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Emission Control Technology and Quality Assurance Needs at Uranium Milling Facilities

Includes Supporting Methods for Testing, Operating, and Maintaining Air Pollution Control Devices

Prepared by J. D. Ludwick

Pacific Northwest Laboratory
Operated by
Battelle Memorial Institute

Prepared for
U.S. Nuclear Regulatory Commission

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ABSTRACT

Pacific Northwest Laboratory, under contract to the U.S. Nuclear Regulatory Commission, conducted an investigation of particulate emission control devices for application to process exhausts at uranium milling facilities. The scope of this investigation included devices now in use, as well as those devices that have potential application for milling sites. This report presents the results of the study. Emission control devices are categorized and described, including high-efficiency and moderate-efficiency devices as well as other (some novel) devices useful in specific situations. Preoperational considerations discussed include selecting devices, instrumentation, and testing programs. Operational and maintenance considerations related to dry and wet removal processes are described. Quality assurance documents and topics are also discussed.

SUMMARY

This study identifies methods for reducing airborne particulate pollutants from processes utilized in the uranium milling industry. The purpose of this study is: 1) to provide information on the available technology and the procedures for its use so as to provide a safe working environment, and 2) to provide background information for use in the development of regulations pertaining to uranium milling operations and also for the designers and licensees of their facilities.

Regulations require uranium mill operators to limit radioactive material releases from all plant processes. Air pollution control devices are installed at uranium mills to limit radioactive releases to the environment.

The environmental impact from the proposed uranium milling operations are based on calculations by the NRC of the estimated rate of particulate production adjusted to reflect the removal efficiency of the air pollution control devices installed on each process. General information concerning the efficiency of various types of air pollution control devices is presented in this report to provide operators with background information for selection of equipment that is appropriate to reduce air particulates generated at their facilities.

The overall effectiveness of these devices is dependent upon a number of parameters in addition to the fundamental efficiency of these devices for removing particulates. Those parameters include the testing, operation, and maintenance of these devices and the implementation of a documented program to ensure that factors affecting quality are addressed.

The following seven methods to control the release of particulate materials are in general use at uranium milling facilities and throughout industry.

Very-High-Efficiency Techniques. Air flow is directed from areas of lower potential contamination to areas of greater potential contamination by maintenance of a pressure differential across control devices such as filters.

- high-efficiency particulate air (HEPA) filters
- deep-bed sand filters
- deep-bed glass fiber filters

Moderate-Efficiency Techniques for Emission Control of Airborne Particulate Materials. This group of air filtration devices is the most widely used for general industrial applications. They utilize a number of filtration techniques.

- wet collectors
- fabric collectors (baghouses)
- inertial devices (cyclones)
- electrostatic precipitators.

Additional Techniques for Control of Airborne Particulates

Novel and advanced techniques are useful to control airborne particulates from process exhaust streams. Their potential application to uranium milling operations is dependent upon the individual circumstances at each process exhaust. These include:

- electrofluidized bed
- TRU charged droplet scrubber
- University of Washington electrostatic scrubber
- wet-wall electroinertial unit air cleaner
- fluid electrode precipitator
- electrostatic fiber-bed filter
- sintered metal filters
- submerged gravel scrubber
- high-temperature aerosol filtration with deep-bed filters.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

This report contains the results of a study, conducted by Pacific Northwest Laboratory (PNL)[a] and sponsored by the U.S. Nuclear Regulatory Commission (NRC), to delineate particulate air filtration devices for uranium milling operations and for their testing, operation, and maintenance including a supporting quality assurance program.

Information derived from this study is intended for use as background data and bases for the development of new regulations pertaining to uranium milling operations. It is also intended to be useful to uranium mill owners and operators for planning and implementing air pollution control programs.

Release of waste materials to the atmosphere from uranium milling operations must be controlled in order to protect the public health and safety. NRC regulations (and state regulations in Agreement States) require uranium mill operators to limit the amount of radioactive material that is released into unrestricted areas and to make every reasonable effort to keep radiation exposure and the release of radioactive materials as far below the limits specified as reasonably achievable. Regulations applicable to uranium milling are contained in 10 CFR Part 20, "Standards for Protection Against Radiation." These regulations include the need for the licensee to comply with provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," Subpart B, which states, "Operations covered by this subpart shall be conducted in such a manner as to provide reasonable assurance that . . . the annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from those operations." Air in the immediate vicinity (restricted area) of such operations as uranium ore crushing and grinding and yellowcake drying and packaging frequently contains such materials in excess of the amount permissible for release to unrestricted areas.

Air pollution control devices are installed at mills to limit releases of radioactive materials to the environment. Before mill startup, the licensee submits information to the NRC concerning designed effectiveness of such devices (Regulatory Guide 3.5, "Standard Format and Content of License Applications for Uranium Mills") in order for the NRC staff to estimate maximum potential annual radiation dose to the public resulting from radioactive materials that are not removed by these devices. To confirm that design characteristics of the air pollution control devices are met in construction and to ensure that their pollutant removal efficiency is maintained during operation, certain procedures are necessary. Such procedures, in general use in the air pollution control industry, are presented in this report.

(a) Operated for the U.S. Department of Energy by Battelle Memorial Institute.

This report also describes the scope of a number of quality assurance programs to provide adequate assurance that structures, systems, components and procedures used for air pollution control will satisfactorily perform all functions important to safety. Present NRC regulations address the need for quality assurance for certain facilities. These are found in 10 CFR Part 20, Section 20.1, which states, "every reasonable effort should be made by NRC licensees to maintain radiation exposure, and releases of radioactive materials in effluents to unrestricted areas, as far below the limits specified," etc.

Milling of uranium ore results in the production of considerable amounts of airborne particulates from mechanical operations. In the ore handling areas, particulates arise from crushing, grinding and sizing operations. The highly concentrated yellowcake uranium product can also become airborne as particulate matter, especially during drying and packaging operations. Radioactive particulate materials of concern include natural uranium, thorium-230, radium-226 and lead-210. This report addresses airborne particulate emissions from all the described operations, although airborne particulates from the yellowcake operations are of greater concern to safety.

1.1 PREOPERATIONAL ESTIMATES OF RADIATION EXPOSURE

An applicant for a new license or renewal of an existing license for a uranium mill is required to provide detailed information on the proposed equipment, facilities and procedures at the installation. These regulations are delineated in 10 CFR Part 40.32, "General Requirements for Issuance of Specific Licenses." This information is used by the NRC to determine whether the applicant's proposed equipment, facilities and procedures are adequate to protect the health and safety of the public and whether the activities will significantly affect the quality of the environment. A license application will be approved if, among other things, "after weighing the environmental, economic, technical and other benefits against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values."

Calculations by the NRC of the environmental impact from the proposed uranium milling operations are based on the estimated rate of particulate production adjusted to reflect the removal efficiency of the air pollution control devices installed on each process. General information concerning the efficiency of various types of air pollution control devices is presented in this report to provide operators with background information for selection of equipment that is appropriate to reduce air particulates generated at their facilities. More specific information is available provided the equipment, or identical models thereof, is tested subsequent to manufacture by acceptable methods and in a manner which provides assurance that factors influencing quality are addressed.

1.2 OPERATIONAL ESTIMATES OF RADIATION EXPOSURE

"Effluent Monitoring Reporting Requirements" of 10 CFR Part 40 require mill operators to submit semiannual reports to the NRC specifying the quantity of each of the principal radionuclides released to unrestricted areas in

gaseous effluents. This information is used by the NRC to estimate maximum potential annual radiation doses to the public resulting from effluent releases. Mill operators estimate the quantity of the radionuclides released based on a combination of three factors, including:

1. Scheduling the sampling of effluent releases to the environment from points of release downstream of the air pollution control devices;

2. Assumption of normal uniform operation for the control device over the reporting time interval; and

3. Measurement of the total effluent flow rate (considering the time of control device operation and the amount of product produced).

Routine exhaust stack flow rate measurements provide the information needed to estimate the total volume of emissions released to unrestricted areas (i.e., factor 3). Determination of factor 1 requires the scheduled application of appropriate air sampling techniques to the effluent air; however, factor 2 is an assumption.

Confidence in maintaining normal uniform operation can be gained by instituting a documented program that includes the proper testing, operating and maintenance of the air pollution control devices. This will provide more reliable data for use by the NRC staff to make accurate estimates of radiation exposure.

The operating conditions of the control device and the operating parameters in use determine its effectiveness or efficiency. To maintain air pollution control efficiencies at their reasonably expected best performance levels, a program is needed which includes maintenance and inspections to prevent condition deterioration and which delineates acceptable operating parameter ranges. Such a program will help to reduce emissions as far below the limits as reasonably achievable as well as to improve the quality and reliability of the emission data.

2.0 PARTICULATE CONTROL TECHNOLOGY

In this section, technologies available to control the emissions of particulate matter into the atmosphere are discussed, including those technologies currently in use at uranium milling facilities and those that could be used. Also discussed are some novel particulate control technologies that are undergoing research and development.

2.1 VERY-HIGH-EFFICIENCY TECHNIQUES FOR EMISSION CONTROL OF AIRBORNE PARTICULATE MATERIALS

The basic philosophy for controlling the emission of airborne particulate material is directional air flow coupled with a control technology (predominantly filtration). Air flow is directed from areas of lower potential contamination to areas of greater potential contamination by the maintenance of a pressure differential between the areas. The lowest pressures are maintained at the locations of the greatest potential contamination. Air is exhausted from the facility at these locations through control devices such as filters. Other control devices may also be used on various pieces of equipment or for various areas that possess known potential for the generation of airborne particulate material. Control devices for these purposes are selected for the local conditions and span the range of conventional and nonconventional devices. The exhaust from these devices is combined with the general facility exhaust and passed through the facility airborne particulate control technology. In all cases addressed here, the control technology used is a form of filtration.

2.1.1 High-Efficiency Particulate Air (HEPA) Filters

A HEPA filter is a throwaway, extended-medium, dry-type filter having: 1) a minimum particle removal efficiency of greater than 99.97% for 0.3-μm particles, 2) a maximum resistance, when clean, of 250 Pa (1 inch H_2O) when operated at rated air flow capacity, and 3) a rigid casing extending the full depth of the medium (see Figure 2.1).[1]

Collection efficiency can be a function of particle size and nominal air velocity (see Figures 2.2 and 2.3). A review paper[1] presents an excellent compendium of the essential information on the construction and testing of certain air-cleaning systems (including those using HEPA, deep-bed sand, and deep-bed glass fiber).

