0028759

CONF-720823
Volume 2

PROCEEDINGS
of the
TWELFTH AEC AIR CLEANING CONFERENCE

held at
Oak Ridge, Tennessee
28 - 31 August 1972

Sponsors: The Harvard Air Cleaning Laboratory
Harvard University

Divison of Occupational Safety
Division of Waste Management
and Transportation
U.S. Atomic Energy Commission

Oak Ridge National Laboratory

JUN 1993
RECEIVED
EDMC

Editor
Melvin W. First

January 1973

EFFECTS OF HIGH-LEVEL GAMMA RADIATION EXPOSURE OF HEPA FILTERS*

C. L. Cheever, C. H. Youngquist, P. R. Hirsch,
J. C. Hoh, D. S. Janetka, and H. R. Fish
Argonne National Laboratory
Argonne, Illinois

Abstract

Evaluation of the effects of stepwise exposure of five 12 x 12 x 6 inch HEPA filters to cobalt-60 gamma radiation are reported. Two of the filters had glass-pack seals and cadmium plated steel frames, two had glass-pack seals and chromized steel frames, and one had a pressed wood frame. An additional pressed wood frame filter was tested as a non-irradiated control. The filters were irradiated to nominal exposures of 10^7, 10^8, 5×10^8, 10^9, and 1.5×10^9R. At the start and after each period of irradiation, the filters were tested at rated flow to determine the percent penetration of compressed air generated DOP aerosol. The filters were then stressed at two to three times rated flow and the penetration tests were repeated at rated flow. Two of the steel frame filters were irradiated in an argon atmosphere and the other filters were irradiated in air. All tests showed acceptable (< 0.03%) penetration results. There was no significant change in penetration except as measured in the last step for filter number four.

Flat sponge neoprene and PVC gaskets were also irradiated in both argon and air as above. The effects were measured by observation, leak rate measurements, and Shore durometer hardness tests. The neoprene gaskets are preferred, although they became hard. The PVC gaskets became tacky and were unacceptable.

The HEPA filters continued to perform acceptably after irradiation to $> 10^9$R of cobalt-60 gamma radiation.

Introduction

Tests have been conducted at Argonne National Laboratory (ANL) to evaluate effects on and performance of high efficiency particulate air (HEPA) filters subjected to high dosages of gamma radiation. The tests were carried out to provide engineering guidelines for the installation of HEPA filters inside the argon atmosphere main cell of the new ANL Hot Fuel Examination Facility (HFEF)[1,2]. There is an advantage in having the first HEPA filters in series installed inside the cell in this type of facility. This retains most of the radioactive particulates within the shielded cell and remote handling equipment is available for removal of contaminated filters. The estimated maximum exposure to any of the in-cell HEPA filters due to gamma radiation from irradiated reactor fuel elements was 4×10^8 roentgens (R) per year. Accordingly, tests were designed to measure changes in penetration of compressed air generated dioctyl phthalate (DOP) aerosol[3], visible effects, and changes in gasket hardness due to stepwise cobalt-60[4] gamma irradiation of HEPA filters to 10^7, 10^8, 5×10^8, 10^9, and 1.5×10^9R. The gamma irradiation doses were designated for the filter face nearest the cobalt-60 source. The filter face away from the source would receive about 70% of this exposure due to distance and somewhat less than this due to

*This work was performed under the auspices of the U. S. Atomic Energy Commission.

attenuation by the filter materials. The radiation dose rate was 5×10^5R per hour at the front faces of the filters. Total irradiation times were 20; 200; 1,000; 2,000; and 3,000 hours to obtain the above dosage steps. Irradiation dosimetry was by measuring the change in transmittance of cobalt glass and this technique had been compared to ferrous sulphate dosimetry measurements. The radiation dose measurements are considered to be within ± 5% accuracy.

The size 12 x 12 x 5-7/8" HEPA filters used in these evaluations were manufactured by Flanders Filters, Inc., and were constructed as indicated in Table I.

