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The Development of a Lightweight, Compactible/Disposable Hepa Filter

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The problem of how to dispose of spent, radioactive high efficiency and hepa filters is of increasing concern to operators of both government and commercial nuclear facilities. Incineration, shredding and compaction, chemical digestion or vitrification have all been suggested as possible means of handling and disposal.

The 24" x 24" x 11-1/2" size filter is the workhorse of the industry because it is used in the greatest numbers and because it is now the largest nuclear grade filter. This filter weighs between 35 and 70 pounds (clean) and thousands of such filters are removed annually from radioactive service.

The dilemma is worsened by the fact that hepa filters are constructed of rigid, heavy duty frame materials, separators, sealants and faceguards which, once assembled, aid in protecting them from damage; in transit, during handling and installation, in harsh operating environments or during a design basis accident. In other words, a device that is expected to survive any number of hostile incidents is not designed for convenient disposal.

At this time, no one method of disposal has been selected over another. Thus, the design of an easily disposable filter must address the several methods at hand. At Flanders, development has been progressing on a hepa filter that shows some potential for all of these methods. During the initial planning and design phases several assumptions were made as the basis for the design criteria. First, a filter that is to be shredded and compacted, or simply compacted, should not have a rigid frame material. Second, a filter that is chemically digestible should be limited in the number of different construction materials (one would be ideal). Third, where incineration is used it would be convenient if all materials of construction were combustible at or below the melting point of the boron silicate microfibers which make up the element itself.

A standard 1000 CFM hepa filter consists of four major materials of construction; filter medium, frame material, sealant and separators. Two others, faceguard and gasketing material, occur frequently. The separatorless design filter was the obvious choice to eliminate one major component, the separators. Almost eight pounds of aluminum is supplied with each 1000 CFM filter. By itself, a trimmed SUPER-FLOW® element or pack weighs only 5-1/4 pounds.

Standard separator type and SUPER-FLOW filter elements are framed in similar fashion. After the pack has been assembled it is the correct width for the frame but has excess material top and bottom. These edges are trimmed and are known as the "cut" edges of the pack. Historically, these cut edges have been the most difficult to seal when bonded to the frame material because each edge consists of a multitude of tiny channels, all potential leak paths. Therefore, one of the simplest methods of effecting a leakproof bond is to immerse or "pot" the cut edges into a sealant during its fluid state (Figure 1).

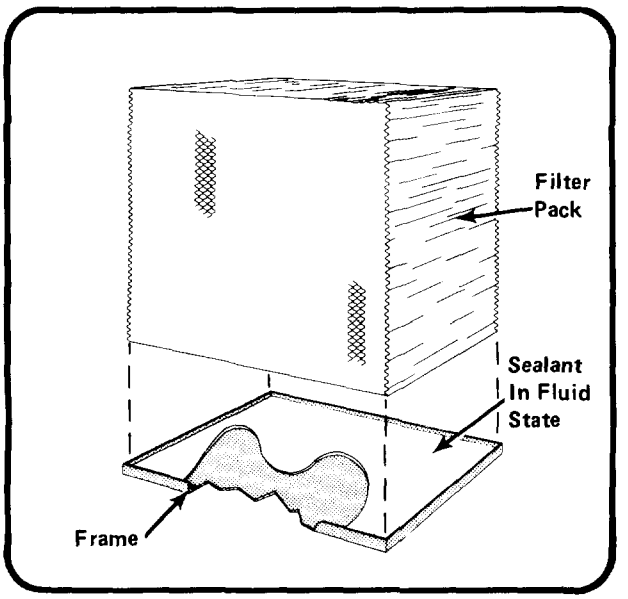

Figure 1
Bonding the Element to the Frame (One Side)

The procedure for producing a disposable filter, or "crust" filter as we have begun to call it, is similar to the potting process except all four sides of the pack are potted into a liquid material which will become the crust (Figure 2).

The first crust filters were made of reinforced glass, but the resins used were determined to be a potentially hazardous health risk to plant workers and the focus shifted to urethane, a component that is currently in use as a sealant and which has been qualified at both Edgewood Arsenal and Underwriters Laboratories. Any material which cures from a liquid state to a solid and which has good bonding characteristics is a prospective material for crust filters.

Once a side has been potted and has cured, a release agent in the mold enables the pack and crust to be removed. The mold is of such shape that the completed crust has two shoulders around the frame and peripheral to the filter faces. The resultant embodiment is a universal cartridge which may be fitted with any number of headers or flanges to adapt the filter to any number of installations, such as various gasket seal, fluid seal or nipple connected arrangements common to industrial and laboratory uses (Figure 3)*

It is recognized that the crust filter cartridge is inherently more vulnerable to damage since most of protection in conventional filters is the frame itself. Several other features of the crust filter give it unique characteristics and should aid in overcoming this problem. First, in working with various plastic frame filters for non-nuclear applications it has been the experience of Flanders that the separatorless element, when used with resilient sealants and frame materials, is capable, as a finished filter, to be racked out of square without damage and can tolerate much more of this than can the stiffer separator type construction.

Also, the periphery of the SUPER-FLOW element, prior to being framed, is of such a shape that when potted the result is a ribbed crust on all four sides. Outwardly the crust can be flat in appearance since the natural ribs are all inside and hidden from view. The crust is, therefore, of varying thicknesses, but the internal ribs are oriented in the direction of the thrust when the filter is installed. If required, additional strengthening ribs can be formed on the outside.

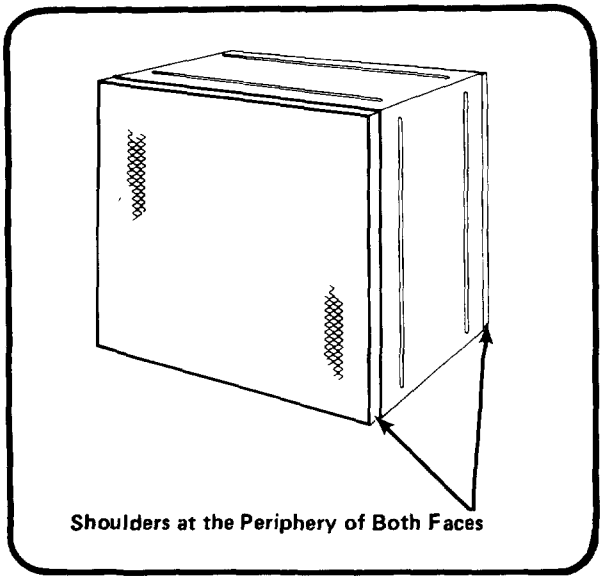

Figure 2
Filter Cartridge (Crust) Without Headers

A glass faceguard, a 6 x 6 mesh woven material, is expected to be standard with the crust filter. When the filter is constructed the faceguard is "captured" beneath the header (Figure 3) when it is affixed to the crust, much the same as screens are put upon screen doors.

*Patent Applied For

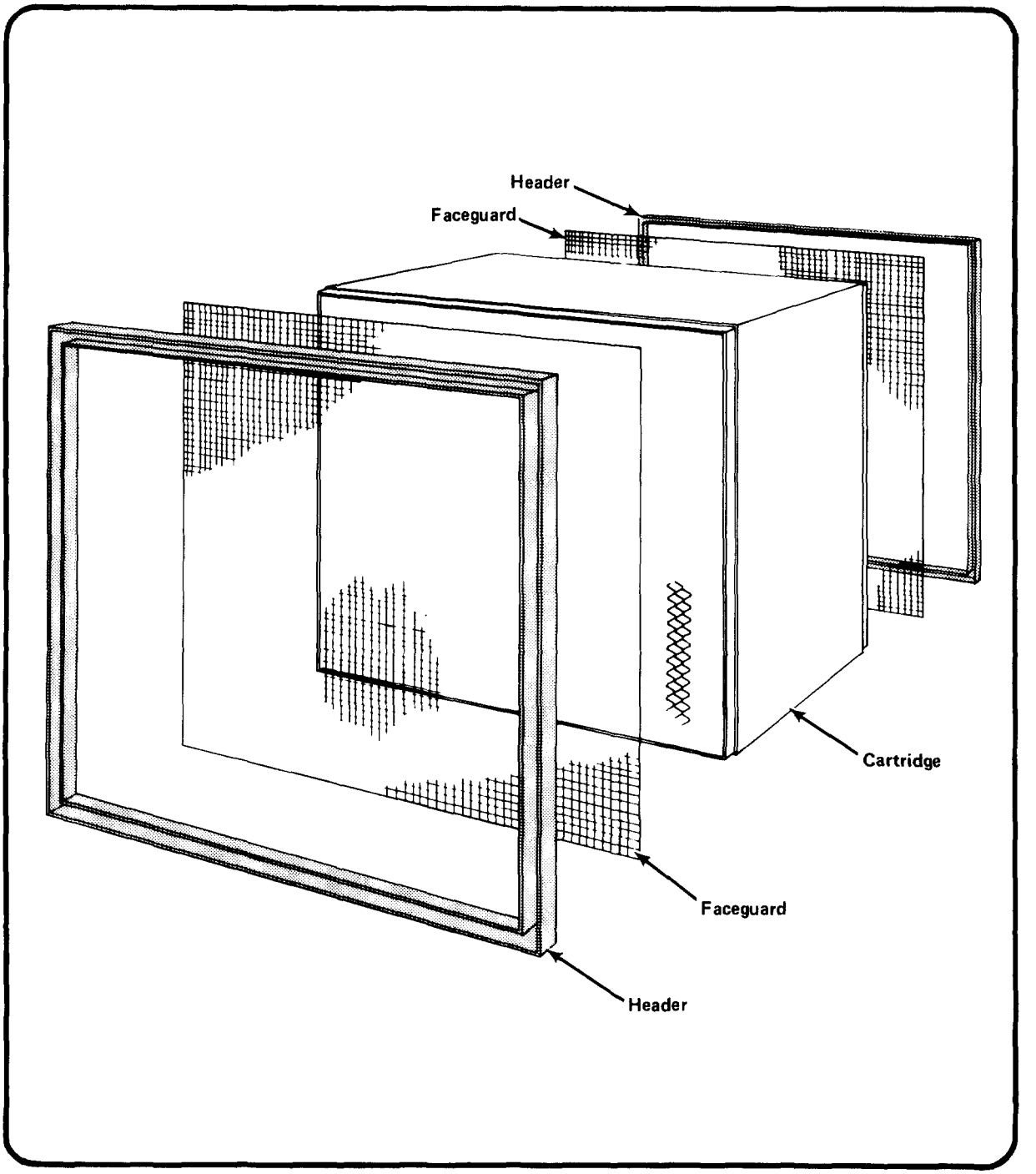

Figure 3
Exploded View of Cartridge Assembly

Dependent upon the eventual framing, the headers can be of various metals or plastics. Since the cartridge itself will bow out of square without a header, some reinforcement is necessary. The selection of the header determines the weight of the crust filter, but including headers the weights have run from 15.75 pounds to 20.75 pounds, far less than the lightest weight 35 pound hepa filter!

Finally, it is anticipated that some installations, for example, walk-in plenums with gasket filters, will require a basket, retainer or other intermediate device which will serve to transfer the load from existing

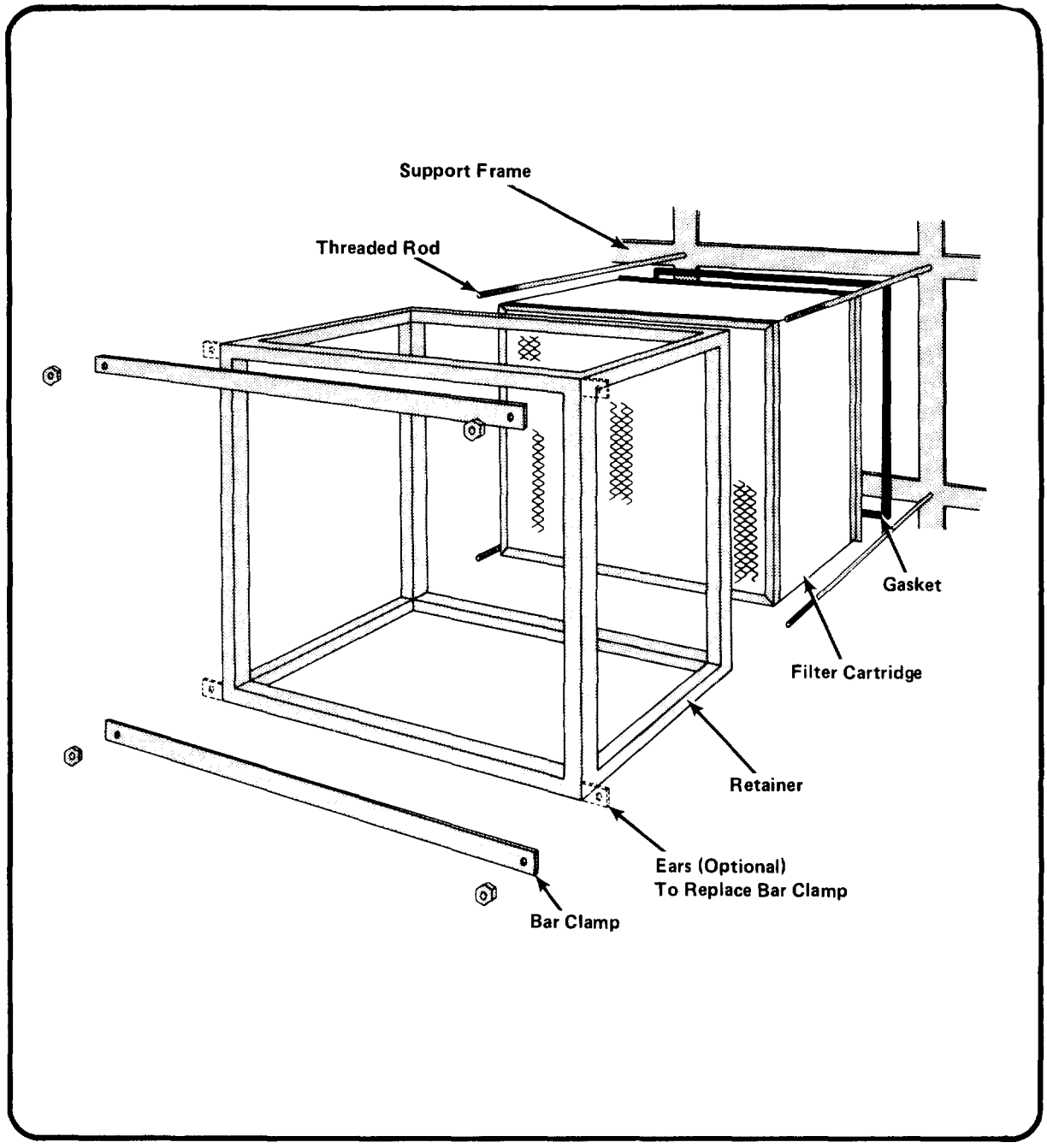

Figure 4
Exploded View of Cartridge Element Installed in Typical Walk-In Plenum Filter Bank

mechanisms onto the filter gasket (Figure 4). This retainer, if metal clad, could also give additional fire protection. When the crust filters were changed out the retainer would be reusable.