Control of airborne particulate emission has been the theme of a biennial meeting of the nuclear industry in which filtration has been one of the major topics for over three decades.[2-9] In the sixteenth of these conferences, a review[10] of some significant developments in high-efficiency filtration for nuclear application was presented and included these observations:

- Although intended as standards for the construction and testing of engineered safety systems for U.S. licensed nuclear power stations, ANSI N 509-1980, "Nuclear Power Plant Air Cleaning Units and Components,"[11] and ANSI N 510-1980, "Testing of Nuclear Air

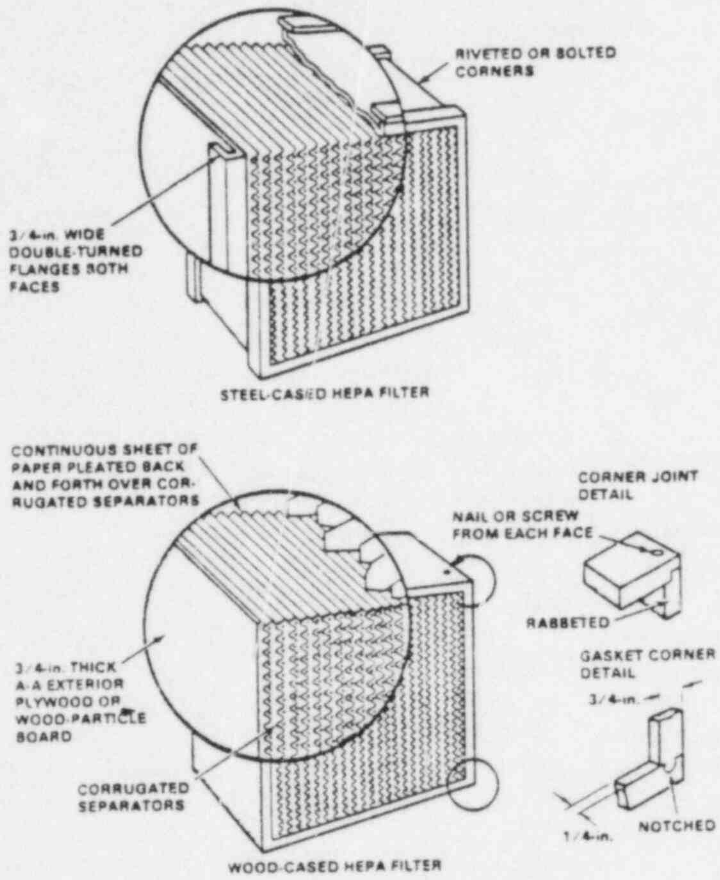


FIGURE 2.1. Construction of Open-Face HEPA Filter Units[1]

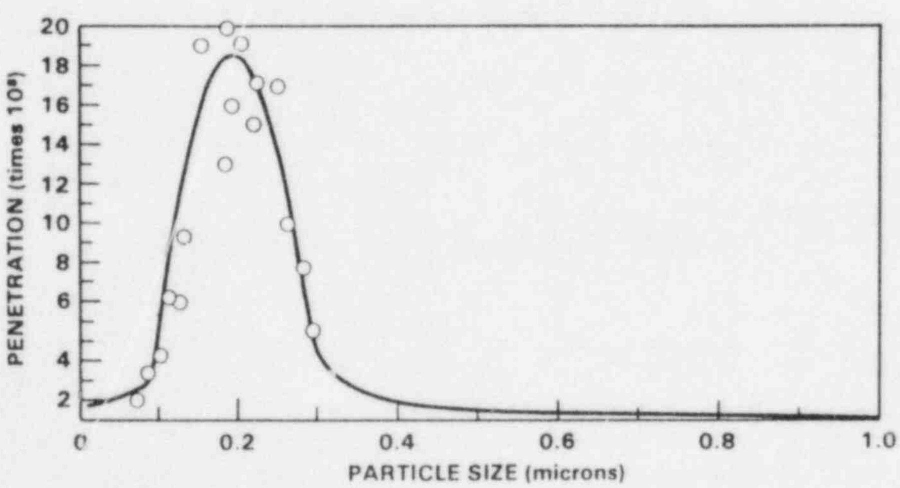


FIGURE 2.2. HEPA Filter Penetration for Monodispersed Particles[12]

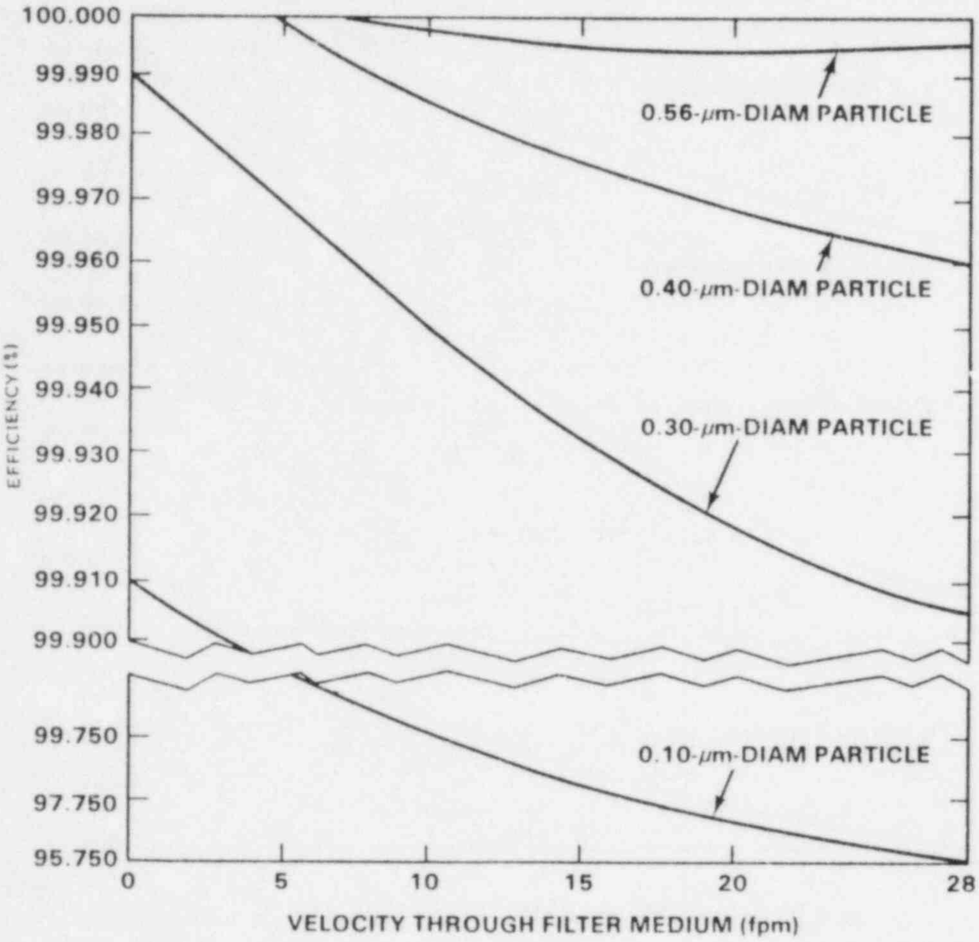


FIGURE 2.3. HEPA Filter Efficiency Versus Flow Rate(1)

Cleaning Systems,"(13) can be and usually are applied to air cleaning systems in a wide range of facilities.

- Gains in understanding basic filtration mechanisms have been modest; with improvements achieved primarily from experimentation.(12-16) Much remains to be done in this area.

- Research continues in many areas - testing methods, reliability under severe stresses, construction techniques to improve filter performance, etc.

- Filter manufacturers have improved construction that has resulted in filters exceeding the required particle retention efficiency of 99.97% by an order of magnitude while improving resistance to chemicals, flames, elevated temperature, and radiation.

Due to their size and cost, HEPA filters have the flexibility to fit into many arrangements. Small increases in the volume of exhaust processed can

often be handled by simply increasing the number of filters and size of fans. If increased particle removal capability is required, exhausts can be passed sequentially through HEPA filters.

2.1.2 Deep-Bed Sand Filters

Deep-bed sand filters have been used as air-cleaning devices for over 30 years.[1] Major advantages of such filters include: large capacity, low maintenance requirements, high heat capacity, fire resistance, and the ability to withstand shock loadings and large changes in air stream pressure. Major disadvantages include: high capital cost; large area; high pressure drop and power cost; uncertainty in selection, availability, and grading of suitable sand; and disposal of spent units.

Figure 2.4 is an example of a larger deep-bed sand filter. The area is 31 m (103 ft) by 43 m (140 ft) and consists of layers of rock, gravel, and sand to a depth of 2.3 m (7.5 ft). Composition and depth of each layer is shown in the figure. Design flow of the one illustrated is 35 m^3/s (74,000 cfm)[17]; however, smaller units are in general use. Collection efficiency for dioctyl pthalate (DOP) particulates (Figure 2.5) is on the same order as HEPA filtration.

2.1.3 Deep-Bed Glass Fiber (DBGF) Filters

Another technology for the control of airborne particulate materials is DBGF filters. A good source of information on the subject is available.[1] As an alternative to deep-bed sand filters, DBGF filters have the following advantages: more predictable physical characteristics, larger air flow per unit volume at lower pressure drop, lower operating costs, and potentially lower spent unit disposal costs. Their disadvantages compared to sand are: lower particle collection efficiency, less resistance to corrosion and fire, lack of heat capacity and self-healing characteristics, and lack of resistance to shock and high-pressure transient.

Table 2.1 gives the calculated particle removal efficiencies for DBGF filters and Figure 2.6 shows the pressure drop for various loadings of a smoke simulant.[18]

2.2 MODERATE-EFFICIENCY TECHNIQUES FOR EMISSION CONTROL OF AIRBORNE PARTICULATE MATERIALS

There are a number of conventional devices with moderate filtration efficiency for the control of airborne particulate material that are in general use throughout industrial facilities. A general description of each type of device (wet collector, baghouse, cyclone, and electrostatic precipitator) is presented in the following subsections, with references to more detailed information. A summary and comparison of the device characteristics is presented in Table 2.2.

LAYER	DEPTH, in.	SPECIFICATIONS
A	12	1-1/4-in. TO 3-in. GRAVEL
B	12	5/8-in. TO 1-1/2-in. GRAVEL
C	12	1/4-in. TO 5/8-in. GRAVEL
D	6	#8 TO 1/4-in. SAND
E	12	#20 TO #8 SAND
F	36	#50 TO #30 SAND