Table I

Test HEPA Filters

Filter Number	Frame Construction	Filter Media	Separators	Sealant
1	Cadmium plated steel	Waterproof glass fibers	Asbestos	Glass fiber pack
2	Cadmium plated steel	Waterproof glass fibers	Asbestos	Glass fiber pack
3	Chromized steel	Waterproof glass fibers	Asbestos	Glass fiber pack
4	Chromized steel	Waterproof glass fibers	Asbestos	Glass fiber pack
5	Fire retardant particle board	Waterproof glass fibers	Asbestos	Polyurethane foam
6	Fire retardant particle board	Waterproof glass fibers	Asbestos	Polyurethane foam

The above filter media meets the MIL F 51079A standard. Organic starch binder is not to exceed 5% by weight, of the glass fiber media. Metal frame, glass fiber pack filters were selected for the tests because it was thought they would be quite resistant to radiation damage. The particle board frame, polyurethane foam sealant filters were tested to provide comparative information. Filter number six was not irradiated but was tested along with the irradiated filters as a control.

Filters were irradiated with aluminum sheet metal plates attached to their faces for internal purging at a rate of 5 cc per minute with argon or air as indicated. Also, gaskets were placed between sheet metal aluminum plates and the void space was purged as above during irradiation. This was done to provide an argon atmosphere for the filter media and also for one surface of the gasket material and to provide similar conditions with an air atmosphere.

Filter Tests

Measurement of DOP aerosol penetration through the test filters was carried out with the equipment shown in Figure 1.

The ANL fabricated single Laskin nozzle generator shown in Figure 1 was used to produce DOP aerosol of about 0.8 microns light scatter mean diameter. The TDA-2C linear Aerosol Photometer with a 0.01% scale as shown in Figure 1 was used to measure the test aerosol concentration upstream and downstream from the filter. The penetration was taken as the average of 2 to 4 penetration test readings. Initially and after each irradiation step, filters were tested at rated flow of 135 cfm, then stressed for 15 minutes to 1 hour at 2 to 3 times rated flow and then retested for DOP penetration. The stressing at increased flow rate was done to simulate the increase in pressure differential across the filter media as dust loading increases with usage. Since the air flow tests were of short duration, effects that might be apparent only after prolonged service would not be detected. No significant changes were found in any of the DOP penetration tests subsequent to stressing. DOP penetration test results are listed in Table II.

Table II

% DOP Penetration

Gamma Exposure, R:	0	10^7	10^8	$5x10^8$	10^9	$1.5x10^9$	Irrad. Atmos.
Filter No.							
1	0.0007	0.0012	0.0015	0.0021	0.0016	0.0017	Air
2	0.0012	0.0020	0.0020	0.0027	0.0020	0.0017	Argon
3	0.0018	0.0021	0.0024	0.0025	0.0021	0.0024	Air
4	0.0019	0.0017	0.0021	0.0023	0.0019	0.0120	Argon
5	0.0035	0.0046	0.0052	0.0052	0.0053	0.0058	Air
6*	0.0016	0.0022	0.0019	0.0020	0.0021	0.0022	Control

*No radiation exposure, control.

The face of filters number 1, 3, 6, and 5 are shown in Figure 2 after irradiation to 1.5×10^9R. Filter number 6, lower left, was the control showing no discoloration. Filter number 5, lower right, shows the polyurethane foam adhesive completely darkened and looking almost charred. The labels and particle board were also darkened. Filters number 1 and 3 at top showed some evidence of discoloration of separators and the white labels turned brown.

Gasket Tests

Closed cell neoprene and PVC gaskets were irradiated along with the HEPA filters and to the same nominal gamma radiation doses. The neoprene and PVC gaskets were nominal 3/4" wide by 1/4" deep flat gaskets. The neoprene gaskets had dovetailed corner joints while the PVC was continuously molded. The closed-cell black sponge neoprene gaskets were manufactured to ASTM D1056-SCE 43

specifications. Prior to irradiation and after each irradiation step, the gaskets were placed between steel plates and loaded to 43 pounds per linear foot. This loading simulated the HFEF in-cell method of gasket compression by a 300 pound distributed weight on each of the 24 x 24 x 12" HEPA filters. The measured rate of in leakage was as shown in Table III.

Table III

12" x 12" Gasket Leakage at -2" H_2O, liters/min.

