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REGULATORY GUIDE

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REGULATORY GUIDE 3.32

GENERAL DESIGN GUIDE FOR VENTILATION SYSTEMS FOR FUEL REPROCESSING PLANTS

A. INTRODUCTION

Section 50.34, "Contents of Applications; Technical Information," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires, among other things, that each application for a construction permit for a production or utilization facility, including fuel reprocessing plants, include the principal design criteria for the facility. At fuel reprocessing plants, a principal risk to health and safety is the uncontrolled release and dispersal of airborne radioactive material. Structures, systems, and components important to safety in a fuel reprocessing plant include, among other things, features designed to prevent, limit, or mitigate the release of radioactive material. These features include protection by multiple confinement barriers and systems, ventilation systems, and offgas systems.

Regulatory Guide 3.18, "Confinement Barriers and Systems for Fuel Reprocessing Plants," provides information relative to establishing principal design criteria for confinement barriers and systems that will minimize the amount of radioactive material released to the environment or to areas normally occupied by personnel. Regulatory Guide 3.20, "Process Offgas Systems for Fuel Reprocessing Plants," provides information relative to establishing principal design criteria for equipment associated with process offgas treatment systems for fuel reprocessing plants. The ventilation systems for a fuel reprocessing plant are designed to confine, channel, and control airborne radioactive contaminants and provide normal ventilation functions. Many acceptable bases for the design of ventilation systems for fuel reprocessing plants are available and have been used. These bases can differ significantly because there has not been sufficient guidance toward standardization. In the interest of standardization, this guide describes bases acceptable to the NRC staff for the design of ventilation systems for fuel reprocessing plants.

B. DISCUSSION

Ventilation systems for fuel reprocessing plants are designed to supply properly conditioned air to occupied and unoccupied areas, ensure that air is confined to prescribed flow paths for discharge via a final filter or treatment system and stack, and ensure that proper monitoring and filtration or treatment are provided. Ventilation systems for current generation fuel reprocessing plants usually consist of once-through air supply and exhaust air systems together with associated air filters, fans, dampers, ducts, monitoring equipment, and control instrumentation. Air filters can include medium efficiency prefilters and high-efficiency filters such as sand filters, fiberglass packs with deep bag polishing units, and HEPA (high-efficiency particulate air) filters.

Fresh air is drawn into the plant and conditioned by the air supply system and distributed to various zones occupied by personnel. Part of the air is directed from these zones into areas of greater potential for contamination but also accessible to personnel, and thence into process zones. Air from process area zones is removed through a ventilation exhaust and filtration system which discharges through a stack to the environment. Provisions may be made for alternative release points downstream of final exhaust air filters in the event that flow through a stack is blocked due to structural failure.

Part of the ventilation air for normally occupied zones may be recycled to the air supply system through recirculating air systems. Independent recirculating air systems may be used in selected areas of the plant having particular occupancy requirements such as control rooms or control areas that are designed to permit occupancy to operate the plant safely under normal conditions and to maintain the plant in a safe condition under accident or other abnormal conditions.

Ventilation systems will be subject to variations in operating temperatures and pressures and to environmental conditions associated with normal operation, maintenance, plant shutdown, and testing. They may also be subject to effects of natural phenomena such as seismic motion and floods and of missiles, fire, explosion, and other accidents.

The systems must continue to perform their safety functions effectively under all conditions by confining radioactive or other potentially dangerous materials. They should be designed to ensure that the concentration of radioactive materials in the effluent gases is as far below the limits specified in 10 CFR Part 20 as practicable.

The continuity of necessary ventilation can be ensured by means such as standby equipment and fail-safe control systems. The ability of the systems to perform their safety functions effectively can be ensured by periodic testing of safety-related components during normal operation of the systems to demonstrate their ability to perform at design efficiency and to verify availability for emergencies.

C. REGULATORY POSITION

Ventilation systems for a fuel reprocessing plant should ensure the confinement of hazardous materials during normal or abnormal conditions, including natural phenomena, fire, and explosion. The release of radioactive material to the environment or to an area in which levels of radioactivity are normally sufficiently low to permit personnel access should be reduced to a level as low as practicable in accordance with 10 CFR Part 20.