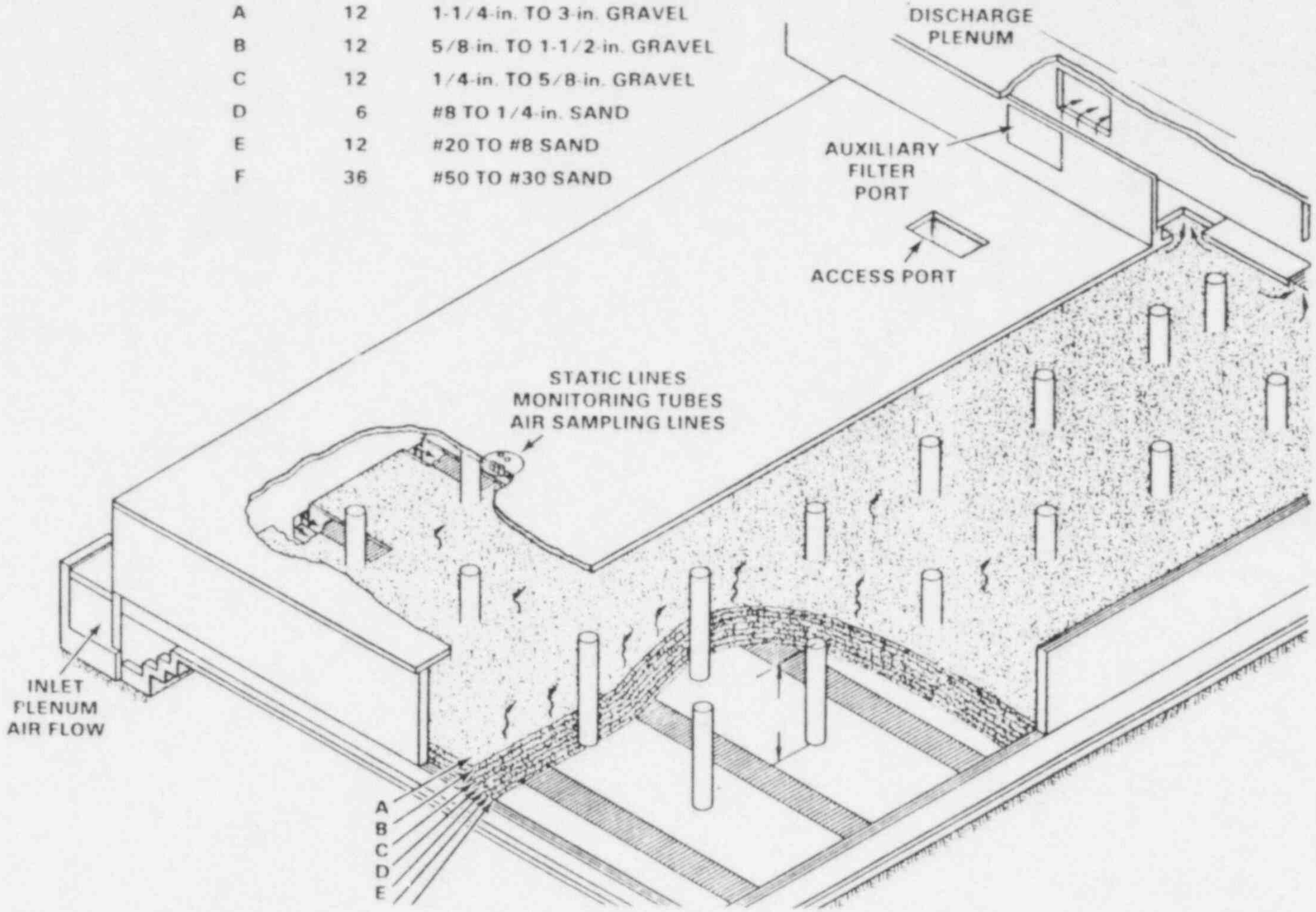


FIGURE 2.4. Isometric of Sand Filter

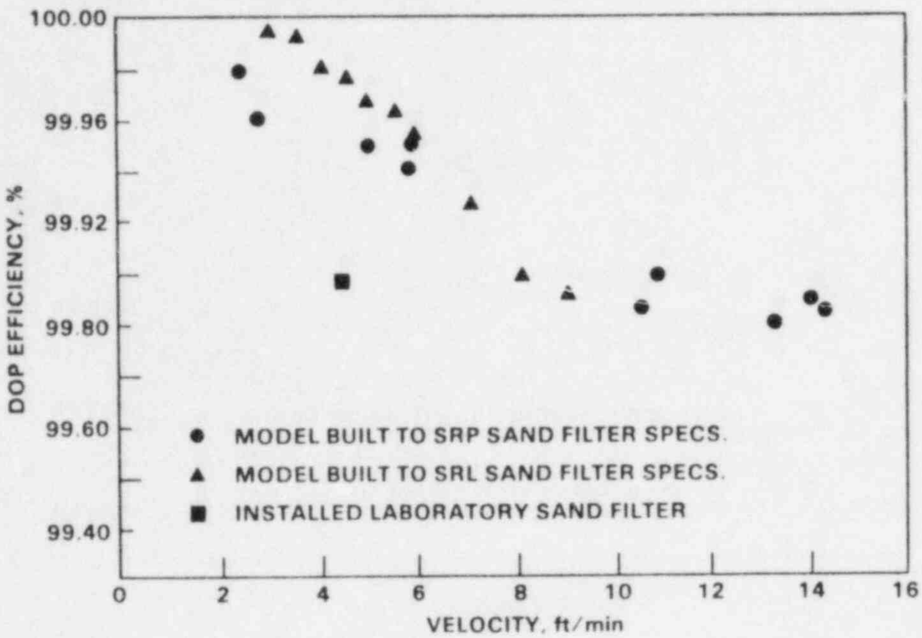


FIGURE 2.5. Sand Filter Efficiency Versus Velocity(16)

TABLE 2.1. Particle Collection Efficiencies for DBGF Filters; Dioctyl Pnthalate (DOP) Test(17)

Flow, m^3/min	Total ΔP, Pa	Efficiency, % Total
0.76	340	99.95
1.42	750	99.94
3.68	1250	99.92

2.2.1 Wet Collectors

There are more types of wet collectors than any other of the conventional airborne particulate material control devices covered here. The devices range from simple scrubbers (i.e., spray towers), wet centrifugal scrubbers, and wet dynamic precipitators, to orifice and venturi-type scrubbers.(19,20) Packed towers are another type of wet collection device that could be included in this group; but are more suitable as contact beds for gas, vapor or mist removal. Schematics of the wet collection devices are shown in Figures 2.7 and 2.8. Wet collectors can handle high-temperature and moisture-laden exhausts and, as in packed towers, can offer some level of gas, vapor or mist removal. Wet collectors can show a wide range of performance. For well designed collectors, efficiency depends on energy inputs and is independent of operating principle.

One type of device found in many air-cleaning systems upstream of filtration devices is entrainment separators, or demisters. Many are similar to packed beds and, although not considered airborne particulate material control

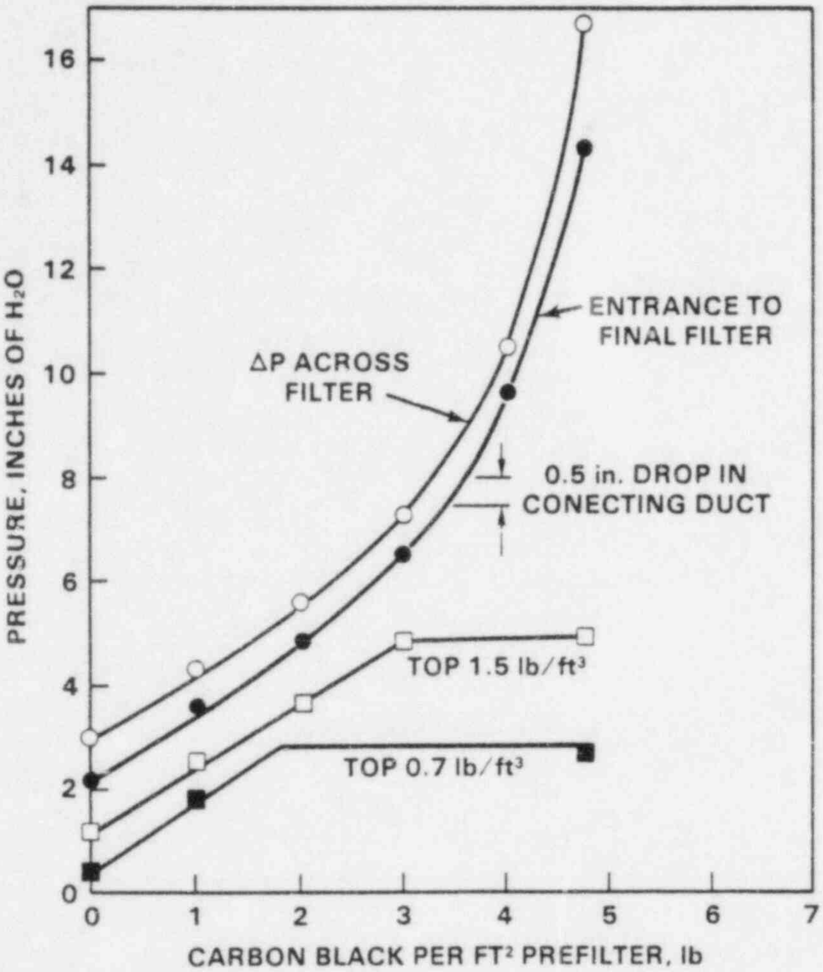


FIGURE 2.6. Pressure Versus Pounds of Carbon Black ("Fiberglas" filter smoke simulation)[18]

devices, their function is to remove particulate material. One study[21] was found that measured the removal efficiency of two types of demisters. These efficiencies are shown in Figure 2.9.

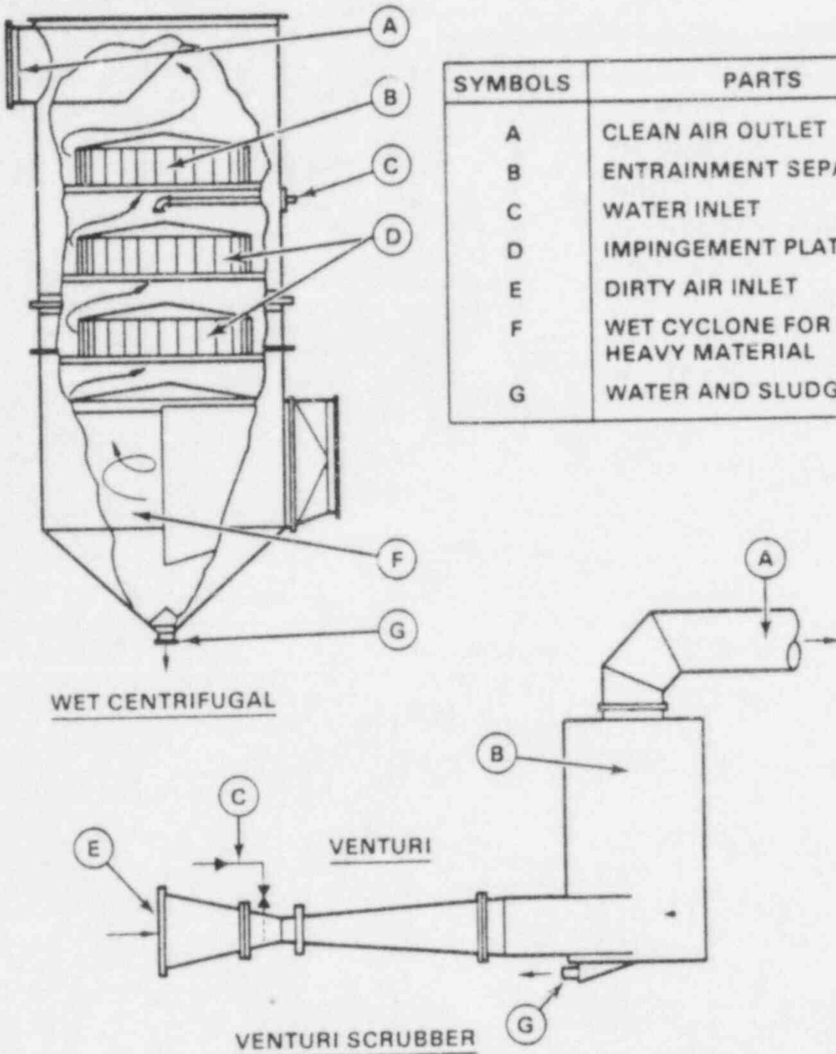
2.2.2 Fabric Collectors (Baghouses)

Fabric arresters are high-efficiency (see Figures 2.10 and 2.11), medium-cost collectors.[19] The fabric is arranged in envelope or tubular (stocking) shapes and the entire arrangement is called a baghouse. Several such arrangements are shown in Figure 2.12. The filtering process, especially for submicron particles, is not simple sieving but is obtained by the buildup of a mat of material on the inlet side of the fabric initially by interception, impingement, diffusion, and electrostatic attraction.[19,20] As dust is collected on the fabric, resistance to flow increases and the fabric must periodically be

TABLE 2.2. Comparison of Some Important Dust Collector Characteristics[19]

Type	Higher Efficiency Range on Particles Greater than Mean Size, m	Pressure Loss, in.	Water Usage, gal/1,000 cfm	Space	Sensitivity to Flow Change: Pressure	Sensitivity to Flow Change: Efficiency	Humid Air Influence	Max. Temp., (°F) Standard Construction(a)
Electrostatic	0.25	1/2	-	Large	Negligible	Yes	Improves Efficiency	500
Fabric:								
Conventional	0.25	3-6	-	Large	As cfm	Negligible	May make Recondi-tioning difficult	180 (b)
Reverse jet	0.25	3-8	-	Moderate	As cfm	Negligible		180
Glass, reverse flow	0.25	3-8	-	Large	As cfm	Yes		
Wet:								
Packed tower	1-5	1.5-3.5	5-10	Large	As cfm	Yes		
Wet centrifugal	1-5	2.5-6	3-5	Moderate	As $(cfm)^2$	Yes		
Wet dynamic	1-2	(c)	0.5 to 1	Small	(c)	No	None	Unlimited
Orifice types	1-5	2.5-6	10-40	Small	As cfm or less	Varies with design		
Higher efficiency:								
Fog tower	0.5-5	2-4	5-10	Moderate	As $(cfm)^2$	Slightly	None	(d)
Venturi	0.5-2	10-100	5-15	Moderate	As $(cfm)^2$	Yes		Unlimited
Dry centrifugal:								
Low-pressure cyclone	20-40	0.75-1.5	-	Large	As $(cfm)^2$	Yes		750
High-efficiency centrifugal	10-30	3-6	-	Moderate	As $(cfm)^2$	Yes	May cause condensation and plugging	750
Dry dynamic	10-20	Note 2	-	Small	Note 2	No		750

(a) See National Fire Prevention Agency (NFPA) requirements for fire hazards; i.e., zirconium, magnesium, aluminum, wood working, etc.
(b) 180°F based on cotton fabric. Synthetic fabrics may be used to 275°F.
(c) A function of the mechanical efficiency of these combined exhausters and dust collectors.
(d) Precooling of high-temperature gases will be necessary to prevent rapid evaporation of fine droplets.