In conclusion, submission to Underwriters Laboratories for the heated air test to obtain the UL 586 label will be a significant benchmark in the progress of this project. Mistakes were made in a preliminary test when the two filters tested were found to have insufficient fire retardant additives in the urethane and no intermediate framing was used during the test. Resubmittal is expected in the near future. Several DOE project managers have expressed an interest in submission of samples for compaction, chemical digestion and incineration.

DISCUSSION

FIRST: I recall that some years ago Flanders Filters made a filter cast entirely from fibers that was suitable for high temperature use in that the frame and the filter material including the separators, were all constructed of precisely the same material. The filter could be heated repeatedly to 1500° F, and rapidly cooled to room temperature without damage. Does the crust that you have described have this characteristic?

ALLAN, T.: First of all, urethane is not suitable for high temperature. The filters you recall were hand sculpured and in those days were $400 - $500 apiece; so, I dare say they would probably be $3,000 - $4,000 today. We are looking for something that will apply to most applications, rather than just high temperature.

FISH: Does the pack take the compression required to seal the gasket to the frame? How does filter pack seal in the retainer, or does it?

ALLAN: In the paper, we discuss the use of an intermediate retainer that could be used to "sandwich" the flange or header of a single flange filter between the retainer and the mating framework. This would serve to distribute the load from the tie-down mechanism onto the gasket without undue stress to the cartridge filter.

Evaluation of Hepa Filters Meeting Mil-F-51068 Purchased on the Open Market. Are They Nuclear Grade?

Thomas T. Allan
Robert V. Cramer
FLANDERS FILTERS, INC.
WASHINGTON, NC

Historically, the principle manufacturers of hepa filters in the U.S. have participated in a number of programs to ensure the best possible use and application of hepa filters for nuclear service. The basic specification, Mil-F-51068[1], requires that manufacturers of nuclear grade hepa filters submit their filters for testing and qualification to both Edgewood Arsenal and Underwriters Laboratories. The specification also lists various acceptable construction materials, construction methods, types of assembly, marking and performance testing.

In recent years, certain manufacturers of hepa-like filters have shown an increasing inclination to offer quotations and sell filters in response to requests for quotations on filters meeting Mil-F-51068. These manufacturers are not encumbered by the high costs of participation in specification writing committees, in-house quality assurance programs, qualified products lists, Underwriters Laboratories testing or even ownership of the essential tool of the hepa filter manufacturer, a Q 107 Penetrometer.

To support this argument, a Request for Quotation form for a bogus company, Nuclear Test Sales and Service, was first printed and then typed up to request bids on filters as follows:

> "Hepa Filter, 24" x 24" x 11-1/2", Wood Frame, Type 1B, Aluminum Separators, Per Mil-F-51068 (latest edition)." (See appendix).

Following the receipt of quotations seven filters were ordered from seven manufacturers. They were shipped directly to an independent warehouse, were put unopened into a wood crate and reshipped to the retest facility at Rocky Flats for evaluation. It was determined at the test station that none of the filters were in compliance with the specification.

Table 1 shows that four of the filters exceeded the maximum DOP penetration, allowed (.030%) at either the 100% or 20% of the test flow rate (1000 CFM) and that four filters exceeded the maximum resistance of 1.0" w.g. Only two of the seven filters passed both efficiency and resistance. However, a test patch of the medium in one of these two remaining filters failed the penetration test and the other failed on tensile strength (Table 2).

All seven manufacturers were unanimous in totally disregarding the basic requirements of the military standard; none had a UL 586 label, many had butt joints at the gasket corners instead of dovetail joints, four of the seven did not have rabbeted frame joints, construction was generally sloppy, the frame material on all but one was non-fire retardant plywood or particleboard (pressboard), staples rather than screws or nails were used on four of the seven filters, not one was supplied with faceguards and none are known to have been submitted to Edgewood Arsenal for testing for the Qualified Products Lists.

It is believed (but not known) that at least four and perhaps five of the seven manufacturers do not possess the Q 107 Penetrometer required to test the hepa filters (Figure 1) and yet all the manufacturers imply in their sales literature that their filters have a minimum efficiency of 99.97% by DOP test. Several of the filters supplied by manufacturers who reportedly do not own a penetrometer had apparently false penetration values written on the label. Others simply stated "99.97".

Test Reports*

Table 1 - Filter Tests

Filter	Resistance In W.G. (Q 107)	DOP Penetration %		Remarks
		100%	20%	
A	1.10	.006	.006	No UL Label, Butt Joint Gasket, Plywood Frame.
B	.95	.012	.016	No UL Label, Butt Joint Gasket, Loose Pack, Pressboard Frame Very Irregular.
C	1.02	.100	.280	No UL Label, Shipping Damage, Loose Gasket, Butt Joint Gasket, Holes in Media, Frame Loose.
D	1.10	.030	.800	Irregular Separators, No UL Label, No Visual Damage,
E	.95	.006	.006	Uneven Pack, No UL Label, Poor Quality Plywood (Splinters)
F	1.15	.010	.008	Butt Joint Gaskets, No UL Label, Pressboard Frame.
G	1.00	.100	.350	No Visual Damage, No UL Label, Pressboard Frame.
(Acceptable Limits)	1.0	.030	.030	UL 586 Label, Listing on QPL, Fire Retardant Particleboard or Plywood

Table 2 - Mil-F-51079A Tests (Paper)

Filter	Tensil		Resistance (Q 127)	Penetration (32L per Minute)	Media Thickness	Water Repellency
	M	X				
A	3.30	3.25	37 MM	.014	.018	38"
B	4.53	4.18	36 MM	.042	.014	25"
C	4.45	2.70	39 MM	.016	.013	26"
D	5.10	4.06	39 MM	.010	.020	41"
E	3.56	2.01	38 MM	.010	.015	47"
F	4.70	4.68	40 MM	.026	.014	33"
G	5.78	4.65	38 MM	.014	.016	31"
(Acceptable Limits)	2.5 Min.	2.5 Min.	40 MM Max.	.030 Max.	.015 Min.	20" Min.

*Transcription from the Inspection and Test Report of the Rocky Flats - DOE Filter Certification Laboratory.
NOTE: Tables 1 and 2 - Shaded areas indicate non-compliance to specification.

As the market for hepa filters in the United States and abroad has grown the number of manufacturers in the USA has increased from the original three to more than fifteen. Most of these newer manufacturers have concentrated on sales to non-nuclear applications; clean rooms for micro-electronics manufacturers, laminar flow devices for parenteral drug manufacturers and certain non-nuclear containment systems. The users in these industries do not always demand verification of filter performance, either at the factory or in service, and construction specifications are frequently non-existent. This has opened the door to a wide variety of products all which are produced and sold as hepa filters.

In the 1960's the now defunct American Association for Contamination Control convened a committee to write the specification CS-1T[2] which, at Flanders, has been used as the basis for our own categories for hepa filters; the Type A (Industrial Grade), Type B (Nuclear Grade) and Type C (Laminar Flow Grade). These filters differ not so much in performance, but in the tests performed upon them to qualify them for service in a specific application. The categories serve to alert the specifer, owner and/or buyer that all are not identical. It should be mentioned here that Flanders now manufactures a fourth category of hepa filter, a so-called generic hepa filter manufactured under the White Label Brand. This decision was made to respond to the demands of the marketplace as these newer manufacturers began to offer low quality products at lower prices. These generic filters will not be sold for nuclear service, but there is no guarantee that they will not be resold for that purpose.

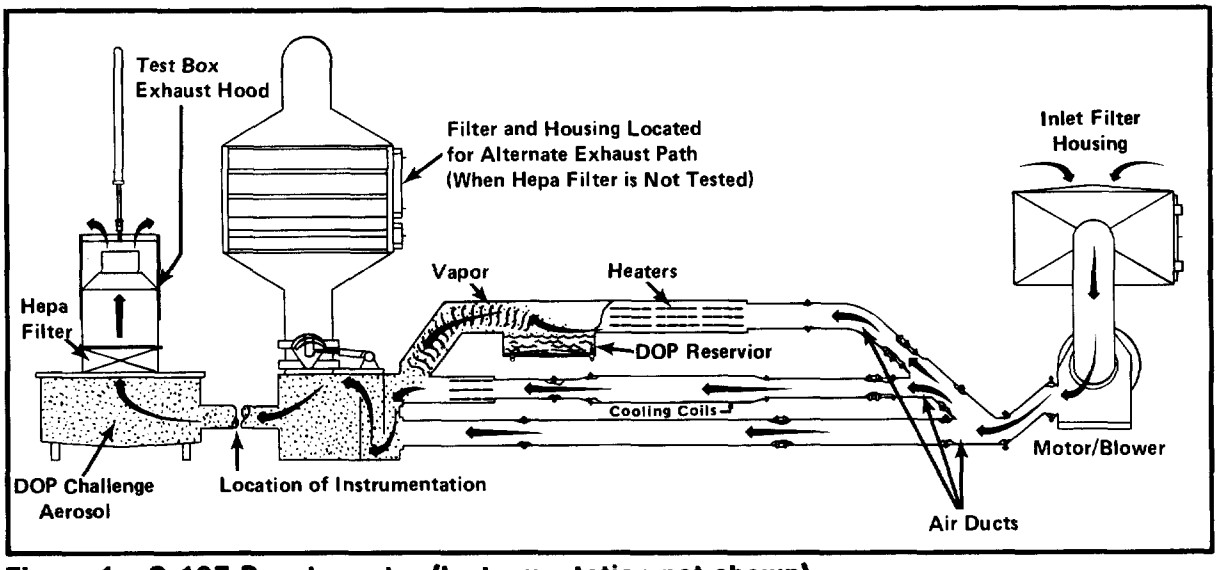

Figure 1 - Q 107 Penetrometer (Instrumentation not shown)

That some of the manufacturers are ignoring the basic requirements for filters destined for nuclear service is not surprising. Experience has shown that many users are frequently confused by the myriad of military, federal and site specifications written for hepa filters. It is not uncommon, for example, to receive requests for probe-tested hepa filters from nuclear facilities operated for the Department of Energy.

The current system for qualification of hepa filters by those manufacturers who do participate in industry programs is not a panacea and although it offers some security it too should be scrutinized. A recent heated air test at Underwriters Laboratories witnessed by Flanders showed a temperature at one location on the filter face to be 1300° F, not 700° F, ±50! The result was a concave hole on the face of the filter the size and shape of the interior of a coffee cup. The glass medium and aluminum separators had melted and fused together. Even more remarkable was the fact that this damaged filter passed UL's cold DOP test. Flanders also observed during another product evaluation session that UL's instrumentation being used as acceptance tools had exceeded the calibration due date by two years!

Submission of filters to the U.S. Army at Edgewood Arsenal carries with it its own problems. Edgewood is not always open for business and is therefore unresponsive to changes in construction materials, new techniques or new product ideas that might eventually benefit the user. (I would like to add my remark about Edgewood Arsenal is directed toward the system of a 5 year interval between start-up times as stipulated in the military standard. In fact, the interval is far greater. The staff at Edgewood Arsenal have always been willing to work with manufacturers on an unofficial level.)