1. General Safety

a. Ventilation systems should be designed to confine radioactive materials as close to the point of origin as practicable and prevent uncontrolled release of radioactive aerosols, noxious fumes, and vapors into rooms and areas normally occupied by personnel.

b. Confinement of radioactive materials should be provided by multiple-zone confinement barriers and systems. Negative pressure differentials should be maintained between building confinement zones and also between the confinement zones and the outside atmosphere to ensure that air flow is from zones of lesser potential for contamination to zones of greater potential for contamination. Features of confinement barriers and systems, including pressure monitoring and alarm requirements, are discussed in Regulatory Guide 3.18.

c. Ventilation systems should be designed so that the failure of any one component (equipment or control device) will not affect the continuous operation of the ventilation systems. Ventilation systems and components should have fail-safe features with provision for alarm indication.

d. Onsite emergency power should be provided to operate the ventilation systems and components, including instruments and controls, important to safety. Ventilation systems should be capable of operating during normal power outage at capacities required to maintain confinement of contaminants. The onsite emergency power sources and the electrical distribution circuits should have independence and testability to ensure performance of their safety functions assuming a single failure.

e. The ventilation systems should be designed to withstand any credible fire and explosion and continue to act as confinement barriers. The ventilation systems should be constructed of fire-resistant materials of construction and should include fire-resistant filters, heat and smoke detectors, alarms, heat removal devices, fire-suppression equipment, and fire doors and dampers or other proven devices to restrict the spread of fires. The design of the fire protection system should include provisions to protect against adverse effects in the event of operation or failure of this system. For example, a drain system of critically safe geometry should be provided to prevent a criticality incident in the event of water discharge on activation of a water spray heat removal system or in the event of water leakage on failure of a heat removal system component such as a spray nozzle while the system is not in operation.

f. Ventilation systems should be capable of operating during a fire in the areas they ventilate and safely handle products of combustion through appropriate ventilation channels. A supply air system should remain operational; however, the option to discontinue air supply to the involved space or spaces should be maintained. Any system that may be shut down should be protected against backflow.

g. The materials of construction for the ventilation systems should be fire-resistant to protect against fires occurring inside or outside the systems. All filters should be of a fire-resistant type and, where applicable, listed by Underwriters' Laboratories (Ref. 1) or the Factory Mutual Research Corporation (Ref. 2). Filters and exhaust fans, especially a final filter plenum and exhaust fan enclosure, should be so located as not to be exposed to the direct effects of fire or explosion in the operating areas. Smoke and heat detectors listed by the Underwriters' Laboratories (Ref. 3) or the Factory Mutual Research Corporation (Ref. 2) should be provided in the ventilation systems.

h. Fire- and smoke-suppression equipment should be so located as to ensure that the integrity of final high-efficiency filters or filter systems is not degraded. Spark and flame arresters and isolation valves may be used at filter installations in intermediate stages of effluent cleaning. Where appropriate, a heat removal system should precede a high-efficiency filtration system serving as a final means of effluent cleaning (see regulatory position C.4.a(6)).

i. Normally, plant design and operating procedures should limit quantities of combustibles. Where sources of combustible solvents, gases, and vapors are identified or postulated to be present in a ventilation system under normal or abnormal conditions, suitable continuous monitoring systems should be employed. These monitoring systems should sound audible alarms and display visual alarm indications to operating personnel when the prescribed safe limits for combustible gas and vapor mixtures are reached. The monitoring and alarm system itself should not introduce an ignition source and should not affect the confinement integrity of the ventilation system. The monitoring and alarm system should be designed for in-place calibration and testing.

j. The ventilation systems should be designed to withstand tornado conditions without loss of confinement capability resulting from mechanical damage to the system or components or from the reduced ambient pressure at the intake and exhaust openings of the building. Protection against missiles should be provided for the intake and exhaust openings, as well as for any exposed (outdoor) ductwork or equipment between the intakes and exhaust filters.

k. Components of the ventilation systems should be designed to withstand the effects of earthquakes and remain functional to the extent that they will prevent the uncontrolled release of radioactive materials to the environment.