SYMBOLS	PARTS
A	CLEAN AIR OUTLET
B	ENTRAINMENT SEPARATOR
C	WATER INLET
D	IMPINGEMENT PLATES
E	DIRTY AIR INLET
F	WET CYCLONE FOR COLLECTING HEAVY MATERIAL
G	WATER AND SLUDGE DRAIN

FIGURE 2.7. Venturi-Type Dust Collector(19)

reconditioned by shaking, vibrating, or reverse-jet or reverse-flow collapse. Reconditioning techniques form subclassification groups in fabric collectors. Woven cotton or wool is frequently used, although a wide range of materials (including fine metallic mesh) is possible. Readers are referred to Reference 19 for an overview of the topic, to Reference 20 for a thorough engineering treatment and to References 21 and 22 for more recent developments.

2.2.3 Inertial Devices (Cyclones)

The use of centrifugal force to throw a dust particle to the periphery of an air stream has been used in cyclone and other types of inertial collectors for many years.(19) These types of devices are most suitable for medium to coarse particles (see Table 2.2 and Figure 2.11). Inertial collectors can be classified into two groups (high and low) based upon their particle removal

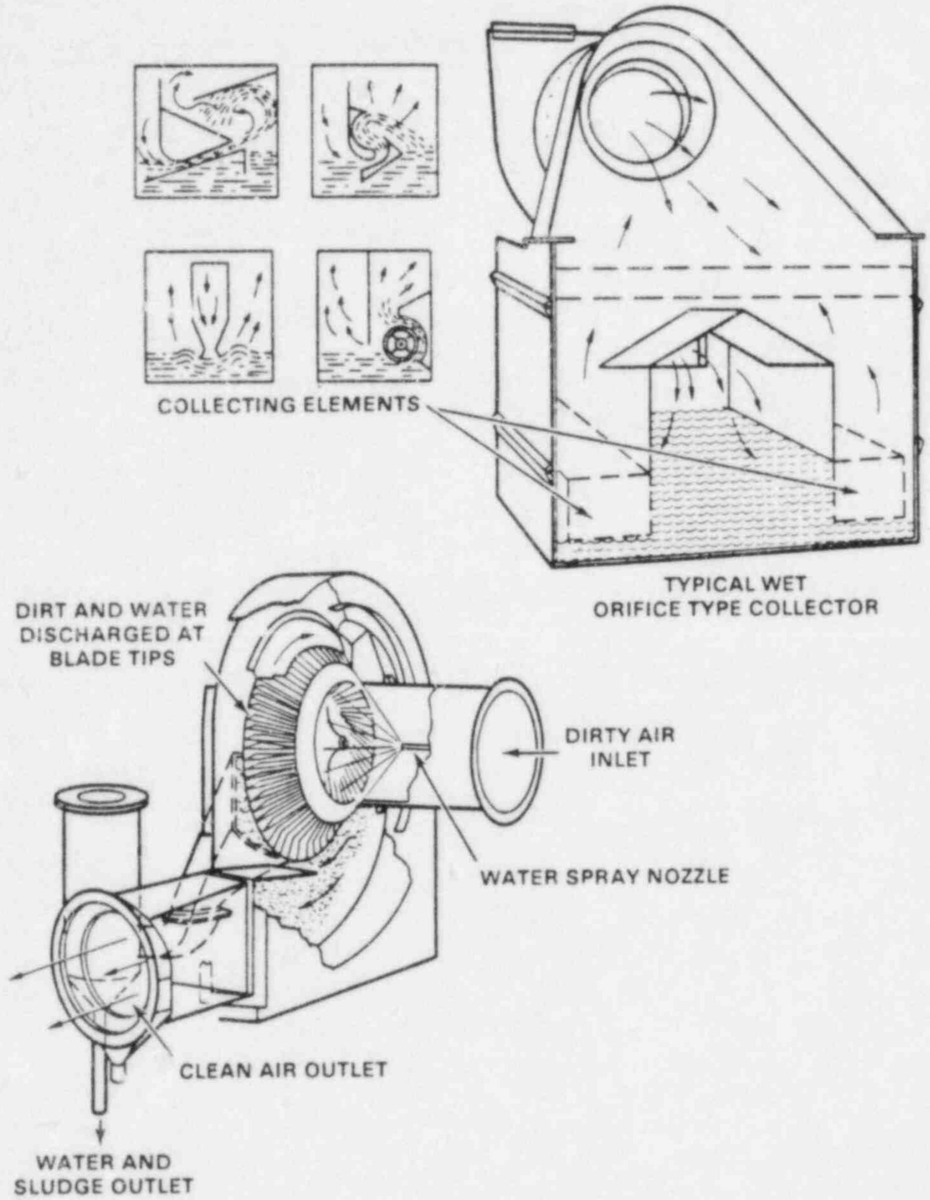


FIGURE 2.8. Orifice-Type Dust Collector[19]

efficiency, especially for particles 10 μm and less. Figure 2.13 is a schematic of various representative inertial devices. The low-pressure cyclone often acts as a precleaner for high-efficiency devices. Higher efficiencies are obtained by increasing peripheral velocities or angular acceleration. High-efficiency centrifugals use several techniques to achieve these ends, while the dry-type dynamic precipitator uses specially shaped blades on the exhauster wheel. Readers are directed to References 19 and 20 for more detailed information.

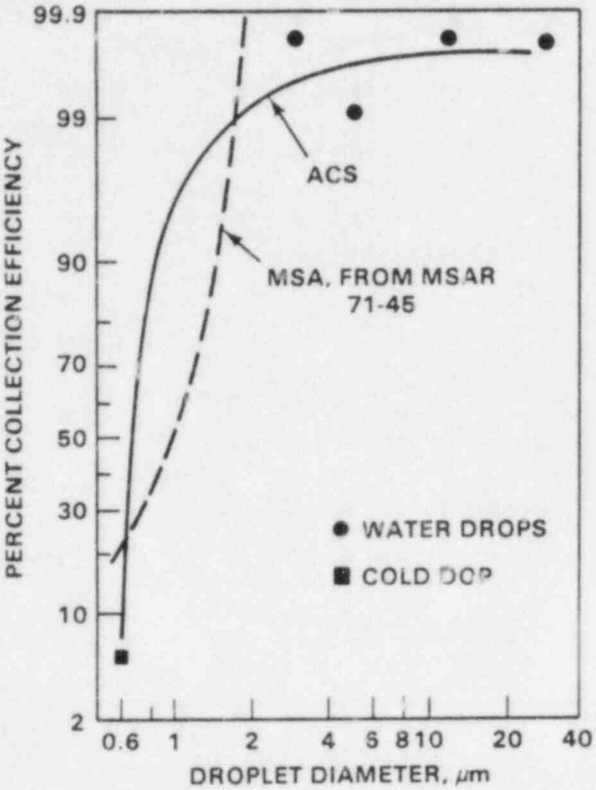


FIGURE 2.9. Percent Collection Efficiency Versus Droplet Diameter, MSA and ACS Entrainment Separators[23]

2.2.4 Electrostatic Precipitators

The high-voltage electrostatic precipitator (ESP) is the predominant industrial, high-efficiency, high-cost device for the control of airborne particulate material.[19] Figure 2.14 is a schematic of an ESP. The principal of collection relies on the ability to impart a negative charge to particles in the gas stream, causing them to move and adhere to the grounded or positively charged collector plates. Most precipitators are made for horizontal air flows with velocities of 100 to 600 ft/min. Voltage difference between electrode and plate is generally 60,000 to 75,000 volts. Removal of the collected material is obtained by rapping or vibrating the element continuously or at predetermined intervals.[19] Some advantages of ESP[20] are: high removal efficiencies (in excess of 99%); efficiency is a function of particle size and type of ESP (see Figures 2.10 and 2.11); there is no theoretical lower limit for a size of particle that can be collected; pressure and temperature drops through ESPs are small (ΔP seldom exceeds 125 Pa); has few moving parts and can operate continuously with little maintenance; can handle large exhaust flows; and power requirements can be low. Some of the drawbacks of ESPs[20] are: initial costs are high (see References 19 and 24 for further discussion of costs); they cannot be used for all airborne particles (extremely high or low resistivity or

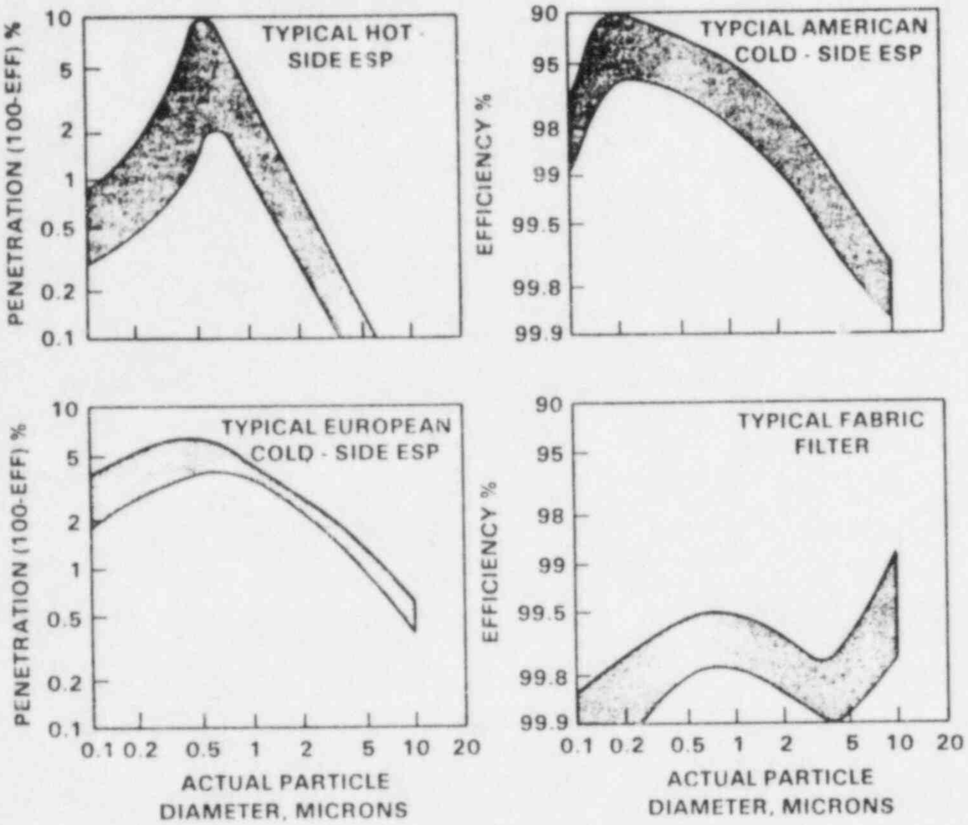


FIGURE 2.10. Typical Fractional Efficiencies for Existing Collectors(24)