Co-60 Gamma Irradiation, R	Neoprene (Air Purge)	Neoprene (Argon Purge)	PVC (Air Purge)	PVC (Argon Purge)
0	0.025	0.075	0.26	0.338
10^7	0.032	0.020	2.12*	0.426
10^8	0.03	0.04	0.50	0.22

*Small groove noted across gasket, cause unknown.

The gaskets were tested for hardness by Durometer A-2 readings[5] with results as shown in Table IV. The PVC gasket became tacky after exposure to 10^8R and after exposure to 5 x 10^8R it became unacceptably gooey.

Table IV

Durometer A-2 Hardness Tests
(average of 5 or more durometer readings)

Co-60 Gamma Irradiation, R	Neoprene Gasket	PVC Gasket
0	15.6	28.5
10^8	26.5	28.8
5 x 10^8	78.7	-

The neoprene gaskets hardened with exposure to gamma radiation as indicated. After irradiation to 10^8R, a gray powder had formed between the gaskets and the aluminum plates for both the neoprene and PVC gaskets. Also, after 10^8R irradiation, one portion of neoprene gasket was damaged due to sticking to the aluminum holder plate. This did not reoccur at the subsequent irradiation levels but indicates the potential problem of gasket adhesion to mounting surfaces.

Although the neoprene gaskets hardened, the seals may be acceptable if the seating remains undisturbed while weighted down.

Summary

Tests were carried out at ANL to determine the effect of high-level gamma radiation exposure[6,7] to selected HEPA filters. Under test conditions, all filters showed acceptable (< 0.03%) DOP aerosol penetration over the entire exposure range of 10^7 to 1.5 x 10^9R. Metal frame, glass pack HEPA filters and

neoprene gaskets have been selected for installation in the main cell of the ANL HFEF facility. Neoprene gaskets hardened but were preferred as the PVC gaskets became unacceptably gooey in these tests.

References

(1) N. J. Swanson, D. P. Minesz, and J. R. White, "The Hot Fuel Examination Facility (HFEF)," Proceedings 19th Conference Remote Systems Technology, 3 (1971).

(2) R. H. Swanstrom and P. R. Hirsch, "Argon Atmosphere Filter System in HFEF Hot Cell," Proceedings 18th Conference Remote Systems Technology, 159 (1970).

(3) W. H. Echols and J. A. Young, Studies of Portable Air Operated Aerosol Generators, U. S. Naval Research Laboratory Report 5929, (1963).

(4) U. S. Public Health Service, Radiological Health Handbook, U. S. Government Printing Office, (1970).

(5) American Society for Testing Materials, Rubber: Carbon Black, Gaskets, ASTM Standards, Part 28 (1969).

(6) American Society for Testing Materials, Symposium on Radiation Effects and Radiation Dosimetry, (1960), ASTM Special Technical Publication No. 286.

(7) R. O. Bolt and J. C. Carroll, Radiation Effects on Organic Materials, Academic Press, (1963).