Clearly a better definition of what constitutes a hepa filter suitable for nuclear service should be established. Additional specifications will not solve the problem. All specification writing, qualification and monitoring of manufacturers' certifications should be streamlined and put under one roof to make the selection of a filter for nuclear service less complex to the unwary buyer. A single identifying label or stamp should be affixed to qualified filters so that manufacturers who have participated can advertise this fact. There is strong evidence to suggest that unqualified hepa filters that have never been tested on a Q 107 Penetrometer have already been put into service in commercial reactors. At a time when the nuclear industry is faced with public skepticism this matter deserves our serious attention.

References

1 Mil-F-51068D (EA) Military Specification, Filter, Particulate, High Efficiency, Fire Resistant.
2 IES CS-1T, Standard for Hepa Filters.

Appendix

NUCLEAR TEST, SALES and SERVICE

P.O. BOX 4121
SEVEN CORNERS, VIRGINIA 22044

REQUEST FOR QUOTATION

ORIGINAL OF THIS QUOTATION MUST BE AT THE ABOVE ADDRESS BY _____ DATE

TO ABC Company

INQUIRY NO. _____

DATE _____

FOR SHIPMENT TO _____

DATE REQUIRED _____

DELIVERY F.O.B. _____ DATE SHIPMENT CAN BE MADE _____

TERMS _____ TO BE SHIPPED FROM _____

QUANTITY	ITEM AND DESCRIPTION	LIST PRICE	NET PRICE	UNIT
	Hepa Filter, 24" x 24" x 11-1/2", Wood Frame, Type 1B, Aluminum Separators, Per Mil-F-51068 (latest edition).			

The Bidder is advised that unless this contract is exempt under applicable rules, regulations or orders of the Secretary of Labor, from the provisions of Subpart B of Part II of Executive Order No. 11246, dated September 24, 1965, as amended by Executive Order No. 11375, dated October 13, 1967, the provisions of Section 202 thereof and Section 503 of the Rehabilitation Act of 1973 are, to the extent they may be applicable, made a part of this order by reference.

THIS INQUIRY IMPLIES NO OBLIGATION ON THE PART OF THE BUYER. IF SUBSTITUTES ARE OFFERED MAKE FULL EXPLANATION. WE RESERVE THE RIGHT TO REJECT ANY OR ALL BIDS AND OR TO ACCEPT THE MOST ATTRACTIVE OFFER

THIS IS NOT AN ORDER

By A.T. Freedy, Buyer

By _____ SELLER'S SIGNATURE

DISCUSSION

BURCHSTED: Did you send your requests for bids to any of the major HEPA filter manufacturers, who are currently listed in the Military Qualified Products List (QPL) F-51068?

ALLAN, T.: Request for bids were not sent to manufacturers of QPL products.

BURCHSTED: This paper addresses a problem we have recognized for some years, and more particularly at present when more companies are getting into the manufacture of HEPA filters. DOE hopes to correct the situation with regard to its own operations by issuing a standard which requires DOE users to purchase HEPA filters defined by objective specifications (a choice of MIL-F-51068 or in-house specs); and specifies certain minimum requirements, including standard values for those requirements, which must be included in in-house specifications. I believe that you have done the nuclear industry a service in getting this issue out in the open.

HEPA filters for any critical application, nuclear and non-nuclear, should be purchased to comprehensive specifications that include requirements for (1) submitting objective evidence of satisfactory completion of certain qualification tests on prototype filters; and (2) satisfactory completion, including actual test values, of penetration and resistance tests on each individual filter unit submitted for acceptance.

ALLAN, T.: Thank you. We would like to work with the entire industry toward this objective.

FISH: I expect that the CONAGT codes will state minimum requirements for HEPA filters, particularly for nuclear applications.

ALLAN: We concur and support these efforts.

MOELLER: Could you clarify how you selected the seven manufacturers from whom you purchased filters?

ALLAN: Request for quotation forms were sent to all manufacturers who advertise HEPA filters. Not all responded. Later, we excluded those respondents known to have participated in the QPL program and we purchased only from those who had not submitted filters to the program.

PRATT: In the U.K., practice is to purchase from approved manufacturers only.

ALLAN: It had been my understanding that this was the practice in the U.S. To our surprise, representatives of the NRC have stated that this is not the case. This should be changed.

STEINBERG: I agree in essence with the speaker, he has performed a good service. In the pharmaceutical and electronic field, we find there are more and more people buying more and more filters that are really not qualified. Of course, this is something that is very close to my heart because I would like to see all the filter manufacturers using DOP test equipment. We warn prospective customers that they should be sure to buy filters that meet the basic definition of the HEPA filter. They must have no more penetration than .03%, must have rigid sides, and so on. The more we can disseminate this information, I think, the better the industry will be. There are about 14 manufacturers altogether.

RECENT CHANGES IN MIL-F-51068 SPECIFICATION

by

George P. Smith *
U.S. Army, Chemical Systems Laboratory

On February 6, 1981, the E revision to MIL-F-51068 was issued. It contained all the engineering changes which were outstanding at that time. Since then, additional changes have been proposed as new requirements. Action is now in progress to incorporate these changes into the subject specification as quickly as possible. In the fall of 1981, these proposed changes were sent for comment to all the filter manufacturers who have filters listed on QPL-51068-1. The results of the comments are reflected in the proposed changes which are given as follows:

a.) the addition of two large size filters: size 7 (1500 cfm) and size 8 (2000 cfm);

b.) the use of TP 304 stainless steel, and 3/4 inch laminated veneer lumber as frame material;

c.) the use of tinted vinyl-epoxy coated aluminum as separator material;

d.) an increase in the air resistance to air flow values for filter sizes 1, 2 and 3;

e.) an increase in the thickness of the aluminum which is used as frame material.

The interest shown by the filter industry in recent years to market HEPA filters which have high capacities and low air resistances has caused users within the nuclear energy program to indicate a need for them and to request such filters to be included in the MIL-F-51068 specification. It was decided that two sizes will be added, namely size 7 with a rated flow of 1500 cfm and size 8 (2000 cfm). The maximum air resistance for each at rated flow will be 1.30 in. w.g. The size of these filters will be identical to those of filter sizes 5 and 6 (24 (+0, -1/8) x 24 (+0, -1/8) x 11½ (+1/16, -0).

DOP (dioctyl phthalate) testing of size 7 and 8 filters will have to be done at 1000 cfm and 20% of rated air flow. The 20% flow presents no problem and is in accordance with the normal test procedures, but the 1000 cfm flow is limited by the maximum size of available and approved DOP test equipment at this

* Mr. Humphrey Gilbert presented this paper orally in the absence of Mr. Smith.

time. DOP test data have been determined by the Chemical Systems Laboratory (CSL) on a number of HEPA filters at rated flow and 20% rated flow and the results showed no significant differences in the values. This was surprising in that the DOP value was expected to decrease with a lowering of flow rate. Based on these observations and until proven otherwise, the maximum DOP penetration for filters size 7 and 8 at 1000 cfm and 20% rated air flow will be 0.03%. It should also be pointed out, here, that these filters will contain filter medium that meets the requirements of MIL-F-51079 and must be listed on QPL-51079-1.

At the request of the filtration experts within the nuclear energy program, TP 304 stainless steel and 3/4 inch laminated veneer lumber will be permitted for use as frame material. The TP 304 steel is in demand by users and will be in addition to the TP 409 steel. The difficulties encountered in obtaining the 3/4 inch plywood and particle board as specified in MIL-F-0051068E has led to the search for other wood materials for making filter frames. One such candidate is a 3/4 inch laminated veneer lumber, for exterior application, with a minimum density of 36 pounds per cubic foot; made of veneers of 1/10 inch or 1/8 inch in thickness and arrayed for lamination with all grains parallel to the length of the member; and complying with the requirements of Reseach Committee Report No. 3155, Feb. 1979 International Conference of Building Officials. Samples of filters with frames made of this material were tested at CSL in accordance with the Heated Air Test of MIL-F-0051068E and found to resist burning. It is proposed that the subject specification should not require a flame spread classification rating per ANSI E84-80 for this material at this time.

Vinyl-epoxy coated aluminum foil separators will be used in future filters to resist some acidic atmospheres. The filter specification will require the 0.0015 inch thick aluminum to be coated on both sides with 0.8 to 1.2 mils of a tinted vinyl-epoxy coating which meets the following off-gas, peel and flexibility requirements:

a.) Off-Gas - Off-Gas volatiles evolving from a 2 x 2 inch sample coated separator shall not exceed 5% by weight when it is heated from 20°C to 1000°C.

b.) Adhesive Peel - the coating shall pass an adhesive peel test with a rating of 3A or better when tested according to ASTM D3559 using Method A.

c.) Flexibility - The coating shall show no breaks, cracks, etc. when tested in accordance with Feb. 141B, Method 6221.

This coating will be tinted with a colored dye to check its uniformity of application on to the aluminum.

Experience has shown that it is very difficult to make size 1, 2 and 3 filters which will pass the maximum air resistance to air flow requirement of 1.0 in. w.g. It has been suggested that the specification show a lower rated air flow requirement for these filters, but CSL recommends that the maximum air resistance be raised to 1.30 in. w.g. instead. This would keep the sizes unchanged.

A review of the requirements of the aluminum frame material indicated that the thickness of the metal was not great enough. It should have at least been as thick as the steel frames and equal to the material which was normally used by the filter industry. Further study led to a recommendation for the use of 14 guage (B & S) aluminum.

It must be mentioned at this point that while new materials are being proposed for the filter specification, new materials are also planned for the filter medium specification (MIL-F-51079). The glass-asbestos filter medium is now in disfavor and relatively unavailable and a replacement is needed. A candidate which is available is a medium that contains glass and Nomex fibers. In order to permit the use of this material, the filter medium specification will limit the maximum binder content of the medium to 7% by weight and the maximum Nomex content to 7% by weight.

After the above changes are incorporated into the filter specification, a QPL testing program will be publicized and scheduled for filters sizes 7 and 8. In addition, the updated filter specification will be fully coordinated with other government agencies that share an interest in it and then it will become available to everyone from the U.S. Printing Office.

DISCUSSION

ALLAN, A.R.: There is an inconsistency between UL and QPL on plywood. It is our understanding that the plywood you described is not acceptable to UL. You say it is, but I don't know the source of the information. We sumbitted sheets of it and it was not accepted. Which brings up the question of who is to be responsible if UL and QPL do not agree on what is allowed. The manufacturer, theoretically, is supposed to be responsible for the results if there is a fire. This is one of the many inconsistencies that has to be ironed out in order to get the manufacturer off the hook.

GILBERT, H.: I think the fact that it is unacceptable is more of a political decision than a proctical descision by virtue of the tests. I was told by Underwriters Laboratory that if it appeared in the MIL-SPECs, it would probably be a goof on their part.

FIRST: Just to clarify this point, are you saying that they would not test it, or that they tested it and they said it would not pass.

ALLAN: We submitted it and it did not pass. It was rejected after the tests.

DEVELOPMENT AND EVALUATION OF ACID-RESISTANT HEPA FILTER MEDIA

G. W. Brassell and W. G. Thorvaldson

ABSTRACT

The purpose of this study was to extend the life of High Efficiency Particulate Air (HEPA) filters by developing a more acid-resistant filter media.

High Efficiency Particulate Air filter media were fabricated from combinations of fiberglass and acid-resistant fibers (asbestos, Nomex®, Kevlar®) and then subjected to an acid environment. Filtering performance (filtering efficiency and air-flow resistance) of media containing different amounts of Nomex and Kevlar was monitored as a function of exposure time and compared to 5 percent asbestos and 100 percent glass media.

I. INTRODUCTION

The work reported in this report is a continuation of a study on "Development of Acid-Resistant HEPA Filter Components," presented by Woodard et al., at the 16th DOE Nuclear Air Cleaning Conference in 1980.[1]

The primary purpose of this particular phase of study was to extend the life of HEPA filters by developing a more acid-resistant filter media. This objective was addressed by fabricating filter media handsheets out of glass/Nomex and glass/Kevlar, and testing them in an acid environment. The results of the accelerated acid test were used to determine if the synthetic fibers were superior to asbestos with regard to acid resistance, and also to establish the amount of synthetic fiber required for formulating the most acid-resistant filter media.

HEPA filter media is normally composed of several different sizes of glass fibers bonded together with a polymeric resin. This media is required to have a filtering efficiency of 99.97 percent and an air resistance of less than 40 mm (water) when Dioctylphthalate (DOP) smoke-tested according to Military Specification F-0051079-D. This glass fiber composite must also be capable of meeting stringent strength and temperature requirements. Thus, fabrication of this filtering media is not a simple paper making process, but is rather a highly developed technology. Until recently, an acid-resistant filter media consisting of nominally ~90 percent glass, 5 percent asbestos, and 5 percent organic binder was used by the nuclear industry. However, the Office of Safety, Health, and Administration (OSHA) identified asbestos fiber as a possible carcinogen, and filter manufacturers were discouraged from using this material. Thus, an urgent need developed for an asbestos fiber replacement.