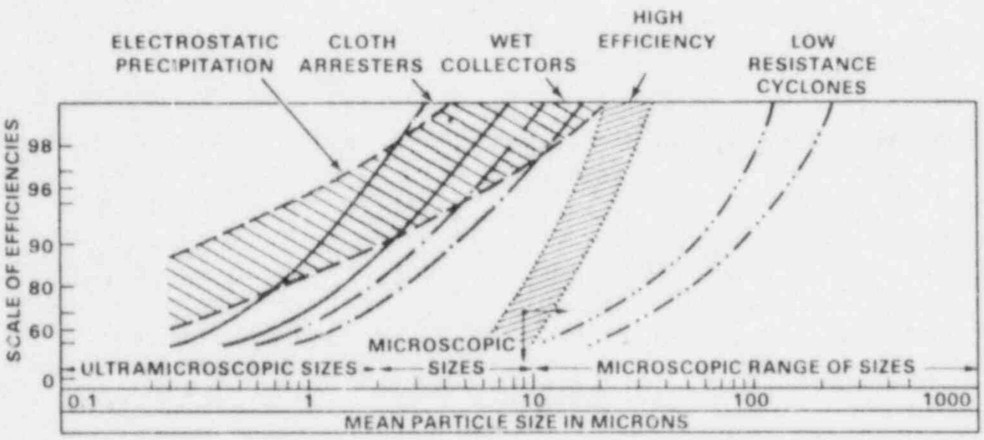


FIGURE 2.11. Range of Particulate Collection Efficiencies for Typical Filtration Devices(19)

other causes make them difficult to collect); space requirements can be high; and special precautions are required to safeguard personnel from the high voltage.

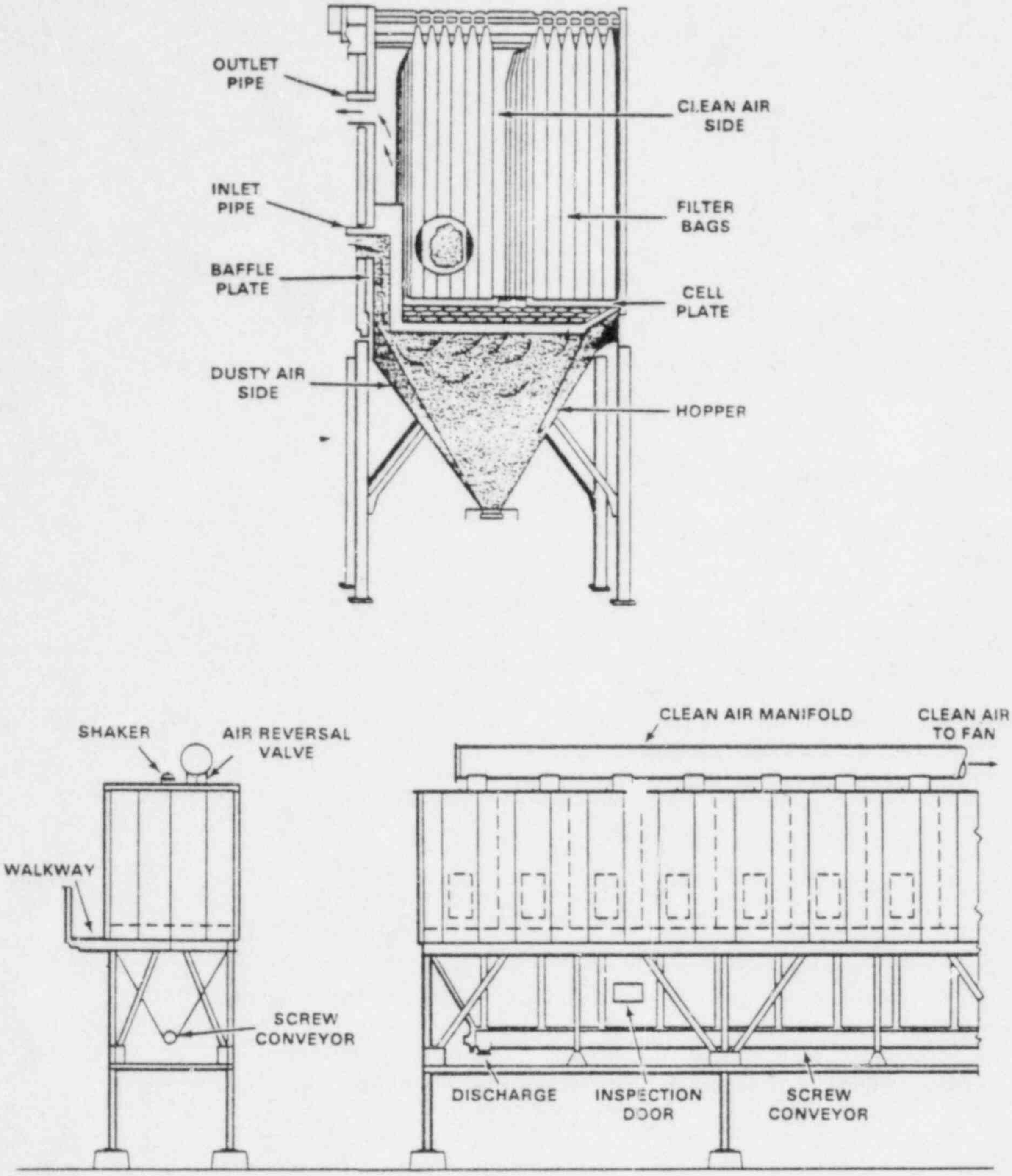


FIGURE 2.12. Fabric Collectors(20)

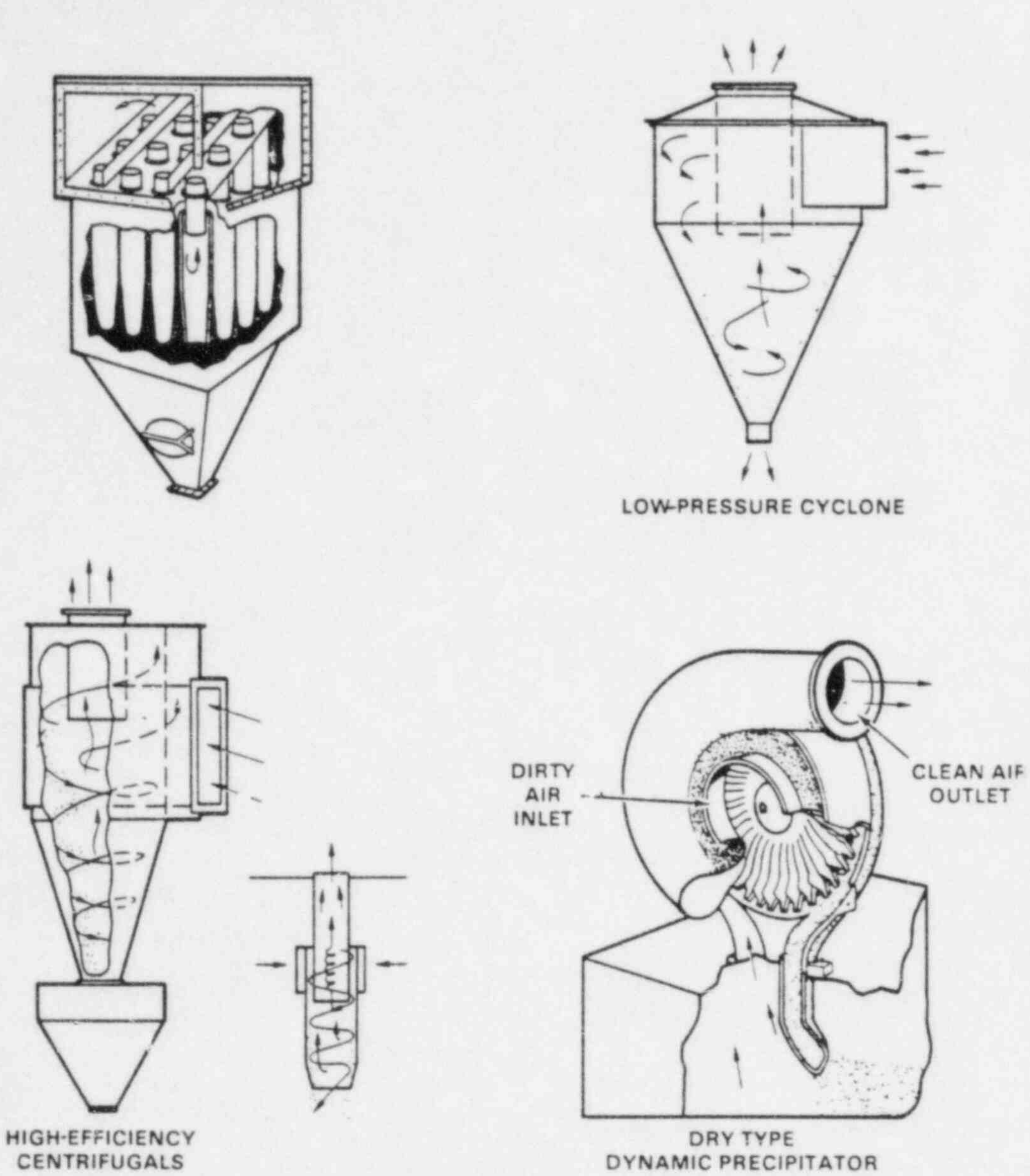


FIGURE 2.13. Dry-Type Centrifugal Collectors[19]

2.3 OTHER TECHNIQUES FOR CONTROL OF AIRBORNE PARTICULATE MATERIALS

A number of other methods are available for providing a reduction in the quantity of particulate materials suspended in exhaust gases. Each method is described briefly in the following section and references are included for readers desiring additional information.

