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TESTING HEPA FILTERS FOR USE IN A HIGH NOISE LEVEL ENVIRONMENT*

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ABSTRACT

During the pulsed cooling phase of nuclear reactor rocket engine tests, as part of the Rover Program at Los Alamos Scientific Laboratory, the possibility of atmospheric release of radioactive particulates exists. To control this potential release, a special air cleaning system employing High Efficiency Particulate Aerosol (HEPA) filters was designed, constructed, and tested. A primary concern was the structural integrity of these filters under the intense noise levels that exist during reactor tests.

Commercially available HEPA filters were subjected to noise levels simulating the acoustic environment that exists near a reactor during testing. These acoustic exposures included both reverberant and progressive fields of varying time intervals and reached maximum sound pressure levels of 148 db. Filter efficiency tests using air-generated dioctyl phthalate (DOP) were performed before and after acoustic exposures and are reported. Details of the acoustic and DOP test methods are also discussed.

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INTRODUCTION

During the pulsed cooling phase of nuclear reactor rocket engine tests, as part of the Rover Program at Los Alamos Scientific Laboratory, the possibility of a release of radioactive particulates exists. Although this does not constitute a problem of atmospheric contamination, the resultant procedures required and costs involved in decontamination of the immediate testing area could be quite extensive. It was, therefore, desirable to control this potential release with a special air cleaning system capable of removing as much of the contamination as feasible.

High Efficiency Particulate Aerosol (HEPA) filters meeting the requirements of the U.S. Atomic Energy Commission (USAEC)^[1] would serve as the most simple and convenient means of obtaining the desired filtration. These filters are designed for a minimum efficiency of 99.97% when subjected to a dioctyl phthalate (DOP) monodisperse, 0.3 μ m aerosol. However, prior to the incorporation of HEPA filters into the design for the air cleaning system, it was necessary to determine their structural integrity in an acoustical environment simulating that found near a Rover reactor during testing.

Calculations, based on noise levels measured during the Kiwi reactor series,^[2] established sound pressure levels that could be anticipated during the testing of two future reactors. Table I indicates the predicted

levels within specific octave bands. The anticipated exposure times to these levels was 45 min for the low levels and approximately 20 min for the higher levels. Sandia Corporation, Sandia Laboratory (SCSL), Albuquerque, New Mexico, was contracted to expose selected HEPA filters to the predicted noise levels for varying time periods.

Specifications for the filters to be used in the proposed air cleaning system followed the requirements set forth in Reference 1. Briefly, these specifications required a filter medium of waterproof glass with aluminum separators, a sealant (medium to frame) of ceramic glass, and the frame or exterior of the filter constructed of 16 gauge cadmium plated steel, 24 x 24 x 11 $\frac{1}{2}$ in. Each filter had a rated capacity of 1250 cfm air flow with 1 in. water gauge or less differential pressure across the filter media.

It was decided that the integrity testing should involve, in addition to the above, HEPA filters that are commonly used in air filtration systems throughout USAEC installations. Consequently, filters from various manufacturers and of varying sizes and construction were selected to be subjected to the acoustic exposures. Table II is a list of all filters exposed.

Test procedures would involve in-place testing for filter efficiency against a polydisperse DOP aerosol prior to and after each acoustic exposure.

I. PRE-ACOUSTIC EXPOSURE

An aluminum framework capable of holding four filters was constructed to simulate the proposed framework for the Filtration for Reactor Out-Gassing (FROG) assembly (see Fig. 1). This framework also provided a means of subjecting the sealing gaskets and retention hardware to the acoustic exposures and in-place tests. It was necessary, for in-place testing, to seal one portion of the framework as only three filters meeting the specifications for the FROG assembly were received for testing. All other filters exposed would be individually suspended in the acoustic chamber.

A. In-Place Testing

Each filter, except those contained in the aluminum framework, was individually in-place tested for filtration efficiency using a polydisperse, liquid DOP aerosol. The aerosol generator used is a modification of a design by the Naval Research Laboratory.^[3] When the generator is operated at 25 psi air pressure within the nozzles, the aerosol has a count median diameter of 0.8 μ m and a geometric standard deviation of 1.6^[4] The aerosol detection equipment consists of a forward light-scattering photometer and amplifier combination.^[5] Figure 2 shows the test

assembly, aerosol detection equipment, and sampling probes used for in-place testing of individual HEPA filters.