A search of the literature on acid-resistant synthetic fibers, together with discussions held with fiber and paper manufacturers concerning fiber material and size requirements, resulted in the selection of Nomex® and Kevlar® as potential candidates for replacement of asbestos in HEPA filter media.[1,2,3]

II. EXPERIMENTAL

Filter Media Handsheet Fabrication

Glass fiber filter media normally contains three different sizes of glass fibers plus a chopped strand. The fibers are designated as 110, 106, and 104. This produces a media consisting of 90 wt percent glass fiber, approximately 5 percent glass chopped strand, and about 5 percent organic binder. The proportional amounts of 110, 106, and 104 glass fiber determine the filtering efficiency and air resistance of the media. This information, along with the type of binder used, is considered proprietary information by some manufacturers. Thus, in this study, an attempt to determine the ratio of 110 to 106 glass fiber on efficiency and air resistance was made. This was accomplished by first eliminating the small 104 fiber and substituting Nomex and Kevlar fibers which approach the size of the 104 fiber.

Filter media handsheets were fabricated with the amount of 110 glass fiber held constant at ~52 percent, varying the amount of 106 glass from 30 to 40 percent, and varying the Kevlar from 0 to 10 percent. The next set of handsheets was fabricated from formulations with the 106 fiber held constant at ~40 percent, the amount of 110 fibers varied from 37 to 52 percent, and the Kevlar varied from 0 to 15 percent. The filtering efficiency and air resistance of these handsheets were determined by DOP testing. From these results the proper ratio of 110 to 106 fiber required for meeting efficiency and resistance specifications was established. Handsheets containing 5, 10, and 15 percent Kevlar fiber and 5, 10, and 15 percent Nomex fiber were then fabricated. Handsheets containing 5 percent asbestos and handsheets composed entirely of glass were also made for comparison purposes.

Accelerated Acid Testing

HEPA filters installed in some production buildings located at R.F. are exposed to acid environments containing from 1-8 ppm HNO_3 and less than 1 ppm HF acid. Under these conditions, a filter may last 3 months or longer before any noticeable acid deterioration. Thus, an accelerated test was designed to expose four filter media handsheets simultaneously to an acid environment. Table I shows the feed concentration, relative humidity, and air flow through the media that was used to obtain the desired acid concentration of 1100 ppm HNO_3 and ~5 ppm HF. The handsheets were mounted in a support fixture and DOP tested with the amount of DOP particle penetration and air resistance recorded (Spec. Requirements: <0.03 percent penetration and <40 mm air resistance) prior to placing in the acid test chamber. The mounted handsheets were then periodically (~100 hours) removed and retested with the effects of time of acid exposure on filter efficiency and air resistance plotted.

TABLE I
ACID CHAMBER CONDITIONS

Area of Filter Media Exposed:	~19 in.^{2}	
Acid Feed Conc.	HNO_3	17.85%
	HF	0.14%
Air Flow	0.8 CFM	
Humidity	50% ± 5%	

III. DISCUSSION

Filter Media Handsheet Fabrication

Filter media handsheets containing 5, 10, and 15 percent Kevlar, and 5, 10, and 15 percent Nomex were fabricated in 12-in. squares using a 1 ft^3 gravity drawn molding machine. Formulations were developed by first determining the effects of varying the 110 glass to 106 glass ratio on air resistance and particle penetration of fabricated handsheets. The results of this study, which are reported in Table II, reveal that the ratio of 110 glass to 106 glass must differ for each percent Kevlar or Nomex composition fabricated if the media is to meet air resistance (<40 mm) and penetration (<0.03 percent) requirements. The information obtained from this study was used to fabricate experimental handsheets (shown in Table III) for accelerated acid testing.

TABLE II
HANDSHEET FABRICATION - 110 TO 106 GLASS RATIO STUDY

% 110 Glass	% 106 Glass	% Kev	% Binder	% 1/2" C.G.**	% 1/4" C.G.	Resistance (mm H_2O)	Penetration
52	40	0	2	3	3	33	0.028
52	35	5	2	3	3	33	0.024
52	32.5	7.5	2	3	3	28	*0.100
52	30	10	2	3	3	27	*0.140
52	40	0	2	3	3	35	0.026
47	40	5	2	3	3	36	0.014
44.5	40	7.5	2	3	3	*42	0.006
42.0	40	10	2	3	3	*46	0.004
37.0	40	15	2	3	3	*53	0.002

*Out of Specification (Res. <40 mm, Pen. <0.030)
**CG = Chopped Glass

TABLE III
HANDSHEETS FABRICATED FOR ACCELERATED ACID TESTING

Acid Tests No. 1

% 110 Glass	% 106 Glass	% Kev	% Binder	1/2" C.G.**	1/4" C.G.	Res.	Pen.
48.5	38.5	5	2	3	3	35	0.002
47.5	35.0	10	2	3	3	36	0.003
47.0	30.0	15	2	3	3	39	0.002
48.5	38.5	(5% Asbestos)	2	3	3	37	0.002

Acid Test No. 2

		% Nomex					
47.7	39.3	5	2	3	3	45	0.008
46.0	36.0	10	2	3	3	39	0.010
43.8	33.2	15	2	3	3	35	0.020
48.5	38.5	(5% Asbestos)	2	3	3	33	0.007

Accelerated Acid Testing

Accelerated acid testing of handsheets was conducted in sets of four sheets. Each set tested included one handsheet containing 5 percent asbestos, which served as a control since asbestos was evaluated in a previous study.[1] The first set of handsheets evaluated in this study included: 5, 10, and 15 percent Kevlar and 5 percent asbestos. The handsheets were fabricated, mounted in holding fixtures, and DOP tested. The mounted handsheets were then placed in the controlled acid environment chamber and exposed. The handsheets were periodically removed, DOP tested, and placed back in the chamber until the sheets were out of specifications with regard to penetration and air resistance. Penetration and resistance values of these experimental handsheets which were exposed for a total of 487 hours, are shown plotted in Figures 1 and 2. Penetration values of the 5 and 10 percent Kevlar went out of specification (>0.03 percent) after about 375 hours of exposure in comparison to about 340 hours for 5 percent asbestos and 425 hours for 15 percent Kevlar. Air resistance values shown in Figure 2 reveal the handsheets containing Kevlar exhibit much lower resistance values then the asbestos at extended exposure time.

Handsheets containing 5, 10, and 15 percent Nomex and 5 percent asbestos were exposed to the same environment as the Kevlar media. The results of this run, which are shown plotted in Figures 3 and 4, revealed the 15 and 10 percent Nomex to be out of specification with regard to penetration after about 300 hours of exposure, followed by 5 percent asbestos at 340 hours. The 5 percent Nomex is slightly better than asbestos, lasting about 370 hours. Again, the air

resistance behavior of the Nomex containing handsheets was superior to the 5 percent asbestos. These different Kevlar and Nomex compositions can be compared to 5 percent asbestos and 100 percent glass media tested in a previous study and shown in Figure 5. Penetration values for 5 percent asbestos media were observed to remain within the specified value of <0.03 percent for twice the length of time as the 100 percent glass before going out of specification.

IV. CONCLUSIONS

- The most acid-resistant Nomex-fiberglass filter media composition, with regard to filtering efficiency, is 5 percent Nomex.
- The most acid-resistant Kevlar-fiberglass filter media composition, with respect to filtering efficiency, is 15 percent Kevlar.
- Fiberglass-5 percent asbestos filter media has double the service life (filtering efficiency) in an acid environment as 100 percent fiberglass media.
- Fiberglass-5 percent Nomex and Fiberglass-5, 10, or 15 percent Kevlar filter media are superior to the fiberglass-5 percent asbestos, with regard to service life (filtering efficiency), in an acid environment.
- In addition to improved filtering efficiency, the fiberglass-Nomex and fiberglass-Kevlar filter media exhibit lower increases in airflow resistance when exposed to an acid environment, than does fiberglass-5 percent asbestos.

ACKNOWLEDGMENTS

The authors wish to thank J. E. Hicks and Humphry Gilbert for their technical assistance, and W. D. Gilbert of the Filter Certification Laboratory for his assistance in fabrication and DOP testing of all handsheets.

REFERENCES

1. R. W. Woodard, K. Terada, and O. I. Bettedahl, "Development of Acid-Resistant HEPA Filter Components," Proceedings of the 16th DOE Nuclear Air Cleaning Conference, October 1980.

2. Robert Parsons (Hollingsworth & Vose), private communication.

3. Robert Plank (Herty Foundation), private communication.

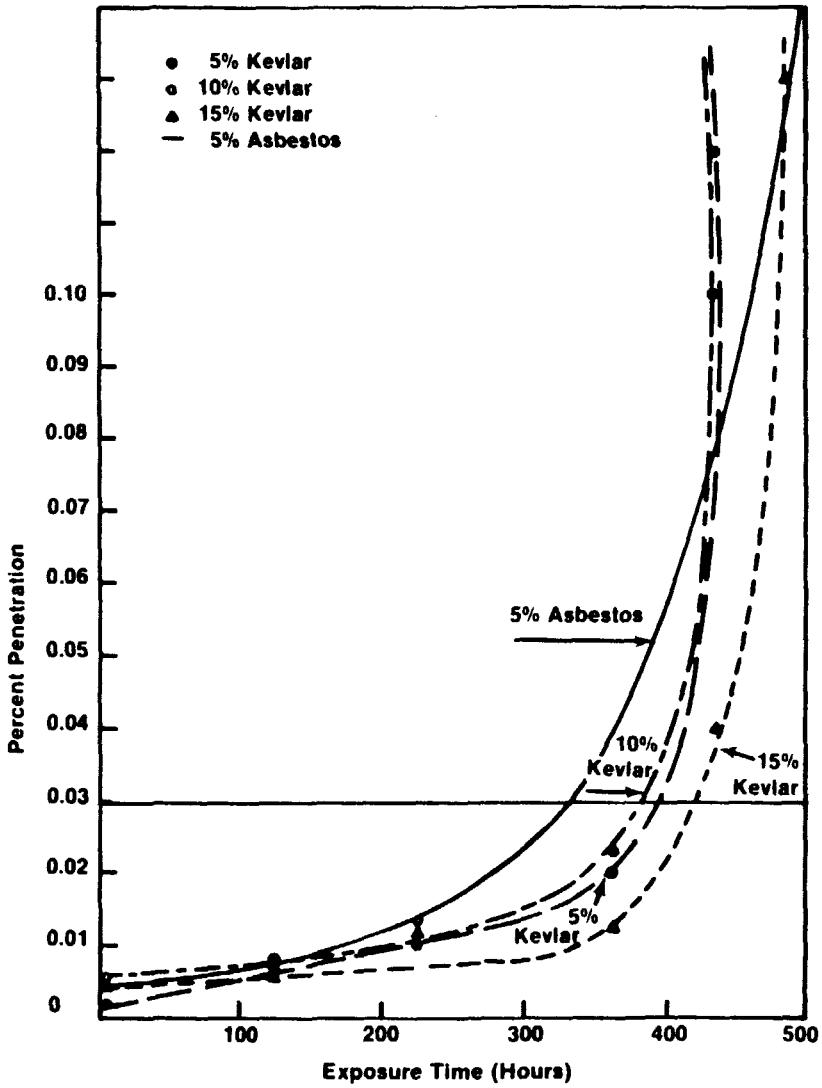

Fig. 1 Kevlar and Asbestos Containing Media Exposed to 1100 ppm HNO_3 and 5 ppm HF.

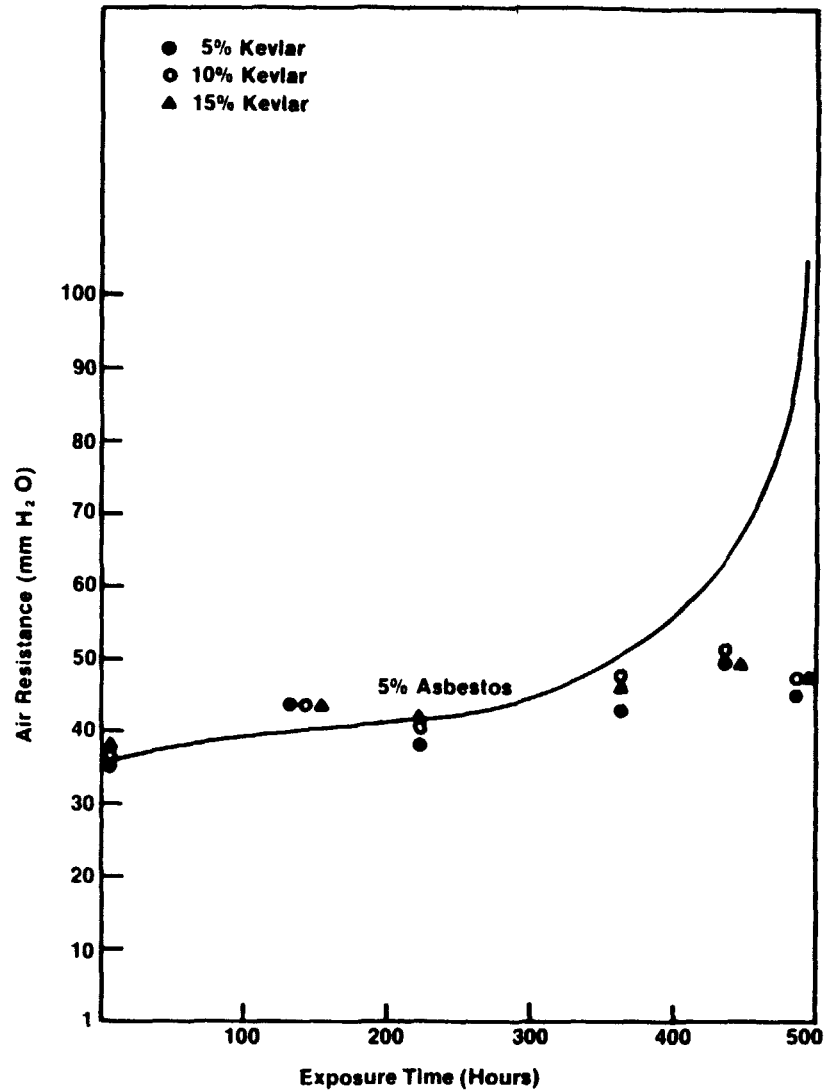

Fig. 2 Kevlar and Asbestos Containing Media Exposed to 1100 ppm HNO_3 and 5 ppm HF.