2. Occupied Area Ventilation Systems

a. Supply air should be properly conditioned and distributed, where practical, in a downward flow pattern to the potentially contaminated areas of the facility.

b. Outside makeup air supply units should be protected from the weather and should be so located as to minimize potential for intake of stack discharge gases. Inlets should be so arranged as to minimize the effects of high winds, rain, snow, ice, and debris on the operation of the system. Heaters may be necessary in areas where icing can cause significant supply filter damage. Trash screens or other proven devices should be provided over supply air inlets to protect air treatment equipment and filters from debris.

c. Where air from occupied areas is directed to contaminated or potentially contaminated areas, consideration should be given to passing this air through suitable filters to prevent backflow of particulate contaminants.

d. Part of the air in normally occupied areas may be recirculated to reduce thermal loads. Air containing noxious, toxic, or corrosive gases and vapors should not be recirculated. Recirculating air systems should be equipped with adequate air-cleaning equipment to ensure the maintenance of air quality in occupied areas. Provisions should be made for monitoring the recirculated air. Upon any indication that the limits for radioactivity in occupied areas specified in 10 CFR Part 20 or in the technical specifications have been reached, the air in the recirculating system should be diverted to the once-through exhaust ventilation system for discharge through a final filtration system.

e. Recirculating air systems independent of ventilation systems may be used in selected areas of the plant having particular occupancy requirements such as control rooms or control areas.

f. Air locks should be provided where frequent entry between personnel occupancy and limited access areas is necessary and where air flow must be maintained in one direction.

3. Process Area Ventilation Systems

a. Fire-resistant medium-efficiency prefilters should be used in process area ventilation systems to remove the bulk of particulate matter in the air streams and thus limit the loading of the high-efficiency filters installed in the exhaust air systems. Each prefilter should have an atmosphere dust spot efficiency rating (Ref. 4) of approximately 80% or better.

b. Where necessary, appropriate means and procedures should be provided in addition to the process offgas treatment systems (see Regulatory Guide 3.20) to protect final HEPA filter systems from exposure to wetting or deleterious chemical attack.

c. The ventilation systems should maintain minimum air velocities of 120 linear feet per minute (design velocity should be ∿150 linear feet per minute) through all process area openings such as fume hood doors and process cell covers to prevent significant reverse flow of contaminated air.

d. Air or inert gas should enter each ventilated glove box through at least one fire-resistant HEPA filter and be discharged through at least one fire-resistant HEPA filter to exhaust ductwork leading to a final filter system (see regulatory position C.4.a(6)). The inlet filter prevents any backflow of contaminants into the work areas, and the outlet filter minimizes contamination of the exhaust ductwork.

e. Consideration should be given to recirculation of exhaust air or inert gas in glove boxes to minimize release of radioactive particulates to the biosphere. If recirculation is used, the exhaust gas from these enclosures should be filtered through at least one fire-resistant HEPA filter before being recirculated.

f. The features described in regulatory position C.7 of Regulatory Guide 3.12, "General Design Guide for Ventilation Systems of Plutonium Processing and Fuel Fabrication Plants," addressed specifically to glove boxes for plutonium processing and fuel fabrication plants are also generally applicable to glove boxes for fuel reprocessing plants.

4. Exhaust Ventilation and Filtration Systems

a. HEPA Filter Systems

(1) Each exhaust filter housing should have a rigid mounting frame for the filter. The leakage of the complete housing structure should be as low as possible from outside to inside and zero from inside to outside or across the filter-sealing barrier (exclusive of the filter). The filter-sealing barrier should be made leaktight without resorting to sealing tapes or caulking.

(2) Where filter access openings in these housings are provided for filter removal, the configurations should permit filter removal and replacement with minimum exposure to personnel performing this task and with minimum release of contaminants outside of the housing.

(3) The filter housings should be equipped with necessary test ports to permit reliable in-place testing of all filter stages with dioctyl phthalate (DOP).

(4) The minimum instrumentation for each filter housing should include a device or multiple devices to indicate filter resistance and airflow rate.

(5) Where filter systems are designed for replacement, isolation valves should be so located that a bank of filters can be completely isolated from the ventilation systems during filter replacement operations.