Three-hundred cubic feet per minute of air was drawn through each filter, with the DOP aerosol being introduced at the intake duct. A Stairmand disk contained in the duct ensures proper mixing of the aerosol with the airstream. An air sample is then drawn into the sensing chamber of the light-scattering photometer and relative concentrations of the aerosol upstream (A) and downstream (B) are measured. The efficiency, in percent, is indicated by $\left(1 - \frac{B}{A}\right) 100$.

The three filters contained in the aluminum framework were in-place tested as a complete assembly, using the test methods described above. Airflow through the assembly for testing purposes was approximately 800 cfm. Figure 3 shows the test assembly with its transition plenums attached, the aerosol detection equipment, sampling probes, and blower providing airflow.

Filter number 2, Table II, indicated a filtration efficiency, prior to acoustic exposures, of 99.98%. The three-filter assembly indicated an efficiency of 99.96% and all other filters, 99.99% or greater.

After the initial in-place tests, all filters were packaged in their original shipping cartons and transported to SCSL by private carrier. It was hoped that this means of transportation would negate the possibility of filter damage that occasionally occurs in transit.

II. ACOUSTIC EXPOSURES AND TESTS

The initial exposure procedure called for the three filters contained in the framework to be exposed to the predicted sound pressure levels in reverberant and progressive sound fields. The loose or individual filters would be subjected to both sound pressure levels but in a reverberant field only.

A. Filter Assembly (Aluminum Framework and Three HEPA Filters)

Exposure No. 1. Reverberant field. The filter assembly was suspended in the acoustic testing chamber (see Fig. 4) and the sound pressure level established at 133 db. The chamber was then equalized, as near as possible, to the low-level spectrum listed in Table I. Total exposure time to this level was approximately 45 min.

Visual inspection after exposure of the framework, filters and gaskets indicated no apparent defects. It was decided to forego efficiency tests at this time and continue to the higher sound pressure level.

Exposure No. 2. Reverberant field. Sound pressure levels were increased to approximately 148 db and the chamber equalized to approximate the high-level spectrum. These levels were maintained for approximately 20 min. Visual inspection of the filters revealed no defects in the filter media; however, a small amount of fiber glass packing at the periphery of the filter had started to become dislodged (see Fig. 5). Efficiency tests of the assembly with DOP aerosol indicated no loss in efficiency of filtration.

Exposure No. 3. The assembly was then subjected to progressive wave fields of the low-level spectrum. This level was maintained for approximately 40 min. A post-exposure visual inspection indicated no change in the filter's condition from that found after the second exposure.

Exposure No. 4. The overall SPL was established at 148 db and equalized under progressive wave conditions. This high-level spectrum was maintained for 20 min and the assembly visually inspected at the end of the exposure. It was noted that the fiber glass packing had been further dislodged. Efficiency testing conducted immediately after acoustical exposure indicated that filtering efficiency had not been impaired.

B. Individual Filters

It was decided at this time to forego the exposure of these filters to the low level spectrum and proceed directly to the high levels.

Exposure No. 1. Fourteen individual filters, as listed in Table II, were suspended in the test chamber and exposed for a period of 20 min to a reverberant field of the high-level spectrum. Visual inspection of the filters after exposure revealed that the filters closest to the sound source had more loose fiber glass packing than the others, indicating the possibility of higher noise levels at this point. By relocating the microphones in the acoustic chamber, it was determined that three of the filters had been exposed to overall sound pressure levels of 152 db.

Exposure No. 2. All filters were removed from the chamber except the three that received the highest levels on the previous exposure. These filters were subjected to a measured overall sound pressure level of 152 db for an additional 20 min.