Figure 1

DOP Filter Test Apparatus

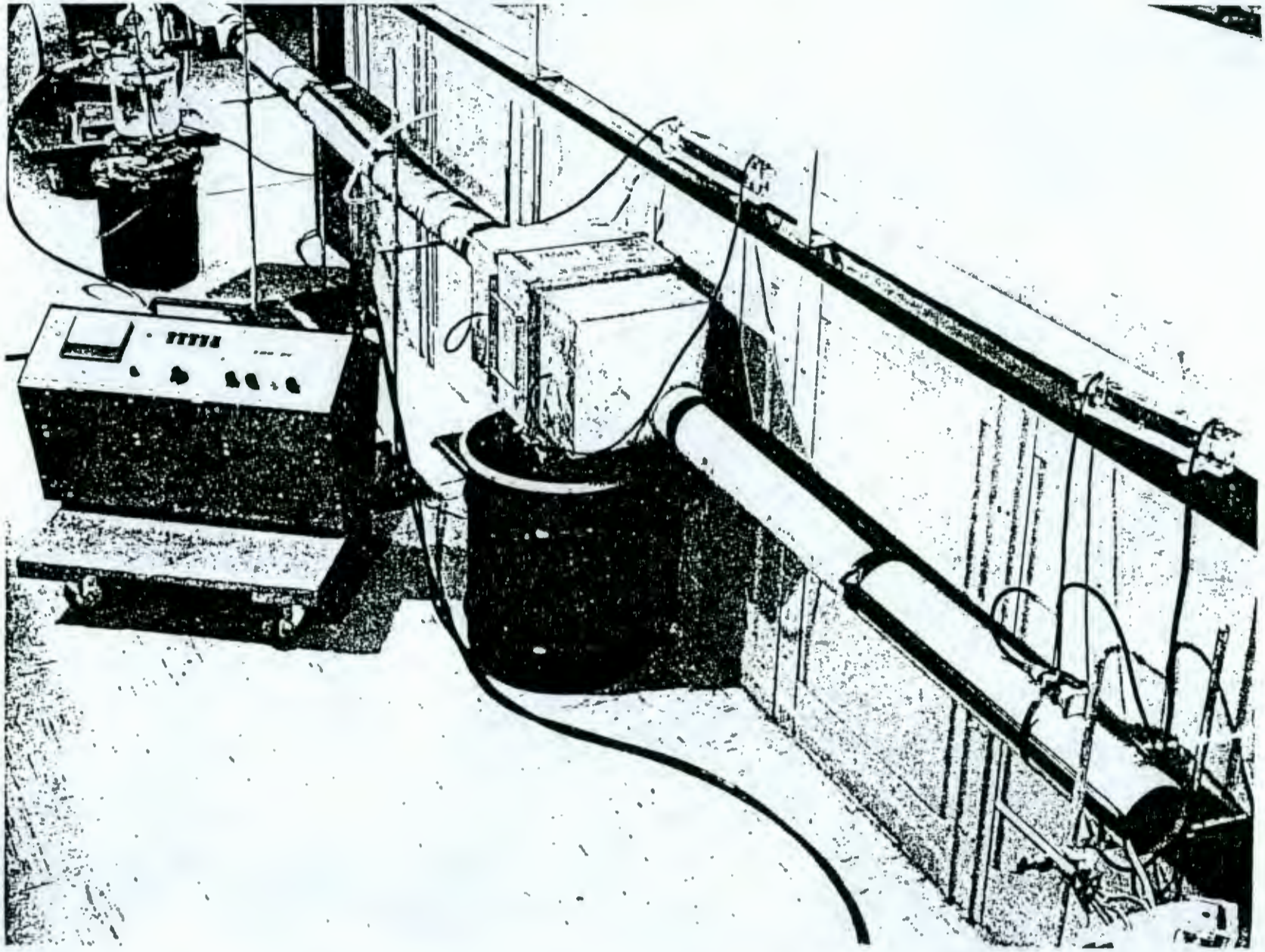
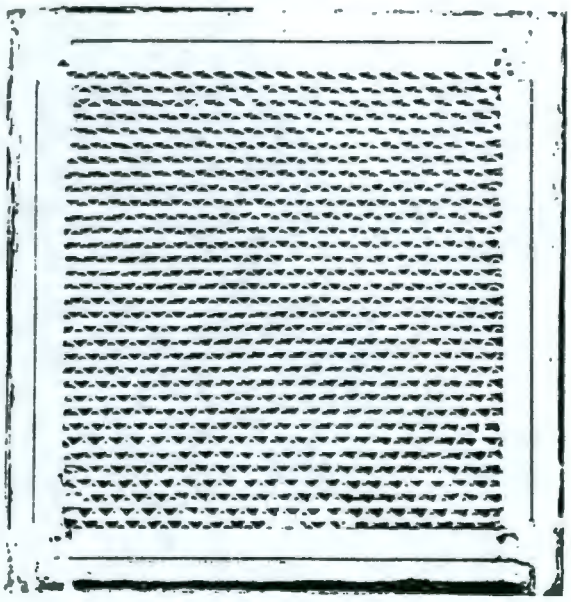
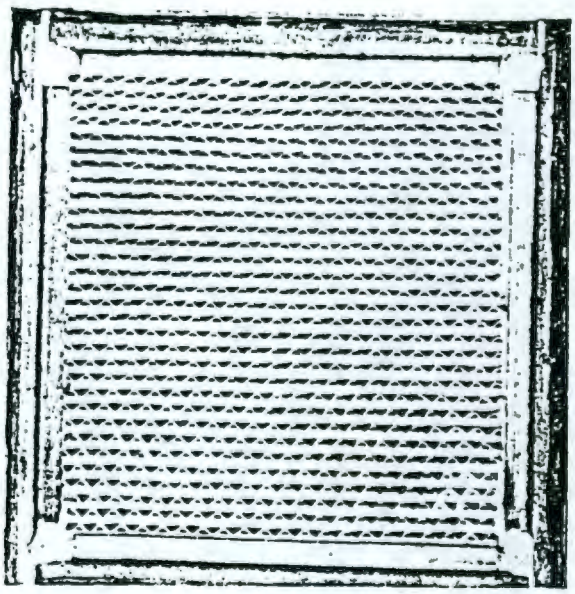