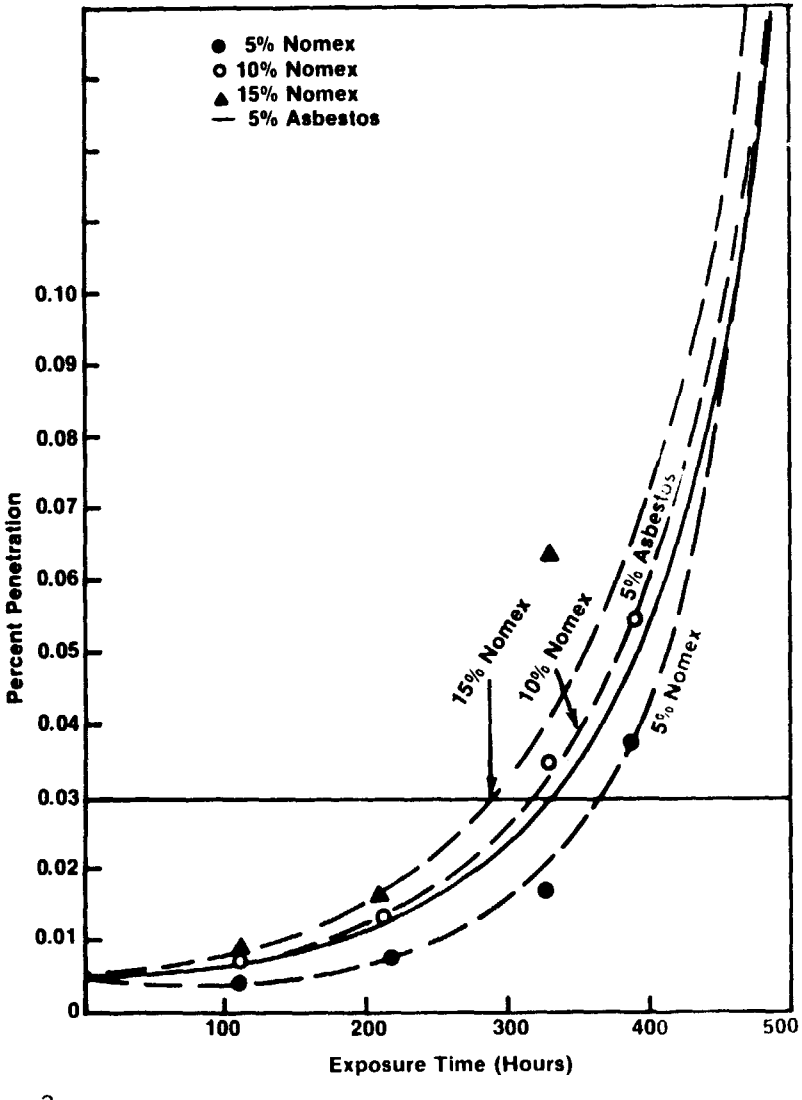

Fig. 3 Nomex and Asbestos Containing Media Exposed to 1100 ppm HNO_3 and 5 ppm HF.

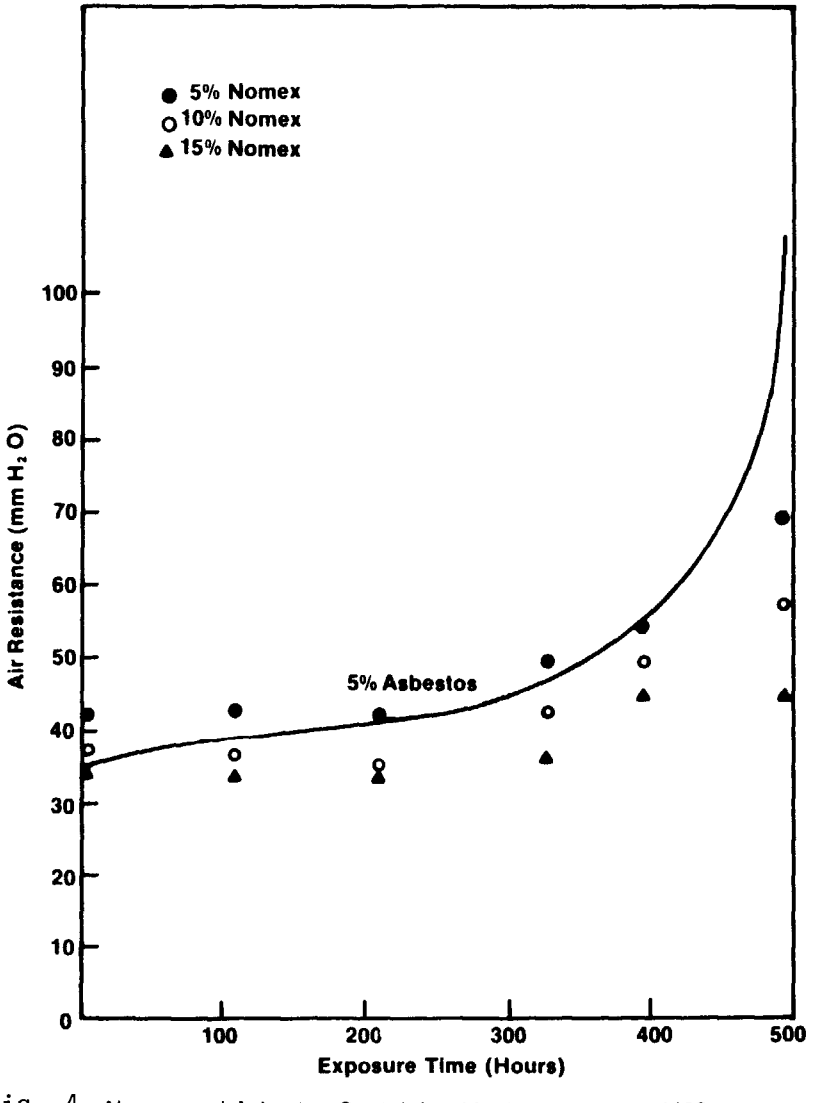

Fig. 4 Nomex and Asbestos Containing Media Exposed to 1100 ppm HNO_3 and 5 ppm HF.

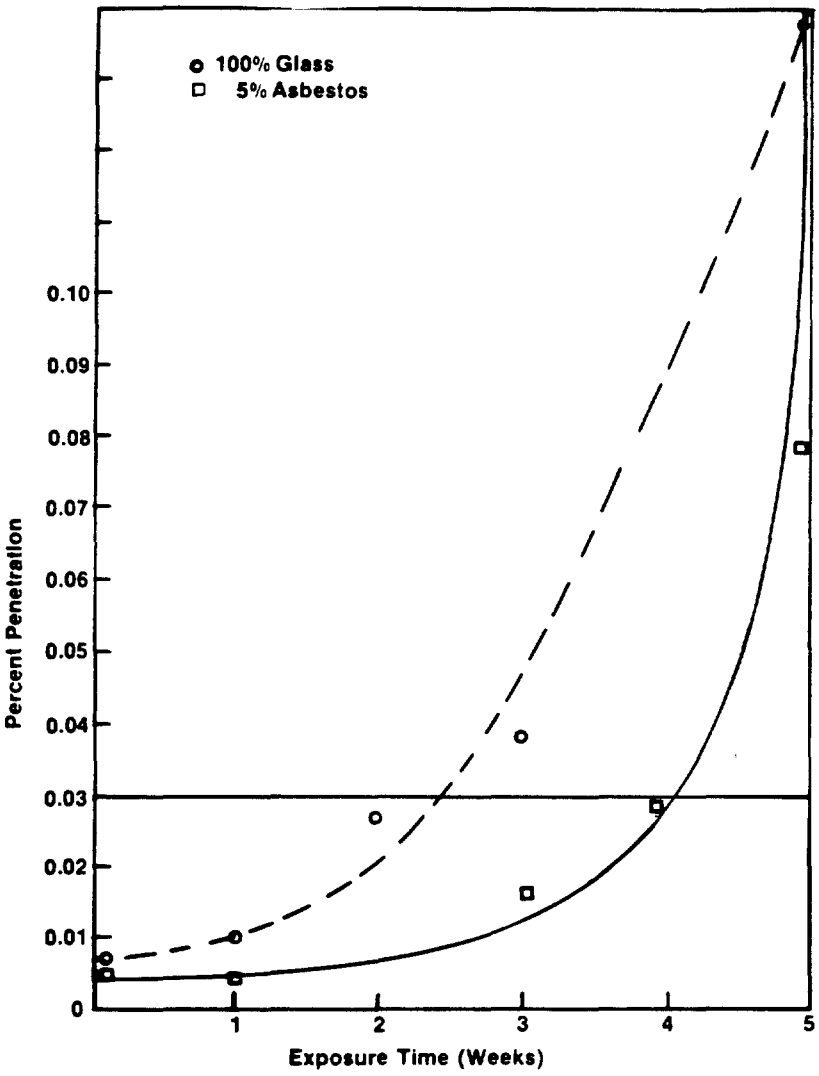

Fig. 5 Glass and 5% Asbestos Media Exposed to 200 ppm HNO_3 and 2 ppm HF.[1]

DISCUSSION

BERGMAN: Why do penetration and pressure drop increase with increasing exposure time to acid? One would susupect that the pressure drop would decrease as the acid attacks the glass fibers and decreases the efficiency.

BRASSELL: There appears to be two competing mechanisms involved in this observation. First, the acid erodes the glass fibers with the erosion rate differing with fiber diameter. Second, the Nomex and Kevlar fibers appear to be either swelling and/or causing retention of moisture, resulting in a slight increase in resistance.

ETTINGER: What is the cost difference between the Nomex fibers and the all-glass or asbestos-glass filters? Does this increase compensate for the saving in time to lower pressure drop vs time characteristics.

BRASSELL: The cost of the Nomex-containing filters is about 25% more than the cost of 100% glass filters. The increased life obtained from the use of Nomex results in a net savings due to reduced labor in change-out and less nuclear waste to dispose of.

COOPER: How were the curves chosen to interpolate between the data points?

BRASSELL: A computer program performed a non-linear (least squares) regression.

A CHANGEABLE BED ACTIVATED CARBON FILTER WITH HIGH ACCURACY AND EFFICIENCY

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ABSTRACT

The conventional active carbon filters used to this day for the adsorption of radioactive fission products in nuclear power plants, cannot meet the requirements any more, such as

1. continuous operation, also in the case of breakdown

2. optimal utilization of the loading capacity

3. minimal radioactive waste volume of loaded active carbon

These disadvantages can be avoided with the help of a changeable bed activated carbon filter working on the principle of a vertical counterflow system, whereby after taking of samples, the charged sorption material is let off downwards by lowering the filter bed level. It is imperative that the entire layer of sorption agent is being moved downwards with parallel faces, as otherwise after repeated letting-off procedures the horizontal load distribution in the filter bed is not homogeneous any more, or even chemical leakages are being produced. Here a changeable bed activated carbon filter is introduced which permits to lower the sorption agent layer over the total filter cross section with a tolerance of $\pm$ 5 % max., relative to the mean lowering level of the layer.

INTRODUCTION

Radioactive fission products may be set free during normal operation of nuclear power plants, owing to leakages or repair work, or during or after breakdowns. The installed air filter systems must most effectively retain these fission products.

A new type of filter for the adsorption of radioactive fission products has been developed in the DELBAG laboratory, in co-operation with the KRAFTWERK UNION (KWU).

This type of filter which we call a changeable bed filter, works on the principle of a vertical counterflow system, in which the incoming air will always first come into contact with the most laden carbon layer of a replaceable activated carbon bed.

The filter has the following features:

- continuous filter operation with the guarantee of a maximum of adsorptional efficiency
- great saving of sorption material due to optimum utilization of loading capacity of the expensive impregnated activated carbon, that means utilization almost up to the theoretical limit of the loading capacity
- minimum radioactive waste volume which must be put into the final storage at high costs
- replacement of activated carbon by discharge in cycles or in layers, of the completely loaded activated carbon directly into a waste drum, owing to the vertical principle of operation by means of gravity alone, and without any additional feeding mechanism
- automatic replacement of sorption material, operators will not come into contact with the radioactive waste volume
- sampling spindles permit samples to be taken directly from within the sorption bed which allows replacement of the sorption material in layers according to the actual height of the nearly completely loaded layer, and not, as was practice until now, replacement of only partially loaded sorption material due to the necessary guarantee of a minimum degree of separation.

DESIGN

The requirement for the safe functioning of such a changeable bed filter, that means for the safe discharge in that way, that no mixing-up with fresh material is allowed, is the precise plan parallel lowering behaviour of the entire carbon bed.