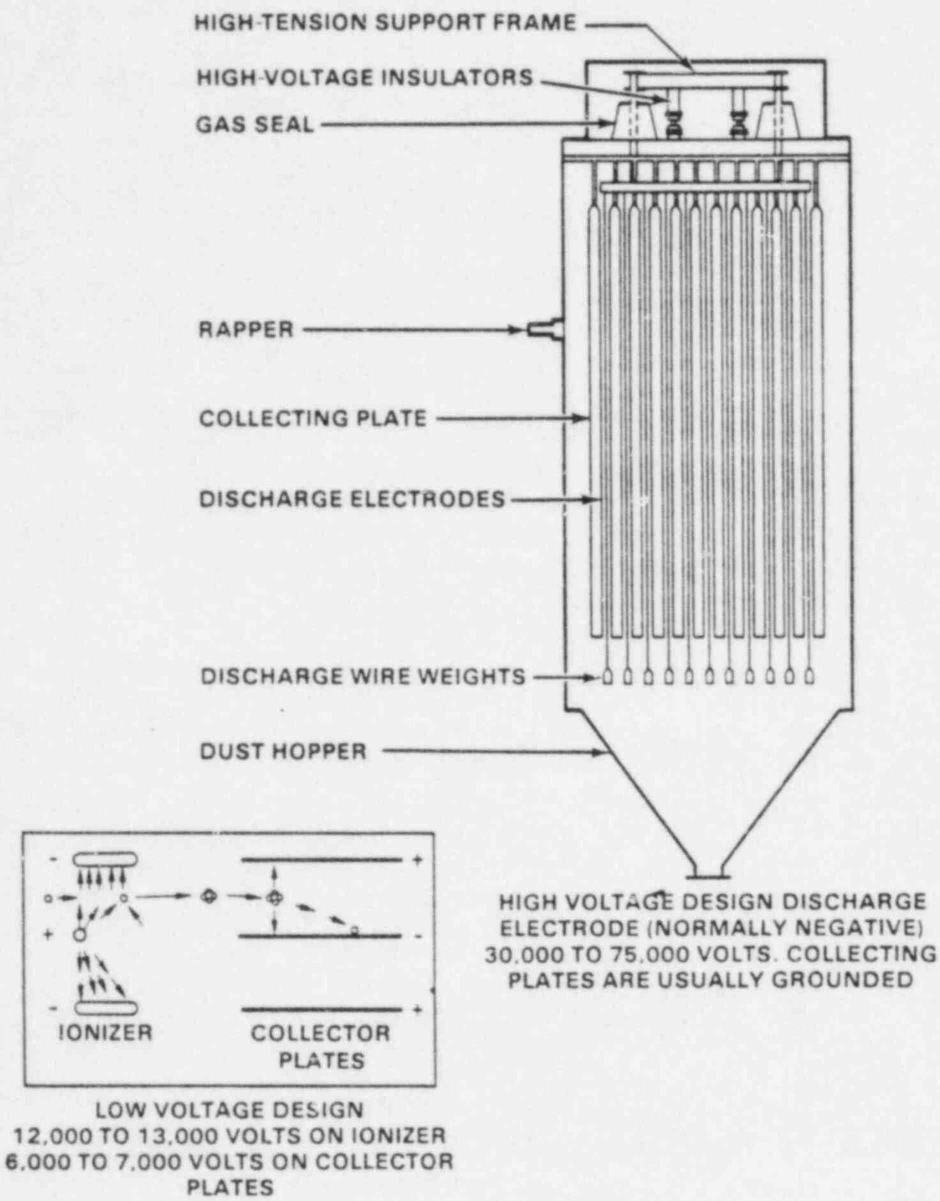


FIGURE 2.14. Electrostatic Precipitator(19)

2.3.1 Electrofluidized Bed(25)

An electrofluidized bed is a shallow bed of particles, fluidized by the polluted gas, with an electric field applied by means of electrodes. The gas-entrained pollutant particles are electrically charged by ion impact before entering the fluidized bed. The bed particles (~2 mm dia) act as collection sites for the pollutant and do not carry a significant net charge.

2.3.2 TRW Charged Droplet Scrubber[26]

The TRW Charged Droplet Scrubber is a hybrid electrostatic precipitator that combines high-energy wet scrubbing collection for micron size particulates with electrostatic precipitation for the collection of submicron particulates. An electrical potential is applied to the water spray system. The charged spray captures particulates as it migrates to the collector plates.

2.3.3 University of Washington Electrostatic Scrubber[27]

The University of Washington Electrostatic Scrubber uses electrostatically charged water droplets to collect particles of opposite polarity. The particles are negatively charged in the corona section. From the corona section the gases and charged particles flow into a scrubber chamber into which electrostatically charged water droplets (positive polarity) are sprayed. The gases and some entrained water droplets flow out of the spray chamber into another positively charged corona section. The charged water droplets and entrained particulates are removed from the gaseous stream in the grounded mist eliminator.

2.3.4 Wet-Wall Electroinertial Unit Air Cleaner[28]

An electrostatic precipitation system was combined with a wet wall to flush away the precipitated material and minimize maintenance. Inertial effects were added to assist in moving material toward the wall. Air enters a duct tangentially to the top of the unit and acquires a rotating movement. Water from the upper water inlet flows down the wall and flushes the precipitated dust into the water outlet at the bottom of the tube. The rotational movement of the air also induces rotational flow of the water, which assists in uniformly wetting the surface of the unit.

2.3.5 Fluid Electrode Precipitator[28]

A fluid electrode precipitator uses flowing columns of grounded water for particulate collection instead of rigid grounded plates used in a conventional electrostatic precipitator. The falling columns of grounded water act as cylinders in cross flow and create vortices that enhance particulate collection. Auxiliary electrodes and discharge electrodes are positioned in arrays to direct the charged dust into the grounded fluid.

2.3.6 Electrostatic Fiber-Bed Filter[29]

Basic components of the system include a corona chamber where the particles are negatively charged followed by a highly porous bed of dielectric fibers that occupy 5% to 8% of the bed volume. An electric field develops in the fiber bed due to the deposition of negatively charged particles. This electric field is significantly larger near a fiber than local coulomb repulsion and dramatically increases the particle capture cross section. The system can be cleaned using air jets or water sprays.

2.3.7 Sintered Metal Filters[30,31]

Sintered metal filters are constructed by fusing a mass of metal particles by application of pressure and temperature below the metal melting point. The filter porosity is about 0.5 μm absolute. The filters can be cleaned by pushing or reversing the air flow.

2.3.8 Submerged Gravel Scrubber[32]

The submerged gravel scrubber is a passive particulate collection system with a high loading capacity which consists of a bed of gravel (or other packing) submerged in a pool of water. Gas laden with aerosol is discharged beneath the gravel, where it subsequently flows upward through the bed. The effective density of the two-phase mixture in the gravel region is less than that of the pool outside the gravel bed and liquid flows upward at a significant rate. This inherent liquid pumping action clears the bed of collected aerosol and provides a very large mass loading capability.

2.3.9 High-Temperature Aerosol Filtration with Deep-Bed Filters[33]

Several types of high-temperature stainless steel and ceramic fiber filters have been evaluated for use. Stainless steel filters that are temperature resistant up to 550°C are available with 22, 12, 8, 4 and 2 μm fiber diameters. Ceramic fiber filters (fiber diameter 8 μm) can be used in the temperature range from 1000 to 1600°C.

3.0 PREOPERATIONAL CONSIDERATIONS

Preoperational considerations include selection of the appropriate air pollution control device, described in Section 2, for application to individual milling processes; equipment testing before or at the time of installation; incorporation of necessary ancillary equipment at the time of construction; and the quality assurance needs, presented in Section 4, for manufacturers and suppliers of the devices.

3.1 TYPICAL AIR POLLUTION CONTROL DEVICES

Several particulate emission sources are produced during uranium milling operations. They include general room air and individual process sources derived from the ore and yellowcake areas. Individual process sources that generate excessive amounts of airborne particulates may incorporate room and building exhausts or air exhausts, such as air exhaust hoods or hooded conveyor belts, to direct generated particulates into the air pollution control device or exhaust system. Wetting of ore before grinding will reduce the quantity of dust produced and a water spray during the operation will help minimize the fraction of dust that becomes airborne. Table 3.1 is a compilation of typical air pollution control devices used in ore handling and yellowcake areas at uranium mills.

TABLE 3.1. Air Pollution Control Devices Currently in Use at Uranium Milling Operations

Mill Operation	Typical Devices
Ore crushing and grinding	Water sprays Orifice or baffle scrubber Wet impingement scrubber Bag filters Filter media
Yellowcake drying and packaging	Wet impingement scrubber Venturi scrubber
Room air-yellowcake area	Wet impingement scrubber Venturi scrubber

3.2 INSTRUMENTATION

Instrumentation necessary to measure and monitor the operational characteristics of air pollution control devices is conveniently installed coincident with installation of the control device. Such instrumentation may include, but are not restricted to, the following:

Control Room

- audible alarms[a]
- light signaling alarms[a]
- automatic shutdown instrumentation (relays/solenoids)[a]
- pressure gages
- pressure receivers
- differential pressure receivers and recorders
- temperature indicators and recorders.

Control Device

- automatic shutdown instrumentation (relays/solenoids)[a]
- audible alarm[a]
- light signaling alarm[a]
- pressure gages
- pressure transmitters
- differential pressure transmitters
- differential pressure manometers
- temperature sensors
- temperature readout
- test probes
- testing devices
- monitoring probes.

More stringent control instrumentation is to be expected at locations where operation parameters on air pollution control devices exceed acceptable limits and where excessive personnel exposure could result from continued operations under these circumstances.

3.3 PREOPERATIONAL NEEDS AND TESTING OF DEVICES

Manufacturers of air pollution control devices report efficiences for these devices based on their design characteristics. Preferably, testing should be conducted by the manufacturer before installation on the same model or on one that is similar to that being installed so that data are available to verify the design criteria. After installation, the device may be tested in place to confirm its pollutant removal efficiency by methods discussed in Section 4.

A number of instrumental installations are necessary for each device to aid in its proper operation, testing and maintenance. A summary of equipment that is typically needed in conjunction with air pollution control devices is presented in Table 3.2.

(a) When operational limits are exceeded.

TABLE 3.2. Typical Ancillary Instrumentation for Air Pollution Control Devices

Instrumentation	Example of Use
Flowmeters	- Dust control spray systems (ore grinding and crushing) - Scrubber water supply - Scrubber preconditioning water supply - Main fan blower air supply system - Sampling Lines
Differential pressure gages/manometers	- Pressure drop measurement across all air filtration devices
Pressure gages	- Scrubber water supply - Air reservoirs for automatic baghouse cleaning - Testing of equipment and devices - Construction, maintenance and inspection - Instrument certification
Access ports	- For most testing needs
Automatic controls	- Scrubber water flow sensor (controls device air flow) - Preconditioning water flow sensor (controls device air flow) - Interlock main fan motor on baghouse with timer on automatic cleaning cycles
Temperature measurement	- Scrubber air inlet - Device air flow (or fan motor ammeter)
Out-of-tolerance alarms	- All automatic controls - All differential pressure readout locations - Scrubber ancillary water flow sensor - Scrubber water pressure

4.0 TESTING

A number of tests and calibrations are needed, with respect to the air pollution control devices, to provide the critical information used in accessing the downwind dose from routine operations at uranium milling facilities. These are presented in the following sections.

4.1 TEST METHODS

Test methods are presented for assessing the filtration efficiency of systems containing one or more particulate air-cleaning devices. These methods may be used as part of a preoperational or operational testing program.

4.1.1 In-Place Testing

The test method, usually referred to as "in-place testing," measures the particle-removal efficiency of the system. The installed air-cleanup device is confronted with a polydispersed aerosol of DOP (dioctyl phthalate, size range 0.3 to 3.0 micrometers). The aerosol concentration is measured before and after the device by means of light-scattering, photometric, or other suitable techniques. The overall system filtration efficiency is then calculated from the two aerosol concentration values. It is the purpose of the in-place test to determine the efficiency of the system so that penetration of the test aerosol through the device or any leakage of the test aerosol around the device is included in the results. Results from this test are also useful for comparison purposes in making future assessments of the operating condition of the air pollution control device.

This test method is contained in ANSI N101.1-1972, "American National Standard-Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles," and in other standards (MIL-F-51068[34] and MIL-STD-282[35]) and constitutes a generally accepted procedure for assessing the filtration efficiency of systems containing one or more particulate air-cleaning devices. The standard is also incorporated into Regulatory Guide 3.2, "Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles," as a means of ensuring that the requirements of 10 CFR Part 20 are met. A format for reporting information pertinent to the test as well as the test data is described in the appendix to this report.

The test method described is also applicable to most dry air-cleaning devices with high particulate-removal efficiencies, such as HEPA filters, baghouses, and other filtering media.