Figure 2

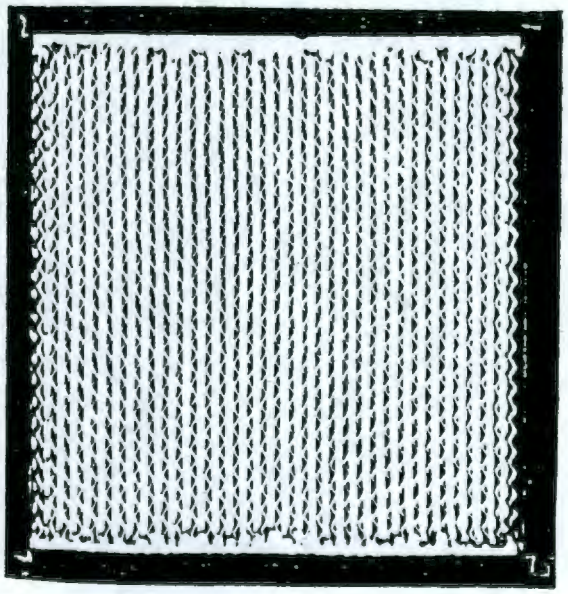
HEPA Filters After Cobalt-60 Irradiation to 1.5×10^9 R.



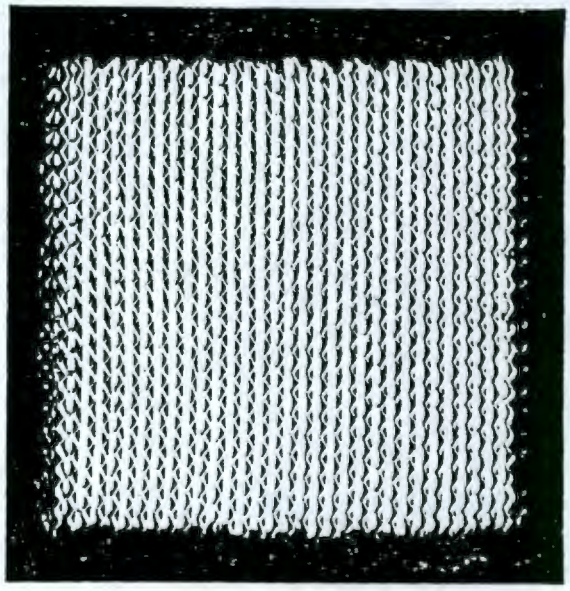
No. 1



No. 3



No. 6



No. 5

DISCUSSION

FIRST: Did you check your filters after radiation to find out how well they might withstand vibration, or other handling? I have the impression they become quite brittle and fragile.

CHEEVER: The filters were only subjected to the vibration of handling and transport to another building for DOP testing between irradiation steps and stressing at about 3 times rated flow for 15 minutes to one hour at each step.

MURROW: Did you notice any particular degradation of the pressboard frames?

CHEEVER: The pressboard frames darkened and may have been less strong; although we made no measurements. The filter frame didn't crumble.

JONES: Were these water-repellant filters or non-water-repellant?

CHEEVER: Water-repellant.

JONES: Will they be exposed to high humidity or dry air in service?

CHEEVER: Our application is in an argon atmosphere cell. This is very dry.

BURCHSTED: Did the hardened gaskets tend to crumble or tend to fall away from the filters?

CHEEVER: No. The gaskets remained intact except at one step. After a 10^8R exposure, one piece of neoprene adhered and pulled off.