(6) A heat removal system and a spark arrester should precede each HEPA filtration system serving as a final means of effluent cleaning. If a cooling spray such as a water spray system is used for heat removal, it should be followed by a combination spark arrester/moisture separator screen to also remove entrained droplets, thereby protecting filters from plugging and damage. A roughing filter and a wire mesh protective screen should be mounted behind these components to remove the bulk of any draft-carried debris and thus avoid loading the HEPA filters installed downstream.

The cooling spray system should operate automatically (with a manual override) when an abnormal heat rise in the cooling chamber inlet is indicated by detectors in exhaust ducts feeding the filter plenum. A manually operated valve actuating the spray system should also be provided as a backup. If a drain system is installed to prevent accumulation of liquid in the plenum, the collection tanks should be of critically safe geometry.

(7) The filtered air should be discharged to the environs through a stack of sufficient height to reduce close-in ground-level concentrations of radioactive or other potentially dangerous contaminants. Provisions should be made for an alternative release point in the event that flow through the stack is blocked because of structural failure.

(8) The stack should be located sufficiently distant from other facilities that structural failure would not result in damage to any process systems or structures important to safety.

(9) HEPA filters used in intermediate and final filtration systems should be designed to military specifications MIL-F-51068D (Ref. 5) and MIL-F-51079B (Ref. 6) and should satisfy the requirements of UL-586 (Ref. 7).

(10) HEPA filter systems should be tested after filter installation using a "cold DOP" test. Acceptance should be based on an efficiency of 99.95% or better for DOP having a light-scattering mean diameter of approximately 0.7 micron. Regular in-place testing of both on-line and standby filter installations should be performed because system deterioration can take place even when the installations are not being used. Test procedures used should comply with the recommendations contained in ORNL-NSIC-65, "Design, Construction and Testing of High-Efficiency Air Filtration Systems for Nuclear Application," (Ref. 8) and in Regulatory Guide 3.2, "Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles."

b. Other Filter Systems

(1) Final filtration systems incorporating high-efficiency filters other than HEPA filters, such as packed glass wool or packed sand units, should have equivalent efficiency and resistance to fire.

(2) Packed glass wool and packed sand filter systems should be tested prior to operation using a "hot DOP" test and provisions should be incorporated in the installations for periodic in-place "cold DOP" testing (see Regulatory Guide 3.2).

(3) HEPA filter systems used in combination with other filter systems should meet the recommendations of paragraph 4.a(10) above.

5. Fans

a. Installed spare fans and isolation dampers should be provided for the ventilation systems. When any one fan is inoperative in a system, a backflow damper should automatically isolate the idle fan from the system. Standby fans should automatically start and have sufficient capacity to maintain minimum system air flow.

b. Alarms should be provided in one or more continuously occupied control areas to indicate malfunction of each ventilation fan (see regulatory position C.6.f).

c. Supply air fans should be interlocked with an exhaust air plenum pressure sensor to prevent supply fan operation unless the exhaust fans are running. This will prevent pressurization of any potentially contaminated area should exhaust ventilation fail.

d. Emergency power should be supplied automatically to fans in the event of failure of the normal power supply (see regulatory position C.1.d).

6. Ventilation System Construction and Layout

a. The materials of construction for the ventilation systems should be carefully selected according to such safety considerations as strength to withstand accident conditions; corrosion resistance, particularly when associated with chemical processes; fire resistance; long operating life to avoid frequent replacement of contaminated equipment; and smooth surface finish to aid in decontamination.

b. Ducts and housings should be designed, fabricated, and erected with a minimum of ledges, protrusions, and crevices that can collect dust and moisture or that could impede personnel or create a hazard in performance of their work. Duct runs and flow distributors should ensure uniform, representative air flow past monitoring and sampling stations as well as through filter installations.

c. The design and construction should provide for convenient inspection, maintenance, decontamination, and replacement of critical components such as filters, fans, and system controls.

d. Housings, filter mounting frames, and ducts should be designed to withstand system pressure changes without distortion, vibration, fatigue, or yielding of such magnitude that inleakage or bypassing of the filters results.

e. Supply, recirculation, and exhaust ducting should incorporate manual and automatic dampers and controls to distribute and regulate the movement of air in each room, area, and ventilation system and to prevent possible backflow in case of pressure reversal.

f. The ventilation systems should be appropriately instrumented to read out and alarm in one or more continuously occupied control areas. These areas should be designed to permit occupancy and to permit actions to be taken to operate the ventilation systems safely during normal or abnormal conditions.