After extensive testing the filter design shown in figure 1 was found to comply with all properties necessary.

The discussed filter type represents a design in which the air crosses a bed of activated carbon in such a way that the air flows from below to the upper part of the apparatus and, vice versa, the activated carbon flows downward when discharging is necessary.

The cross section of the filter is about 1 by 2 meters. Actually the activated carbon is supported by a normally closed discharge system. It consists of a fixed supporting grate and a slide grate, which can be moved by hand, by pressure air, or other means, for operating and for discharging respectively. The special design of the supporting grate has square openings with a mesh size of 50 by 50 mm. In these square openings cone shaped housings with openings 20 by 20 mm are being fastened.

These housings are made from perforated sheet material with holes in it smaller than the activated carbon particles. These holes permit, on the other hand, a nearly unobstructed air flow through the entire filter.

This design guarantees, that during the discharging process the entire carbon bed which behaves like a viscous mass, owing to the adhesion and friction forces, remains mainly in a stationary, quasi laminar flow condition because the relative velocities of adjacent carbon particles are negligibly small, or even zero respectively.

Mixing-up effects between different layers of the activated carbon are thus impossible.

Particular care was taken to keep the time short required for opening and closing of the slide grate.

A sampling contrivance (figure 2) meets the need to control the loading condition of the activated carbon. Samples can be taken directly from the filter bed. The device features a tapered spindle (lenght 500 mm, maximum diameter 50 mm), collecting a representative sample of sorption material into a measuring vessel.

Corresponding experiments have shown that the quantitiy of delivered sorption material is (see figure 3)

- almost independent from the conditions of vibrations of the activated carbon,

- proportional to the number of spindle rotations,

- very good reproducible.

EXPERIMENTAL DETAILS

Whilst the changeable bed activated carbon filter was designed, suitable control tests were carried out to check the accuracy of plane parallel lowering of the carbon bed. For that purpose approximately 10 mm thick layers of coloured plastic granulate having a grain size similar to that of activated carbon, were placed into the carbon bed at different levels, for instance 200, 300 and 400 mm above the carbon discharge system. The carbon bed was then filled with activated carbon to a height of 600 mm.

After the carbon bed had been lowered, step by step, to about 200 mm, the carbon bed was again filled to a height of 600 mm in order to keep the static pressure of the carbon on the discharge system approximately constant. The carbon discharged during any individual cycle was stored separately in case it contained coloured granulate. For subsequent test evaluation 1 litre $\hat{=}$ 500 g were taken from each batch.

DISCUSSION

The coloured granulate from each individual 500 g batch (consisting of carbon and coloured granulate) was manually separated and weighed in order to determine the distribution characteristics of the amount of coloured granulate in the discharged carbon, as a function of the filter bed level, respectively the discharge height. A typical test diagram of this type of filter is shown in figure 4.
It indicates that

a) 98 to 99 % of all coloured layers leave the filter within 3 discharge cycles separately from each other, independent of the discharge height (200, 300 or 400 mm). A discharged coloured layer thus contains only 1 to 2 % of the preceding coloured layer.

b) The form of distribution of the individual coloured layers is independent of the discharge height (200, 300 or 400 mm).

c) The half widths of the distribution vary, in several tests, statistically between 30 and 35 mm, and are independent of the discharge height.

This method of test and its evaluation gives as a result the distribution characteristics of the individual coloured layers, after they have been lowered from a certain height and have left the filter through the grating.

The reproducibility observed during a number of tests in connection with the points a) to c) above, however, permits the conclusion that a very good plane parallel lowering behaviour of the carbon bed was achieved.

This is supported by the fact that no movement on the surface of the carbon granulate was visible during the complete discharge of the filter (lowering the carbon bed by 600 mm). Only about 40 to 50 mm above the discharging grate a change of the surface became visible: the rastered discharge holes in the grate were evenly marked by indentations everywhere on the surface. Obviously the layer-obliterating influenec of the carbon discharging system extends only a few centimeters into the carbon bed and thus remains within the grating dimensions (40 mm height).

With this knowledge a further method of test evaluation becomes pithy, whereby only the parallism of the lowering of the carbon bed is being determined, and the layer-obliterations in the grating itself are neglected.

For this purpose the height of the coloured layers and the coloured surface border layers above the discharging grate was measured after several discharge cycles, at a total of 11 equidistant points of the filter. For evaluation the 4 corresponding values were used, and the measured height above war judged.

The analysis shows:

a) The maximum differences in height around the filter, of a layer lowered by 400 mm, are smaller than 5 %, and respectively

b) the maximum differences in height of a layer lowered by 400 mm, regarding the mean thickness of this layer, are smaller than 2.5 %.

This means that the differences in height observed, or the deviations from the ideal plane parallel lowering of the layer respectively, are within the magnitude of measuring accuracy (approx. $\pm$ 2.5 %), or within that accuracy with which a coloured granulate layer can be placed into a filter of this size.

CONCLUSIONS

The good test results, that means the high accuracy when lowering the activated carbon bed, will result in the application of the changeable bed filter.

In nuclear technology for instance, it will be of interest to know that the sorption material demand can be drastically lowered by application of this type of filter.

At the same time radioactive waste volume of course will be reduced correspondingly.

Furthermore it is possible by improving the sluicing technics (for example remote control of filling and discharging) that the changeable bed filter gives a 100 per cent availability of the activated carbon filter.

During the series of experiments performed it became evident that the described measuring method, which was developed in co-operation with the Kernforschungszentrum Karlsruhe, represents a sensitive criterion for the evaluation of the required accuracy which activated carbon filters of this type must exhibit, respectively can be used for the indication of the suitability of such filters.

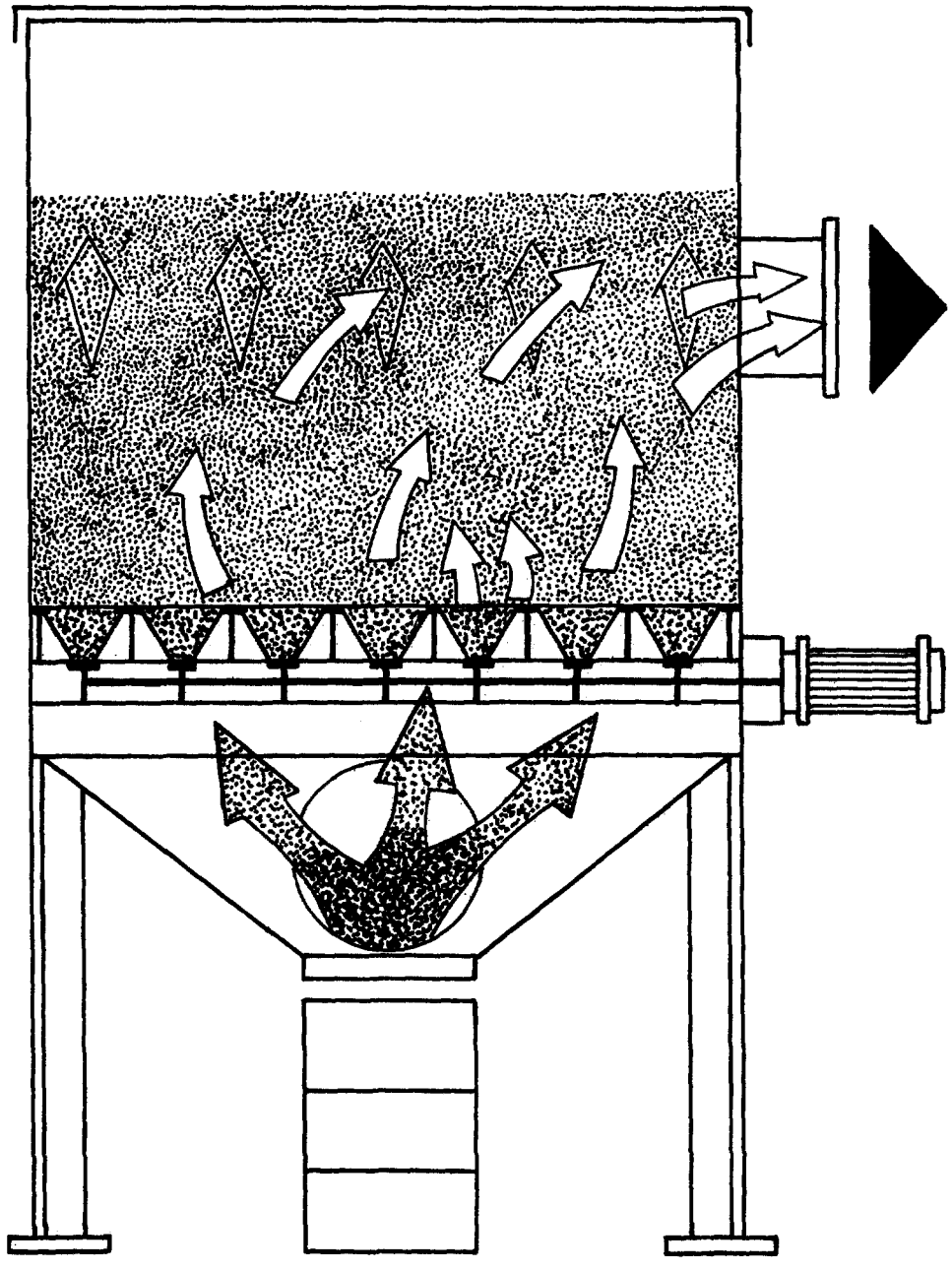


FIG. 1. Standardized scheme of the changeable bed activated carbon filter.

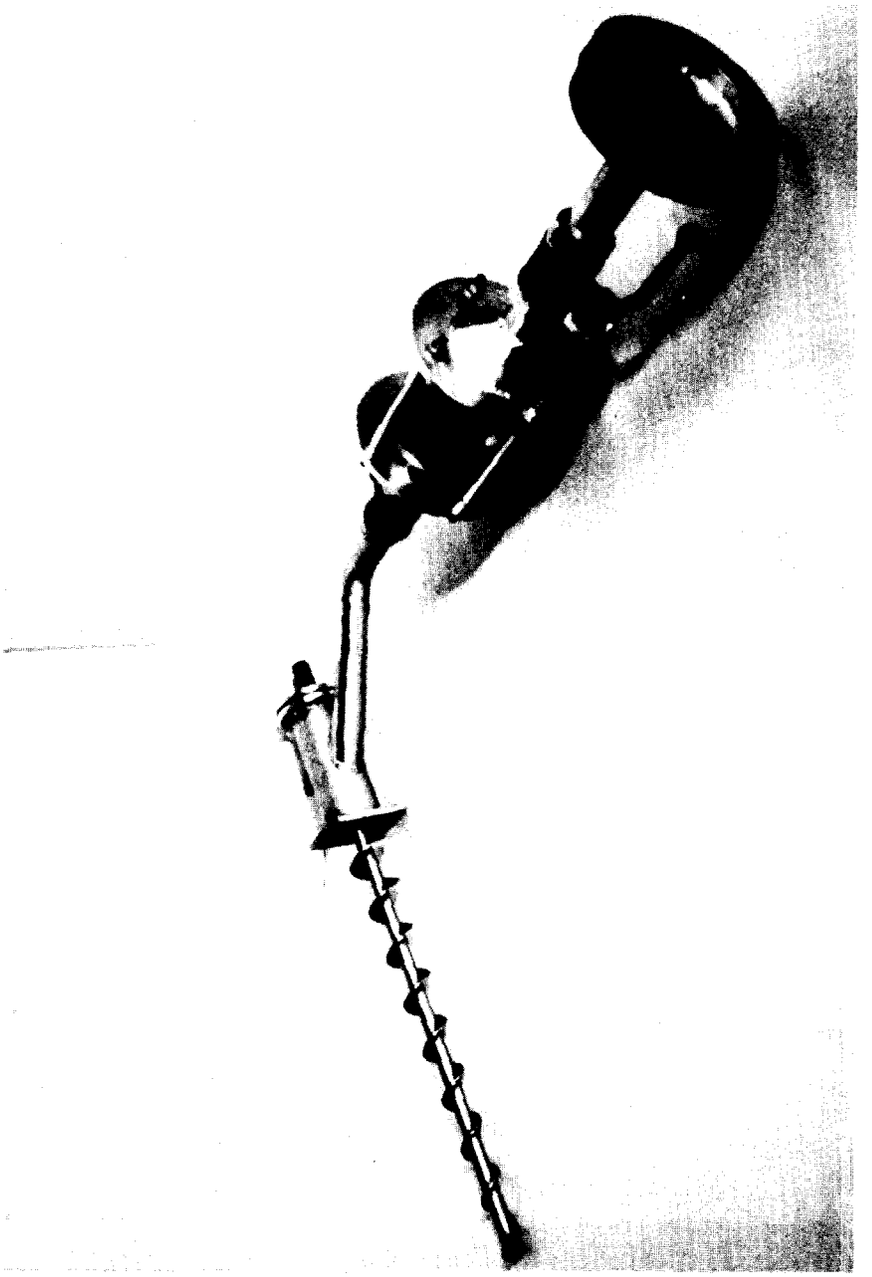


Fig. 2 Sampling contrivance

FIG. 3. Quantity of delivered sorption material at different conditions of vibration of the filter bed for 3 rotations (X) and for 6 rotations (Δ) of the tapered spindle.