4.1.2 EPA Method 5

This method, entitled "Determination of Particulate Emissions from Stationary Sources," is described in 40 CFR Part 60, Appendix A "Standards of Performance for New Stationary Sources." The test method presented is useful for measuring particulate material in the presence of moisture associated with

the wet scrubbers. The amount of particulate material collected from upstream and downstream air passing through the air pollution control device will provide information for calculating the particulate-removal efficiency of the device.

An isokinetic gas probe is used to sample the air stream for particulates. The air is heated to eliminate water droplets before collection on a glass fiber filter. Individual samples are taken first downstream and then upstream of the device. The amount of material collected on the filter is determined gravimetrically.

4.1.3 Simplified Gravimetric Method

Two Teflon® gas sampling probes or sampling lines are installed at comparable locations upstream and downstream of the filtration device. Their location should be as close to the device as possible to minimize duct plateout effects. Particulates are collected on absolute filters (membrane) from gas samples simultaneously pumped from the gas stream, through the two probes. Identical gas stream sampling rates are utilized so that a direct comparison of the weight of the collected particulate materials in a given time is a measure of the efficiency of the device. Periodic measurement of the particulate plateout within the probe is necessary to validate the efficiency measurements. If the particulate plateout in the probe is found to be a significant portion of the particulate collected, then the plateout must be measured and added to the weights from each probe before efficiency is determined.

4.1.4 Condensation Nuclei Counter

Rapid measurement of aerosol concentrations are obtained in condensation nuclei counters. These devices may be moved from one location to another at the uranium milling facility to provide a convenient means of determining the particle-collection efficiency of several air pollution control devices.

The principle of their operation is as follows: The process gas stream is drawn in, compressed, saturated and supersaturated by expansion. Meanwhile, particulates within the gas stream are charged by exposure to an ionizing source of radiation. The changed particulates produce visible tracks in the supersaturated gas that are detected on photocells by their scattered light.

4.1.5 Aerodynamic Particle Sizer

A complete spectrum of the particle size distribution and of the concentration in each size range is rapidly measured by the aerodynamic particle sizer.

A sample of the process gas stream is accelerated to provide a specific amount of energy to the airborne particulates. The larger particulates

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accelerate more slowly than the smaller particulates. The transit time necessary for each particle to cross a split laser beam is measured and interpreted as aerodynamic size. The amount of scattered light reaching a photomultiplier tube is used as a measure of the quantity of particles.

Measurement upstream and downstream of an air pollution control device will provide information concerning the collection efficiency for the complete aerosol spectrum.

4.1.6 Vibrating Reed Generators

Particulate aerosols may be generated from an almost infinite variety of soluble materials by use of the vibrating reed generator. The size of the orifice in the generator and the material concentration will determine the particle size. The frequency of vibration will define the number of monodispersed particulates that are produced by this device. The efficiency of any particulate air filtration device can be determined by comparing the aerosol generated upstream with that measured downstream of the device. This includes either direct comparisons of the weight generated by the vibrating reed with the weight collected by a downstream filtering device or indirect comparisons utilizing light scattering or other electronic techniques on each side of the device.

4.2 CALIBRATION METHODS APPLICABLE TO URANIUM MILLING OPERATIONS

Testing results and dose calculations obtained from evaluation of the efficiency of the air pollution control devices are often dependent upon the accurate measurement of other physical parameters, such as the volume relationship between samples and the total air exhaust flow. A summary of calibration methods applicable to uranium milling operations that are typically used to enhance accuracy is presented in Table 4.1.

TABLE 4.1. Calibration Methods Applicable to Uranium Milling Operations

Parameter	Measurement Method
Volume	Wet/dry test meters ΔP measurement across an orifice Pitot tubes Bubble-o-meters Anemometers
Temperature	Reference to an NBS certified thermometer
Pressure and ΔP	Water and mercury manometers Reference to an NBS certified pressure gage

5.0 OPERATIONAL CONSIDERATIONS

There is a wide variety of operational needs in the uranium milling industry and many of those needs are based upon the type of equipment selected for use during operations. In addition, many different models for each type of air pollution control device are used at uranium mills. These models range in size in order to encompass the differing air-capacity needs throughout industry. In addition, the design features of each manufacturer are somewhat unique; therefore, the specific operational requirements for each model are beyond the scope of this report. Information is presented, however, for several types of air pollution control devices, based on typical models in present-day use at uranium milling operations.

5.1 DRY REMOVAL PROCESSES

Bag or Fabric Filters (Baghouses)[36] (See also Section 2.2.2.). Bag or fabric filters, usually in the form of baghouses, remove particles by filtering the gas through a porous flexible fabric made of a woven or felted material. The mechanisms of particulate collection with fabric filters are impaction and diffusion. The nature and extent of the collecting surface in a fabric filter change with the buildup of the layer of collected particles from one cleaning to the next. The accumulation of particles on the fabric causes a larger resistance to gas flow and a greater pressure drop. The desired pressure drop range is usually maintained by periodic, automatic cleaning of the filters. The automatic cleaning cycle may be initiated from either a differential pressure switch or from a timer. The differences in the cleaning methods distinguish the various types of baghouses (e.g., shaker type, reverse flow, reverse jet, and reverse pulse).[37]

Baghouse Operation. Proper operation of the baghouse is ensured by maintaining the differential pressure of the device in the correct range specified by the manufacturer, which is typically 5 in. of water gage (W.G.) pressure. A manometer or a differential pressure gage and transmitter is often provided and routine observations can be made and recorded by mill personnel. Control room alarms may also alert operators of nonstandard performance. The differential pressure across the dust collector may typically vary from about 1 to 2 in. W.G. when the filter is clean, up to 6 to 7 in. W.G. when the filter is heavily loaded.

Lower differential pressures indicate damaged filters or other air bypass channels which are normally located and repaired. Higher differential pressures indicate that cleaning operations are inadequate and more frequent cleaning cycles may be needed. In this case, the timer or differential pressure cut-in can be adjusted to provide for more frequent cleaning.

Many baghouse systems employ jets of high-pressure air to facilitate filter cleaning. Auxiliary air compressor systems provide this high-pressure air. The effectiveness of the system is dependent on maintaining a proper reservoir of compressed air. The pressures are maintained as specified by the

manufacture (typically 90 to 100 psig). Higher pressures than specified could cause filter fabric failure, and should be prevented by using a pressure relief valve, while lower pressures result in poor filter bag cleaning. This pressure can be monitored and recorded routinely. The main fan blower motor for the baghouse can be interlocked with the timer when such a timer is used to control cleaning cycles.

5.2 WET REMOVAL PROCESSES

Wet Scrubbers. Wet scrubbers generally remove particles by impacting them with water droplets. Before scrubbing can occur, the carrying gas must be collected by enclosing the process involved and then conveying the gas by ductwork into the scrubbed enclosures. The system requires blowers to create a reduced pressure around the milling operation that generates the particulates. High-efficiency wet scrubbers are routinely used to control particulate emissions from the yellowcake process areas.

Three types of wet scrubbers are currently in use in the uranium milling industry: orifice, wet impingement and venturi.[38,39]

Orifice-type scrubbers are devices in which the velocity of air from the collection system is used to provide liquid contact. The flow of air through a restricted, usually curved, passage partially filled with water causes the dispersion of the water. In turn, centrifugal forces, impingement, and turbulence cause wetting of the particles by the liquid.

In wet impingement scrubbers,[38] the collected, dust-laden air stream first passes through preconditioning sprays, where it is entrained by water droplets, and then proceeds through perforated plates to impinge on baffle plates. Water is atomized on the perforated plate because of the relatively high air velocity. Particles are collected on vaned mist eliminators and are withdrawn along with solids collected in the liquid overflow and the impingement plate.

With venturi scrubbers,[40] the gas stream passes through a venturi tube in which water is added at the throat at low pressure. Gas velocities at the throat are high (15,000 to 20,000 ft/min) and pressure drops are large (20 to 50 in. W.G.). In spite of the relatively short contact time, the extreme turbulence in the venturi promotes very close contact, and the principal removal mechanism is believed to be impaction. The wetted particles and droplets are collected in a cyclone spray separator.

Although each type of scrubber has unique design features, operations may be effectively monitored by noting certain common characteristics. These are described below.

Wet Scrubber Operation. Water from a spray head is directed onto the screen or throat of the device to produce flooding. The water pressure is normally maintained at the manufacturers' suggested operating pressure by a pressure regulator (typically 50 to 60 psig). This pressure can be monitored

by an alarm light in the control room. In addition, water flow can be measured with a flowmeter and routinely monitored by mill personnel. About 0.1 to 1 ft^3 of water per 1000 ft^3 air is a typical flow range. A flow switch can be incorporated into the water feed line, and will shut off the main fan blower and/or the process. The flow switch can also trigger a control room alarm in the event of water failure to alert operators of the need to take corrective action.

Air flow in a typical unit is 16,000 ft^3/min, with a typical operating range of 14,000 to 20,000 ft^3/min. The air flow is normally maintained within about 20% of the rated capacity specified in the manufacturers' operating instructions. The air flow rate can be monitored in the control room where an alarm may indicate out-of-tolerance conditions. This can be accomplished either by monitoring fan motor current or by pitot tube pressure measurements.

The pressure drop from scrubber operation (typically 7 in. W.G. in impingement and baffle scrubbers and higher in venturi scrubbers) is usually measured with a U-tube manometer and routinely monitored by mill personnel. In addition, an alarm can be installed to alert control room personnel when the differential pressure exceeds operating limits.

Corrective action may be initiated when the differential pressure exceeds the maximum limits specified by the manufacturer. The process can also be shut down, as necessary, for maintenance when the differential pressure drops below accepted limits.

When inlet-air temperatures are higher than the design criteria that provide adequate air humidification in the scrubber, air can be preconditioned to maintain particulate collection efficiency. Preconditioning is the use of an auxiliary water spray system upstream of the scrubber particle scavenging area. Although each device has its own temperature design limitations, manufacturers typically recommend preconditioning when temperatures exceed 300 to 350°F in venturi scrubbers. Water flow to the preconditioning nozzles is normally measured with a flowmeter and routinely monitored by mill personnel. A flow switch that will shut off the main fan blower and trigger a control room alarm in the event of water failure may be incorporated into the water feed line. When ancillary water sprays are used in scrubbers, a sensor may be installed in the water supply system. Such a sensor could trigger a control room alarm in the event of flow failure.

Dust Control Spray Systems Description and Operation. A dust control spray system is normally installed at processes such as ore grinding and sizing and where ore is withdrawn from hoppers in which considerable turbulence is created by falling ore.

Water or fluid flow to the spray nozzles of the dust control system can be measured with a flowmeter and monitored, as needed, by mill personnel during operations.

Table 5.1 summarizes the operations typically used to ensure proper operation of the air pollution control devices described in this section.

TABLE 5.1. Summary of Operations

Air Pollution Control Device	Monitoring Activities
Dust control systems (grinding, crushing)	- Monitor water spray flowmeter every four hours
Baghouses	- Monitor differential pressure every hour; adjust timer or pressure cut-in switch to cycle automatic cleaning units as needed
	- Monitor differential pressure alarm lights in control room
	- Monitor compressed air pressure gage on air-jet systems every four hours
	- Monitor air flow (motor ammeter or Pitot tube output) in control room
Scrubbers	- Monitor differential pressure every hour
	- Monitor differential pressure alarm lights in control room
	- Monitor air flow (ammeter or Pitot tube output) and alarm lights in control room
	- Monitor water flowmeters every hour
	- Monitor water pressure alarm lights in control room
	- Monitor control room lights for possible process shutdown in the event of water flow failures at preconditioning sprays or at the scrubber

6.0 MAINTENANCE CONSIDERATIONS

Maintenance needs, like operational needs, depend greatly on the equipment selected for use in uranium milling operations. Although the specific maintenance requirements for each equipment type and model are beyond the scope of this report, maintenance considerations are presented for the equipment described in Section 5.