7. Ventilation System Testing and Monitoring

a. Provisions should be made so that components of ventilation systems can be tested periodically for operability and required functional performance. They should include capability for periodic measurement of air flows in exhaust ducts and in or at equipment, hoods, and glove boxes.

b. The capability should be provided to test, under conditions as close to design as practicable, the operating sequence that would bring ventilation systems into action, including the transfer to alternative power sources, and the capability for delivering design air flow. Regulatory Guide 3.22, "Periodic Testing of Fuel Reprocessing Plant Protection System Actuation Functions," provides information relative to periodic testing of protection system actuation functions.

c. Exhaust ducts and stacks that may contain radioactive contaminants should be provided with a fixed sampler and a continuous monitor [Continuous Air Monitoring System (CAMS)] that provides a record of plant effluents. The probes for sampling purposes should be designed for isokinetic sampling and located to obtain representative samples. Each monitoring system should be connected to an emergency power supply (see regulatory position C.1.d). The continuous stack sampler should alert cognizant personnel in continuously occupied control rooms or areas through an audible and visual annunciator if the airborne radioactive effluents reach prescribed limits. Features of sampling and monitoring equipment for process offgases are discussed in Regulatory Guide 3.20.

d. Air-monitoring and warning systems (including CAMS) should be installed in areas where radioactive material is handled. Air-sampling heads should provide a representative sample of the potential airborne radioactivity being breathed. Consideration should be given to locating continuously operating exhaust samplers after each stage of high-efficiency filtration or, as a minimum, providing special connections to allow probes to be inserted for sampling.

8. **Quality Assurance Program**

a. A quality assurance program should be established for the design, construction, testing, operation, and maintenance of all structures, systems, and components addressed in this guide in accordance with the criteria in Appendix B to 10 CFR Part 50. Regulatory Guides 3.3, "Quality Assurance Program Requirements for Fuel Reprocessing Plants and for Plutonium Processing and Fuel Fabrication Plants," and 3.21, "Quality Assurance Requirements for Protective Coatings Applied to Fuel Reprocessing and to Plutonium Processing and Fuel Fabrication Plants," describe, respectively, acceptable methods of complying with Appendix B with regard to overall program requirements and to requirements for protective coatings.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for utilizing this regulatory guide.

Except in those cases in which the applicant proposes to use an acceptable alternative method for complying with specific portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals for construction permit or operating license applications docketed after May 31, 1976.

If an applicant wishes to use this regulatory guide in developing submittals for an application docketed prior to May 31, 1976, the pertinent portions of the application will be evaluated on the basis of this guide.

REFERENCES

1. Underwriters' Laboratories Building Materials List (latest edition). Copies may be obtained from Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Illinois 60611.

2. Factory Mutual Approval Guide (latest edition). Copies may be obtained from Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, Massachusetts 02062.

3. Underwriters' Laboratories Fire Protection Equipment List (latest edition). Copies may be obtained from Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Illinois 60611.

4. ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 52-68, "Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter," Section 9. Copies may be obtained from American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., United Engineering Center, 345 East 47th Street, New York, New York 10017.

5. MIL-F-51068D, "Filter, Particulate, High-Efficiency, Fire-Resistant," Military Specification. Copies may be obtained from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6. MIL-F-51079B, "Filter Medium, Fire-Resistant, High-Efficiency," Military Specification. Copies may be obtained from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

7. Underwriters' Laboratories Standard UL-586, "High-Efficiency Air Filtration Units," (also designated ANSI B132.1-1971). Copies may be obtained from Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Illinois 60611.

8. C. A. Burchsted and A. B. Fuller, "Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Application," ORNL-NSIC-65, Oak Ridge National Laboratory, January 1970. Copies may be obtained from National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22151.

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