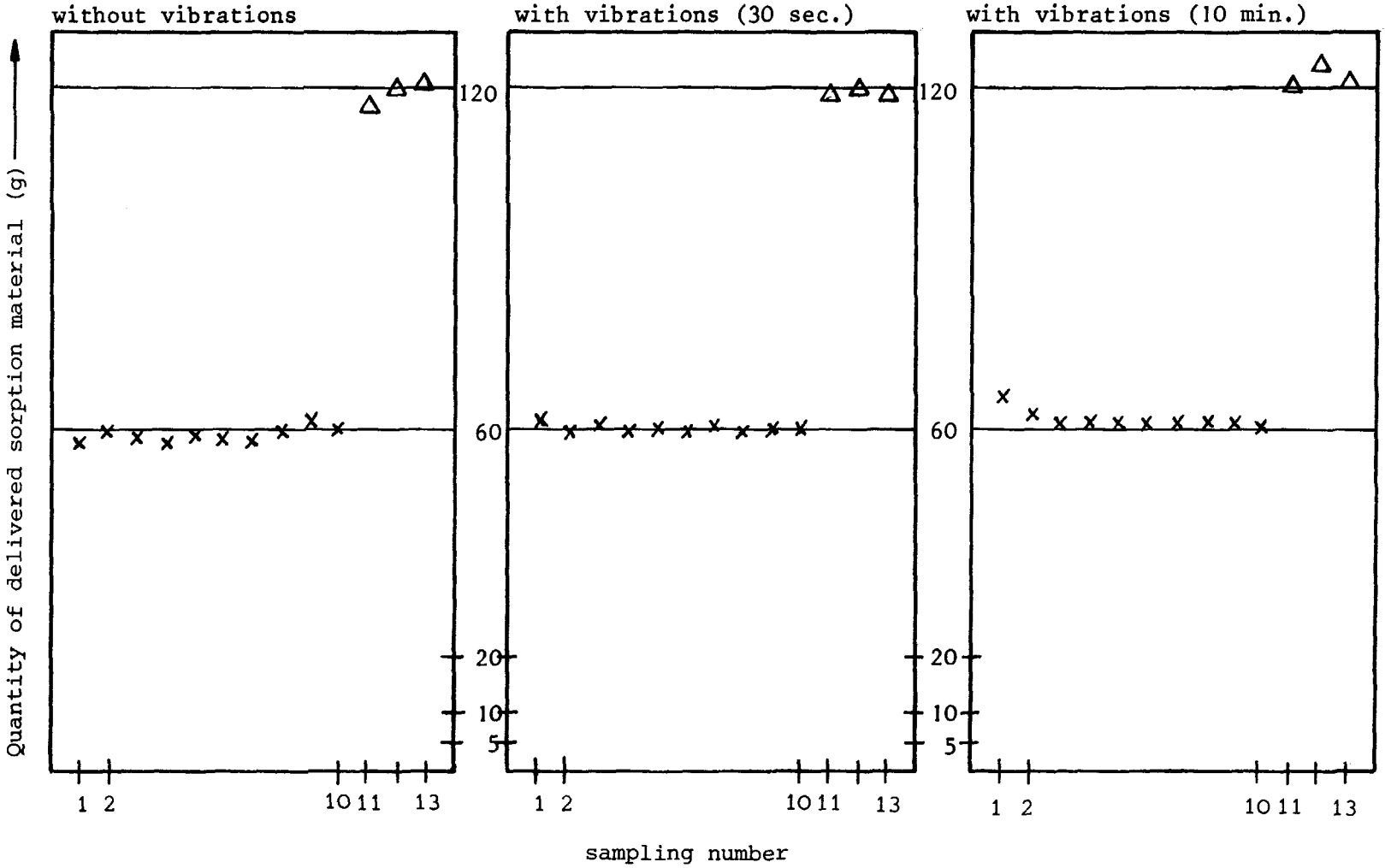
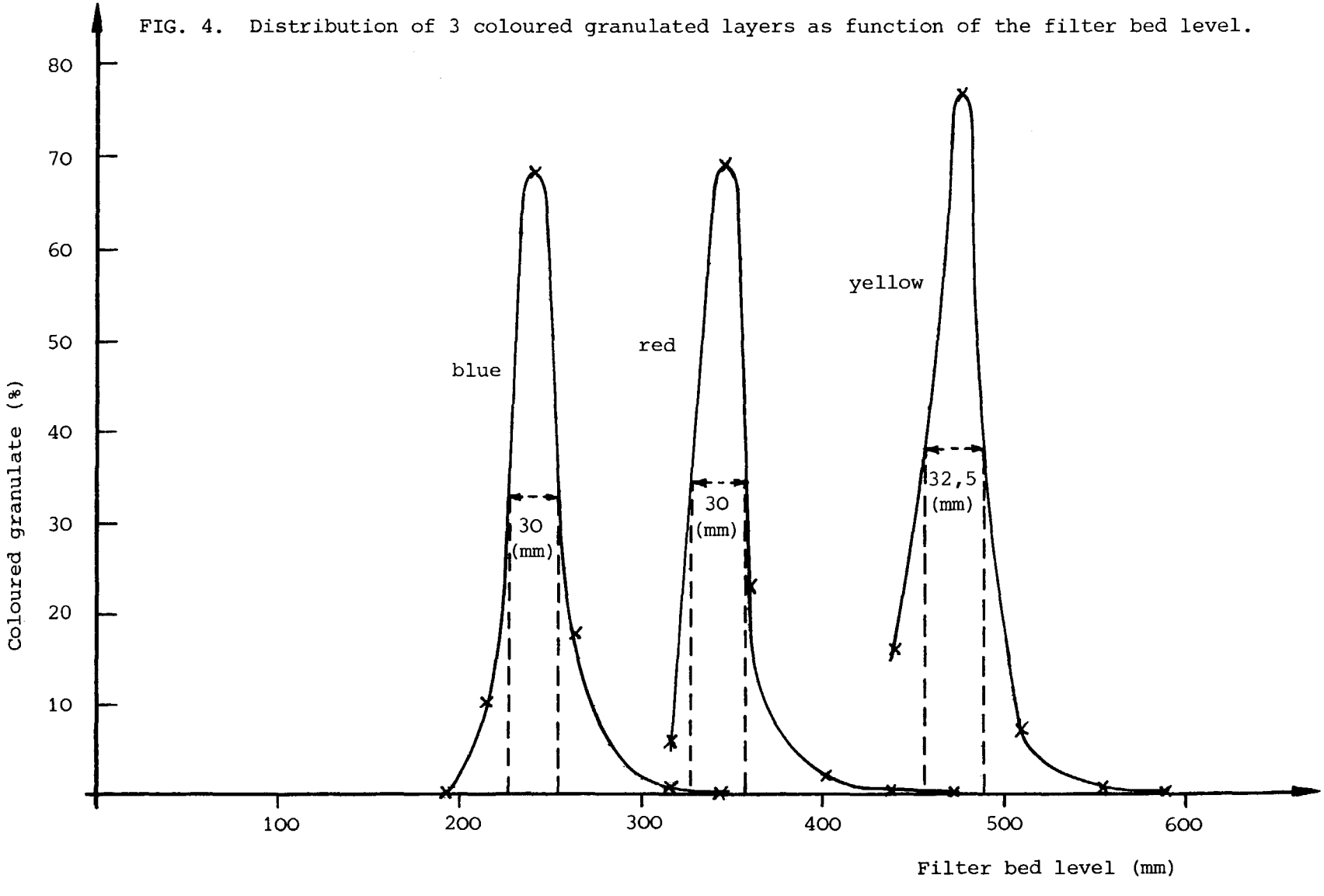


FIG. 4. Distribution of 3 coloured granulated layers as function of the filter bed level.



IODINE REMOVAL BY SILVER - EXCHANGED ZEOLITE FILTERS FROM THE VESSEL OFF GAS IN TOKAI REPROCESSING PLANT

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Abstract

Through the active operation of Tokai reprocessing plant started on September 1977, the measurements of iodine(^{129}I) in the liquid and gaseous streams have been carried out. From the results of measurements, it was confirmed that more than 99% of the calculated amount of ^{129}I in spent fuel was released into the off gas circuit during the dissolution. Most of the released iodine(^{129}I) was desorbed to liquid streams and then transferred to the waste disposal facility, where some amounts of ^{129}I was released into the vessel off gas line.

Through the investigation of iodine distribution in the plant, it was understood that the removal of ^{129}I in the vessel off gas led to a decrease in the amount of iodine(^{129}I) discharged to the atmosphere, so that the silver-exchanged zeolite (AgX) filters were installed in the vessel ventilation system at the waste disposal facility. Then the removal test has been carried out through the active operation.

The decontamination factor (DF) of AgX filter has been kept in the range of 50 to 100 through 20,000 hours loading (over two years since the start of operation in November 1979).

Consequently, it was confirmed that AgX adsorbent was effective for the removal of airborne iodine(^{129}I) from the vessel off gas. At present, by means of the installation of AgX filters on the vessel ventilation system, the iodine(^{129}I) discharged to the atmosphere has been effectively controlled at a low level in the plant.

1. Introduction

The design capacity of Tokai reprocessing plant is approximately 0.7 ton of uranium per day for spent fuel of the light water reactor(LWR).

The active operation of Tokai plant was started in September 1977 after the completion of construction and various tests. Through the active campaigns, about 140 tons uranium of spent fuel, which were shipped from the power stations (PWR or BWR) in Japan, have been reprocessed for the time being (Mar.1982). The maximum burn-up was about 28,000 MWD/TU.

At the beginning of the active operation, we faced the question how to control the fission product iodine(^{129}I) released into the environment. The several examinations were carried out during the active test. For example, the distribution of ^{129}I was investigated in the liquid and the gaseous streams and several adsorbents for the iodine removal were tested on the vessel ventilation system.

The ^{129}I pathways in Tokai reprocessing plant are given in Fig. -1. From the results of these examinations, it was confirmed that more than 99% of the theoretical amount of fission product iodine(^{129}I) contained in the irradiated fuel was released into the dissolver off gas system during dissolution [1] [2] and most of the released iodine(^{129}I) was transferred with the low active liquid waste (LALW) into the waste disposal facility.

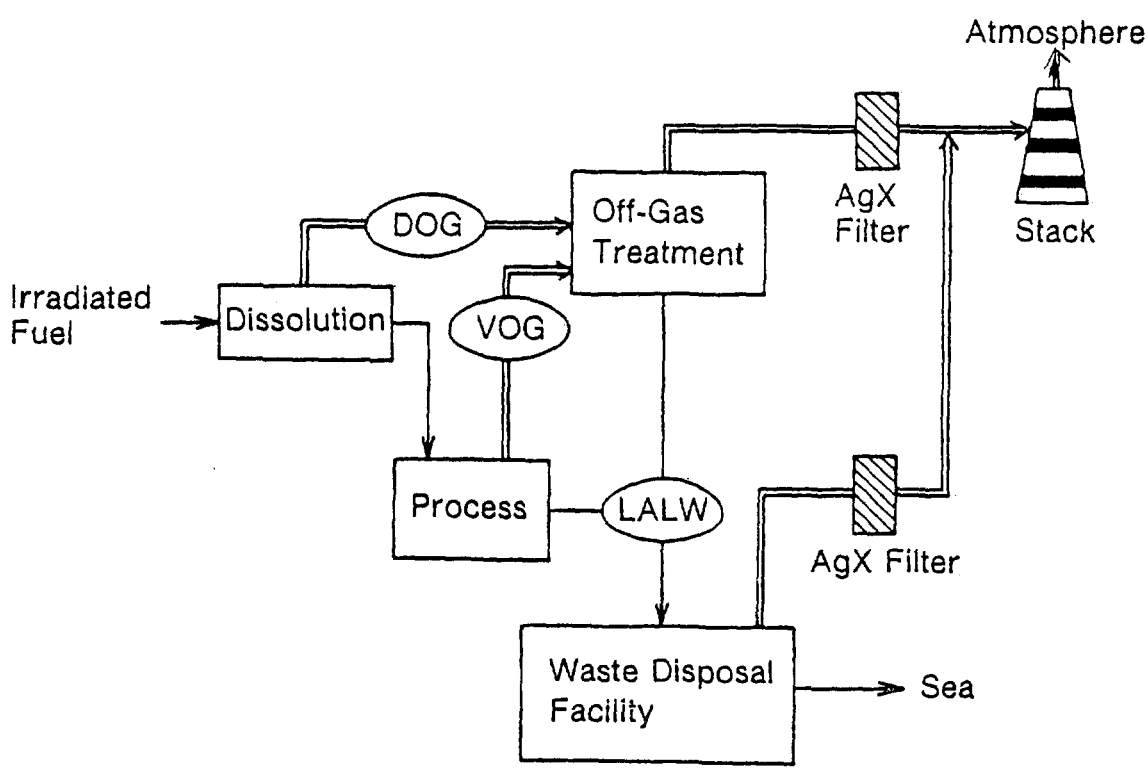


Fig-1. ^{129}I Pathways in TOKAI Reprocessing Plant

Through the detailed study of the iodine distribution in the plant, it was understood that the removal of ^{129}I which was released into the vessel off gas line during the treatment and storage of LALW led to the reduction of iodine(^{129}I) discharged to the atmosphere.