6.1 DRY REMOVAL PROCESSES

Baghouses. The passive nature of the dust removal process tends to minimize maintenance problems in baghouses. However, certain procedures are implemented to maintain the high particulate-collection efficiency of this device. A general view of maintenance activities for baghouse filters is summarized in Table 6.1. These activities are in addition to those procedures recommended by the manufacturer for routine lubrication, inspection and replacement of component parts.

6.2 WET REMOVAL PROCESSES

Scrubbers. Some small differences will be found in the maintenance for each of the three types of particulate scrubbers used in uranium milling to reduce ore and yellowcake dust emission. In general, cleanliness and wear are the major concerns in each of these scrubber types. Efficient operation is ensured by maintaining the impacting and mixing surfaces as near as possible to the originally designed dimensions in the presence of the correct air and liquid flow. Some general guidelines for maintenance of wet scrubbers are listed in Table 6.2.

When scrubbers are restarted, proper spray patterns should be generated by the nozzles (i.e., the spray should wet the impingement elements uniformly, etc.). In addition, excessive fan vibration and the presence of water droplets in the clean air discharge should be checked for.

Significant deficiencies noted during maintenance activities are normally corrected before returning the device to service. Minor deficiencies can be corrected or scheduled for correction when convenient. Early estimates can be made of corrosion and abrasive wear so as to facilitate parts replacements, when needed.

Dust Control Spray System. Water nozzles are normally inspected for plugging and the valves checked for proper operation on a routine basis.

TABLE 6.1. Maintenance Activities Appropriate for Baghouse Filters

Inspection Frequency	Component	Procedure
Daily	Baghouse housing	Inspect exhaust from filters for visible dust
	Compressed air system	Inspect for air leakage (low pressure) and check valves[a]
	Manometer	Inspect for blockage; review daily record; watch for a trend
Weekly	Filter bags	Inspect individual filter bags and attachment hardware
	Dust collection hopper	Inspect for dust and debris buildup in ducting to hopper
Monthly	Baghouse housing	Inspect gasketing on filter housing door to ensure against leakage
Annually	Baghouse housing	Inspect thoroughly, clean, touch up paint where necessary; rod out dust buildup on all accessible hopper surfaces
	Compressed air system	Check alignment of air pulse holes with center of bag filters[a]
	Dust collection system	Check operation of the discharge mechanism

(a) Procedures applicable to pulse or jet baghouses and the remainder are applicable to all baghouses.

TABLE 6.2. Maintenance Activities Appropriate for Wet Scrubbers

Inspection Frequency	Scrubber Type	Procedure
Weekly	All	A complete inspection should be made of the particle scrubbing zone of the device.
	Baffle and impingement[a]	Remove impingement elements and examine for material buildup. Clean elements with a high-pressure spray and wire brush. Invert elements before reinstalling.
Fortnightly	All	Inspect each spray nozzle and plate flooding system for plugging or signs of wear. Inspect recirculated water systems weekly. Plugged nozzles result in inadequate water supply and decreased efficiency. Worn nozzles cause excessive water usage, higher power requirements and accelerated breakdowns.
	All	Retighten all bolts and any fan wheel set screws during continuous operation.
	Venturi	Inspect venturi throat for wear and material buildup.
Monthly	All	Inspect water or slurry separator/collector/sump area. Drain sump and flush with a high-pressure spray until drain flow is clear.
	Baffle and impingement	Open access door on eliminator section and flush down louvers with a high-pressure spray. Clean all materials from the eliminator section into the sump so as to leave the baffle connectors clean.
	Baffle and impingement	Access the mixer section, withdraw and clean inlet vanes of the impingement element.
	Baffle and impingement	Open access ports on fan housing and remove accumulated dust with a gentle water flow.
Semiannually	Venturi	Repack throat dampers.

(a) For maintenance purposes, the impingement and baffle scrubbers are described together because they have similar impingement surfaces and many models exhibit hybrid design characteristics.

7.0 QUALITY ASSURANCE AT URANIUM MILLING OPERATIONS

All nuclear facilities and other nuclear industry-related operations that must consider regulatory guidance are required to implement and maintain a documented quality assurance program. This program identifies the activities and items to which it applies. The establishment of the program includes consideration of the technical aspects of the activities affecting quality. The program provides control over activities affecting quality to an extent consistent with their importance. The program is established at the earliest time consistent with the schedule for accomplishing the activities.

The program provides for the planning and accomplishment of activities affecting quality under suitably controlled conditions. Controlled conditions include the use of appropriate equipment, suitable environmental conditions for accomplishing the activity, and assurance that prerequisites for the given activity have been satisfied. The program provides for any special controls, processes, test equipment, tools, and skills needed to attain the required quality and verification of quality.

The program provides for indoctrination and training, as necessary, of personnel performing activities affecting quality to ensure that suitable proficiency is achieved and maintained.

Management of those organizations implementing the quality assurance program, or portions thereof, regularly assesses the adequacy of that part of the program for which they are responsible to ensure its effective implementation.

In addition to its own quality assurance program, a licensee should require the design organization, manufacturers of components, and constructors (including subcontractors) to establish and comply with a comprehensive quality assurance program and plan. The quality assurance program should be documented by written policies, procedures, and records, and should be sufficiently detailed to permit evaluation by the licensee.

In the following subsections, a summary of the subject matter from several authoritative sources concerning quality assurance requirements and guidance are presented. These sources are often referenced as requirements for quality assurance programs; however, the inclusion of 10 CFR 50, NQA-1 and ANSI N45.2 are for information purposes and does not imply the need for conformance by uranium mill operators. From the similarity of scope of the topics in the different sources, it is apparent that a satisfactory program should address most of the topics presented within the listings.

7.1 CODE OF FEDERAL REGULATIONS: 10 CFR PART 50, APPENDIX B: "QUALITY ASSURANCE CRITERIA FOR NUCLEAR POWER PLANTS AND FUEL REPROCESSING PLANTS"

1. Organization (including responsibility)
2. Quality Assurance Program (scope)
3. Design Control (of structures and components)
4. Procurement Document Control
5. Instructions, Procedures, and Drawings

6. Document Control
7. Control of Purchases, Materials, Equipment, and Services
8. Identification and Control of Materials, Parts, and Components
9. Control of Special Processes
10. Inspection
11. Test Control
12. Control of Measuring and Test Equipment
13. Handling, Storage, and Shipping
14. Inspection, Test, and Operating Status
15. Nonconforming Materials, Parts, or Components
16. Corrective Action
17. Quality Assurance Records
18. Audits.

7.2 ANSI/ASME NQA-1-1983 EDITION: "QUALITY ASSURANCE PROGRAM REQUIREMENTS FOR NUCLEAR FACILITIES"

The topics are identical to those listed in Section 7.1 except as follows:

7. Control of Purchased Items and Services
8. Identification and Control of Items
9. Control of Processes
15. Control of Nonconforming Items.

A number of supplements and appendices are also included in NQA-1 that provide extensive guidance concerning each of the topics listed.

7.3 ANSI/ASME, N45.2-1977: "QUALITY ASSURANCE PROGRAM REQUIREMENTS FOR NUCLEAR FACILITIES"

At this time, many, but not all, of the requirements of ANSI N45.2-1977 have been withdrawn. These requirements have been superseded and incorporated into NQA-1-1983. It is useful, however, to compare the complete scope of this standard with other standards in this report. Again, the topics are identical with Section 7.1 except as follows:

Introduction (including scope, applicability, and responsibility)
15. Nonconforming Items.

A number of additional standards are also available that provide more definitive guidance on selected topics. These are published in ANSI/ASME N45.2.1-N45.2.23. Documents from this series pertinent to the subject matter in this report are listed below:

- N45.2.6-1978, "Qualifications of Inspection, Examination, and Testing Personnel for Nuclear Power Plants"
- N45.2.9-1979, "Requirements for Collection, Storage, and Maintenance of Quality Assurance Records for Nuclear Power Plants"
- N45.2.10-1973, "Quality Assurance Terms and Definitions"

- N45.2.12-1977, "Requirements for Auditing of Quality Assurance Programs for Nuclear Power Plants"

- N45.2.13-1976, "Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants"

- N45.2.23-1978, "Qualifications of Quality Assurance Program Audit Personnel for Nuclear Power Plants."

7.4 REGULATORY GUIDE 4.15, "QUALITY ASSURANCE FOR RADIOLOGICAL MONITORING PROGRAM (NORMAL OPERATIONS)--EFFLUENT STREAMS AND THE ENVIRONMENT"

1. Organizational Structure and Responsibilities of Managerial and Operational Personnel

2. Specification of Qualifications of Personnel

3. Operating Procedures and Instructions

4. Records

5. Quality Control in Sampling

6. Quality Control in the Radioanalytical Laboratory

7. Quality Control for Continuous Effluent Monitoring Streams

8. Review and Analysis of Data

9. Audits.

For the purposes of this report, dealing with the testing, operating, and maintenance of air pollution control devices used at uranium milling operations, quality assurance can be expected to include a minimum of the following topics:

- organizational structure and responsibilities of managerial and operations personnel

- identification of equipment and air pollution control devices encompassed by the program

- documentation of activities affecting quality

- specification of qualifications of personnel

- review and analysis of data and performance auditing

- testing of equipment and devices

- construction, maintenance, and inspection

- instrument certification

- records management.

Most of the subject matter is discussed in the documents already noted in this section. However, guidance concerning testing of equipment can be found in the Institute of Electrical and Electronics Engineers (IEEE) Standard 490-1980, "IEEE Standard Requirements for the Calibration and Control of Measuring and Test Equipment Used in the Construction and Maintenance of Nuclear Power Generating Stations."

An example of daily information in summary form that is useful to ensure proper air pollution control device operation and to estimate results of off-normal operations is presented in Table 7.1. The individual results from daily operations, compiled monthly in the fashion shown, constitute a method for reporting and presenting information for audit purposes. This type of summary will also be useful to the NRC for estimating downwind exposure from uranium milling operations.

TABLE 7.1. Sample Quality A
Control Devices

Mill Identification______________________________

Mill Process____________________________________

Control Device__________ __________ ____________
(Type) (Model) (Serial #)

Date	Yellowcake Production (tons)	Ore Qty. Processed (tons)	Water Flow Rate (ga				
			Scrubber		Preconditioners		Dus
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

(a) Range of observed values during calendar day.
(b) Check if affirmative.
(c) Within ± 20% of planned release.
(d) Check if excessive and estimate release as percent of

surance Data Sheet for Operations: Operational Reporting Form for Air Pollution

Month/Year________________________

Range of Readings[a]												
min) Control System		Baghouse Cleanup Air Pressure (psig)		WP (In. of Water)		Air Flow Rate (cfm)		Aut. Process Shutdown[b]	Out of Tolerance Alarms[b]	Estimated Emissions		Remarks (Explain Alarms and Excessive Emissions)
										Normal[c]	Excessive[d]	

rmal (i.e., 150%).

8507030684-01

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Pacific Northwest Laboratory, under contract to the U.S. Nuclear Regulatory Commission, conducted an investigation of particulate emission control devices for application to process exhausts at uranium milling facilities. The scope of this investigation included devices now in use, as well as those devices that have potential application for milling sites. This report presents the results of the study. Emission control devices are categorized and described, including high-efficiency and moderate-efficiency devices as well as other (some novel) devices useful in specific situations. Preoperational considerations discussed include selecting devices, instrumentation, and testing programs. Operational and maintenance considerations related to dry and wet removal processes are described. Quality assurance documents and topics are also discussed.

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