More detailed data on the sound pressure levels, accelerometer measurements and techniques of the acoustic exposures are given in reference. [6]

III. POST-EXPOSURE TESTING

The three-filter assembly and all individual HEPA filters were again in-place tested as previously outlined. There was no significant loss in filtration efficiency indicated by the final tests.

IV. SUMMARY AND DISCUSSION

Three HEPA filters contained in an aluminum framework were exposed, under reverberant and progressive wave conditions, to SPL's of 133 db and 148 db. Total time of exposures was 85 and 45 min, respectively. In-place tests of the assembly, before and after exposure, indicated no loss in filtration efficiency.

Fourteen HEPA filters of various sizes and construction were subjected to an overall sound pressure level of 148 db, under reverberant conditions, for a period of 20 min. Three of these filters were then exposed for an additional 20 min to a reverberant field of 152 db.

All of these filters were individually tested for filtration efficiency against a polydisperse, liquid DOP aerosol before and after their acoustic exposure. The post-exposure tests indicated that the efficiency of the filters was not significantly impaired by exposures to the stated SPL's for the times involved.

However, visual inspections of the filters revealed structural changes that, with subsequent exposures, could cause the filters to suffer a loss in efficiency. It was noted that the fiber glass packing material, acting as an additional sealant between the medium and frame, had become partially dislodged. This condition increased with time and, potentially, could allow an aerosol to bypass the filter medium.

It was also observed that some of the aluminum separators, in those filters constructed with steel frames, migrated away from the filter medium so as to protrude as much as 0.5 in. from the face of the filter. It is believed that additional migration, creating a lack of proper support for the filter medium, would result in eventual failure of the filter.

Based on the results of the acoustic exposures and efficiency testing, a full-scale filtration system was constructed incorporating 56 of the 24 x 24 x 11 $\frac{1}{2}$ in. filters. This system is capable of handling approximately 70,000 cfm of effluent with, as indicated by in-place DOP tests, an overall efficiency greater than 99.95%.

V. ACKNOWLEDGMENT

Special acknowledgment is given to Sandia Corporation, Sandia Laboratory, Albuquerque, New Mexico, who, on a contract basis, provided the acoustic environment in which the HEPA filters were exposed.

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- [5] KNUDSON, H.W., WHITE, L., "Development of smoke penetration meters," Rep. NRL-P-2642 (1945).
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TABLE I

PREDICTED LEVELS FOR ACOUSTIC EXPOSURES

Octave Band (Hz)	SPL in db (re. 0.0002 dynes/cm ²)	
	Low Level	High Level
37 - 75	112	139
75 - 150	121	141
150 - 300	127	141
300 - 600	127	140
600 - 1200	126	138
1200 - 2400	125	136
2400 - 4800	122	133
4800 - 9600	119	131
Overall	133.5	148

TABLE II

LIST AND DESCRIPTION OF HEPA FILTERS TESTED

<u>Filter No.</u>	<u>Description</u>
1, 2, 3	1000 cfm (23-7/16 x 23-7/16 x $11\frac{1}{8}$ in.) aluminum separators, 16 gauge cadmium-plated steel frame.
3, 4, 5	1150 cfm (24 x 24 x $11\frac{1}{8}$ in.) asbestos separators, 3/4 in. plywood frame.
6, 7	600 cfm (24 x 24 x $5\frac{7}{8}$ in.) aluminum separators, 3/4 in. plywood frame.
8, 9, 10	750 cfm (24 x 24 x $5\frac{7}{8}$ in.) asbestos separators, 3/4 in. plywood frame.
11, 12	500 cfm (18 x 18 x $11\frac{1}{8}$ in.) asbestos separators, 3/4 in. plywood frame.
13, 14	Same as above, different manufacturer.
Framework (3 filters)	3 ea., 1250 cfm (24 x 24 x $11\frac{1}{8}$ in.). Aluminum separators, 16 gauge cadmium-plated steel frame.

FIGURE 1. Simulated FROG framework.

FIGURE 2. Individual filter testing assembly.

FIGURE 3. FROG framework assembled for DOP testing.

FIGURE 4. Assembly suspended in acoustic chamber.

FIGURE 5. Partial dislodging of fiber glass packing.