demisters should be located as far away as possible from the HEPA filters (a minimum of 36 inches [91 centimeters]) and approximately 6 inches (15 centimeters) from the deluge spray sprinkler heads.

4. When automatic deluge spray systems are installed in final filter plenum enclosures that contain prefilters, water spray deluge sprinkler heads should be located upstream from the prefilters. In this configuration, the prefilters act as a demister.

Design of Automatic Deluge Spray Systems

1. Automatic deluge spray systems should be designed per NFPA 13, Standard for the Installation of Sprinkler Systems, and NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection:

   - Density. Water spray density should be 0.25 gpm per square feet over the entire filter area or 1 gpm per 500 cfm air flow, whichever is greater.

   - Spray pattern and sprinkler head type. Spray sprinkler heads should be deluge type sprinkler heads.

   - Location from prefilters or demisters. The spray pattern of the deluge sprinkler head should be in the form of a downward vertical water curtain approximately 6 inches (15 centimeters) in front of the prefilter or demister. In addition, deluge sprinkler heads should be spaced so that each sprinkler head does not exceed 4 lineal feet of curtain coverage.

   - Activation by detection. Deluge spray sprinkler system should operate upon activation of fire alarm system heat detectors or pilot sprinkler heads located in either the final ducting or filter plenum housing. Manual activation should be provided as well.

2. Automatic water spray system equipment should be listed for its intended use as required by NFPA 13 and NFPA 15.

3. Existing automatic deluge spray systems that provide equivalent and reliable fire protection for plenum filtration systems are acceptable.

Design of Manual Deluge Spray Systems

1. Manual spray systems should be designed per NFPA 15 and modified as follows:

   - Density. Water spray density should be 0.25 gpm per sq. feet over the entire filter area.

   - Spray pattern and nozzle type. Nozzles should be deluge spray nozzles that form a full circle solid cone discharge.

- Location from filters. Spray nozzles should be horizontally directed at the face of the first series HEPA filters so that all areas of the first stage filters and framing support system are wetted.

- Activation should be by manually activating deluge valve or opening a normally closed outside screw and yoke (OS&Y) gate valve. Control devices to activate the spray nozzle deluge valve should be provided in the process operators control room. When a deluge valve is utilized, manual activation may be provided at the deluge valve as well.

2. Manual water spray system equipment should be listed for their intended use as required by NFPA 13 and NFPA 15.

3. Existing manual deluge spray systems that provide equivalent and reliable fire protection for plenum filtration systems are acceptable.

Water Supply

Water for the deluge spray systems should be provided by two separate water supply connections for reliability.

Automatic and manual water spray systems water supplies should be hydraulically calculated and capable of supplying a simultaneous flow of the automatic and manual water spray systems as well as the overhead ceiling automatic fire sprinkler systems from the fire area providing air to the plenum for a minimum period of 2 hours. A minimum 2-hour water supply is not required when a limited water supply system, discussed below, is justified and provided for criticality event reasons.

Special System Requirements

Water Drains

1. Water drains with traps and a means to eliminate drain trap evaporation should be provided in plenum floors to provide liquid run-off control.

2. Plenum drains should be piped to either a process waste system or to collection tanks.

3. Process waste systems and collection tanks should be of sufficient capacity to capture all liquid from the water deluge spray systems for the densities and durations required herein.

PROTECTION CRITERIA FOR SPECIAL HAZARDS

Hazards unique to nuclear facilities and not addressed by mandatory codes and standards should be protected by isolation, segregation, or use of special control systems (inert gas, explosion suppression, etc.). In addition, devices for limiting or controlling the effects of a fire (relief valves, filters, blast walls, emergency shutdown systems, scuppers, etc.) should be provided.

Plutonium Processing and Handling Facility (PPHF)

In general, only hazardous gases or liquids that are necessary for a process should be used in Plutonium Processing and Handling Facilities (PPHFs). No natural gas for heating purposes should be used unless the heating occurs in a separate building that is clearly isolated from the primary facility. Other flammable, explosive, corrosive, or toxic gases or liquids that are necessary to the process should be handled under special control and isolated to avoid releases or reactions that might cause injury to workers, the public, or the environment. Those flammable gases that are necessary for a process should be provided by a hard-piped system with the gas supply located outside of the facility in cylinders, rather than from large capacity sources, so as to limit the total quantity available in the event of a fire or explosion.

Plutonium Storage Facility

Combustible packaging materials should be stored in metal containers or structures outside of a Plutonium Storage Facility (PSF) in a location that should not endanger the storage facility or stored material if a fire occurs in the packaging material. The need to provide automatic fire suppression systems for these areas should be evaluated in the Fire Hazard Analysis (FHA) and Safety Analysis Report (SAR).

Storage racks should be noncombustible and designed to securely hold storage containers in place, ensure proper separation of storage containers, and maintain structural integrity under both normal operations and during a fire.

Unirradiated Enriched Uranium Storage Facility (UEUSF)

Combustible packaging materials should be stored in metal containers or structures outside of a Unirradiated Enriched Uranium Storage Facility (UEUSF) in a location that should not endanger the storage facility or stored material should a fire occur in the packaging material. The need to provide automatic fire suppression systems for these areas should be evaluated in the FHA and SAR.

Uranium Enrichment Facilities

Water from fire sprinkler systems should be shielded from mixing with UF6. Uranium Processing and Handling Facilities

The primary confinement system should be constructed of fire-resistant materials, and the process equipment and process being confined should be designed to prevent or minimize the probability of potential flammable or explosive conditions. Confinement enclosures for flammable metals should be designed with self-contained fire protection and extinguishing equipment; in some cases, inert atmospheres may be desirable within the enclosures.

The first type of process should have ventilation that provides sufficient air movement around the process area to prevent exposure of personnel to the hazardous liquid or vapor. The design should incorporate roughing filters and/or other types of traps to remove entrained organic liquid droplets from the process off-gas before the off-gas enters the main ventilation ducting to prevent ventilation ducts from becoming coated with the organic which may create a fire hazard.

Reprocessing Facilities

Design features that should be considered to ensure maintenance of the principal confinement systems include provisions for sprinklers, water fog, or other suitable systems within the secondary confinement to provide for rapid heat removal and minimum pressurization of the process cell or canyon and to minimize the loading of ventilation system filters with combustible products.

Uranium Conversion and Recovery Facilities

To the extent practical, the primary confinement system should be constructed of fire-resistant materials, and the process equipment and process being confined should be designed to prevent or minimize the probability of potential flammable or explosive conditions. Confinement enclosures for flammable metals should be designed with self-contained fire protection and extinguishing equipment; in some cases, inert atmospheres may be desirable within the enclosures.

Physical isolation barriers should be designed for process areas that use hydrogen. Pressurized hydrogen gas storage areas should be surrounded with fire-resistant barriers. The pressurized hydrogen storage tanks should be capable of being isolated from the distribution system using positive shutoff valves. The distribution system should either be double piped (pipe within a pipe) or have hydrogen detectors located at strategic points, with the detector-activated capability of shutting off hydrogen flow at the source.

Fire-resistant, physical isolation barriers should be designed for both the fluorine gas storage area and process areas that use fluorine.

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