Therefore, the iodine removal adsorbent such as a silver -exchanged material, was installed in the vessel off gas line at the waste disposal facility and then the removal test has been carried out through the active operation. As a result of this test, it has been demonstrated that the silver-exchanged zeolite (AgX) was effective for the removal of ^{129}I in the vessel off gas at the reprocessing plant.

2. Iodine removal filter

2.1 Ventilation system

The iodine removal test was performed in the vessel ventilation system at the waste disposal facility. The off gas from the equipments and vessels in this facility was collected in this system and then transferred into the main stack after cleaning by the HEPA filters. The average volumetric flow of off gas was about 600 m^3/hr.

The iodine removal filters, consisting of AgX, were installed in the vessel ventilation duct downstream from the HEPA filter. During the test for the AgX filters, the off gas was heated to about 50°C by the heater installed in the duct upstream from the HEPA filter.

The ventilation circuit used for this test and the arrangement of AgX filters are given in Fig.-2.

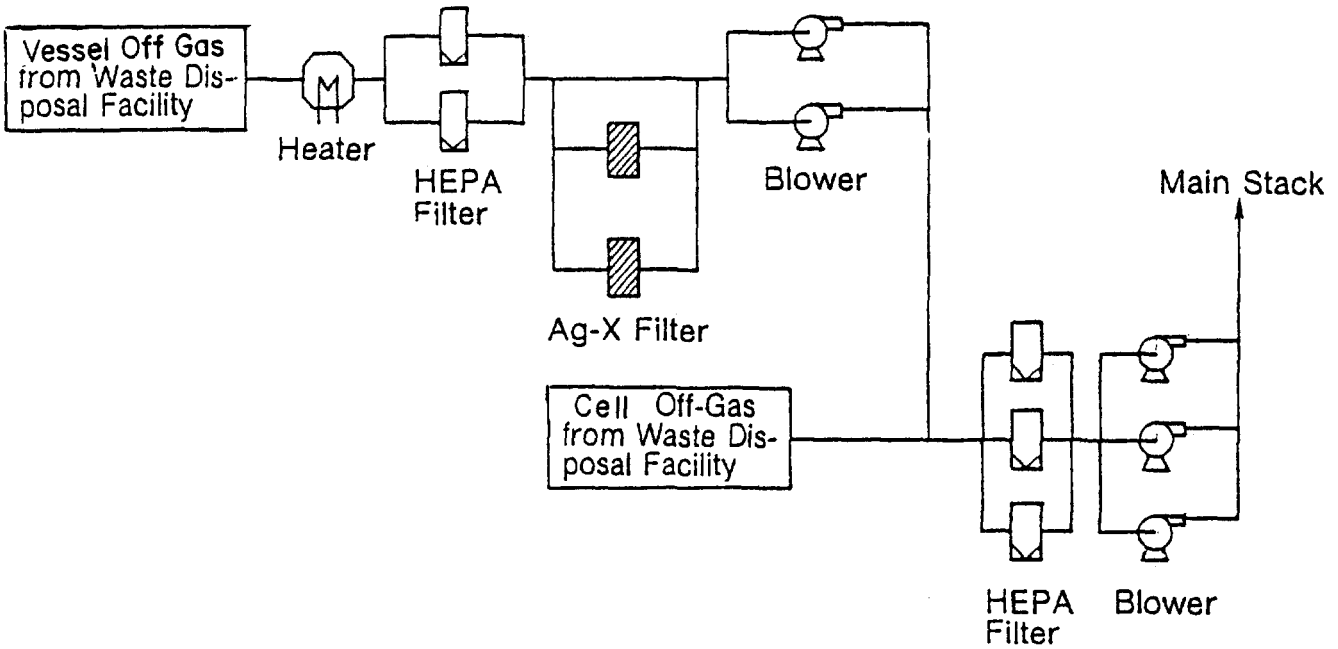


Fig-2. Vessel Ventilation Circuit at the Waste Disposal Facility

2.2 Sampling and measurement

The concentration of fission product iodine(^{129}I) in the vessel off gas was measured at three points as shown in Fig.-3, in order to investigate the removal efficiency of AgX filter for iodine. Charcoal cartridges (impregnated with TEDA) shown in Photo-1 were used for collecting airborne iodine(^{129}I) in the off gas. As shown in Fig.-3, samples of off gas were sucked onto the charcoal cartridges by a vacuum pump. Photo-2 shows the sampling device of ^{129}I in the vessel off gas. The charcoal cartridges were exchanged with new ones at regular intervals of 2 or 3 days and the iodine (^{129}I) collected on the cartridges was measured by photon -spectrometry.

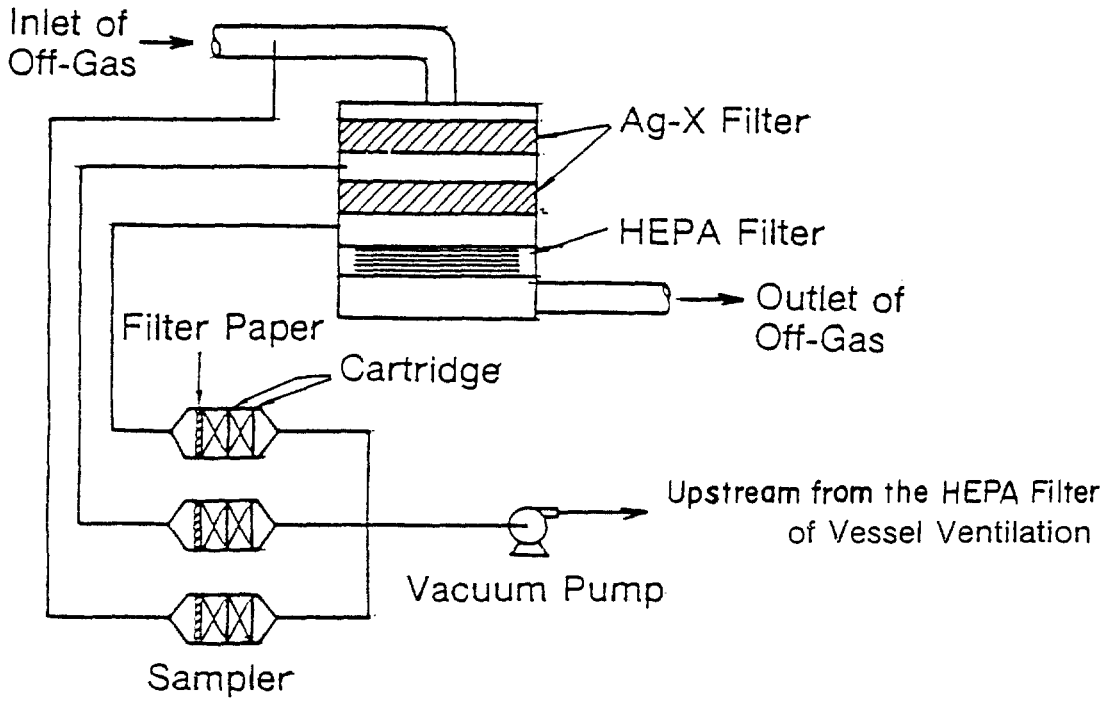


Fig-3. Sampling Points and Circuit of the Iodine Removal Filters

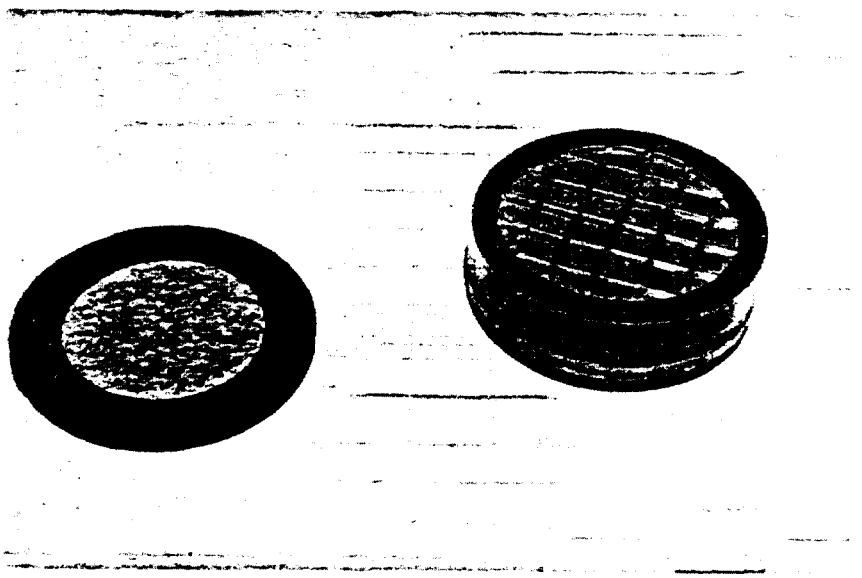
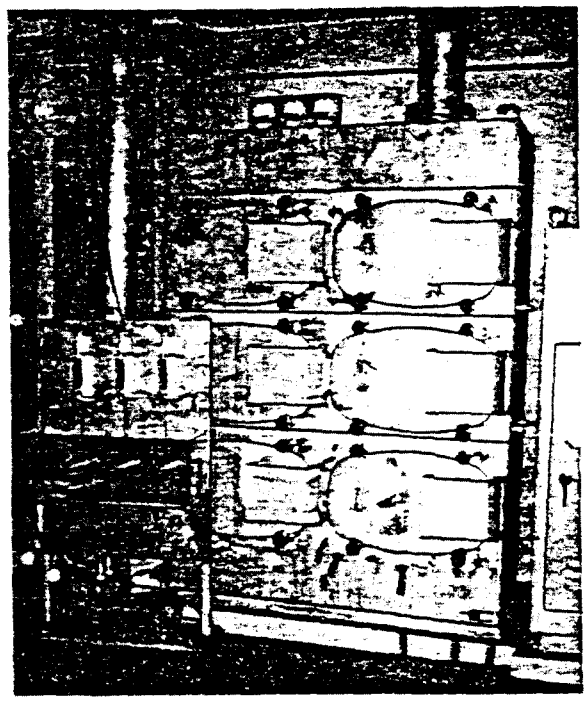


Photo-1 Charcoal filter paper and charcoal cartridge of sampler.



Photo–2 Sampling device of iodine in the vessel off-gas.

2.3 Iodine adsorption materials and test conditions

As an inorganic material for removal of airborne iodine species except the charcoal, several metal-exchanged zeolite and silver impregnated alumina or silica materials have been developed and examined on a laboratory or a plant scale. Among several adsorbents tested, a silver-exchanged zeolite (AgX) is found to be efficient for airborne iodine species for conditions of high relative humidity and with NOx and organic iodide present [3] [4]. The removal efficiency for these materials was confirmed in the preliminary test which was performed prior to the installation of iodine filters, and it was recognized that an AgX was effective for removal of ^{129}I [5].

Accordingly, an AgX was adopted as an adsorbent for the iodine removal test. This adsorbent was the silver-exchanged zeolite (AgX) Type III of CTi-Nuclear Co.,LTD., of which sodium of Type X zeolite was exchanged with silver.

This adsorbent was placed in a filter unit (dimension : 600mm x 300mm x 300mm) with a bed depth of 25mm and the weight of adsorbent was about 29kg per unit. Two filter units were arranged in series in this test, so that the total bed depth was 50mm. The face

velocity was 5 cm/sec. and the residence time was 1.0 sec. at the average flowrate of off gas of about 600 m^3/hr. The off gas was heated to about 50°C by the heater during test. The iodine removal test has been carried out during the active operation since November 1979.

3. Result and discussion

3.1 Relative humidity and NOx concentration in the vessel off gas

During the active operation, the relative humidity and the NOx concentration in the off gas were measured at the vessel ventilation circuit of the waste disposal facility. The results are given in Table-1 and Table-2.

Table-1 The relative humidity in the vessel off gas

No.	Temp. of off gas (°C)	Relative humidity (%)	Remark
1	21 - 24	84 - 93	without heater
2	30 - 35	40 - 60	with heater

Table-2 The Nox concentration in the vessel off gas

NO concentration (ppm)	NO_2 concentration (ppm)	Remark
2 - 5	4 - 11	during evaporation of LALW

3.2 Iodine removal by AgX filter

As a result of the preliminary test, it was recognized that the silver-exchanged adsorbent was effective for the removal of ^{129}I at off gas temperature of about 50°C. Accordingly, the iodine removal filters which were AgX-Type III of CTi-Nuclear Co., LTD., were installed in the vessel ventilation system at the waste disposal facility in October 1979. The iodine removal test has been taken under the active operation since November 1979.

As a result of the test, it was confirmed that the decontamination factor of the AgX filter had been in the range of 50 to 100 through 20,000 hours loading (over two years from the beginning) as given in Table-3 and Fig.-4.

Table-3 Decontamination factor and penetration ratio of AgX filter by ^{129}I

Name of campaign	Loading time (day)	Decontamination factor(1)	Penetration ratio(2)(%)	Remark
GT-PWR	74	100	1.1	
C - 2	371	75	1.3	
81-1a	484	73	1.4	
81-1b	570	58	1.7	
81-2	710	57	1.7	
82-1a	817	27	3.7	

(1) $\frac{\text{Co (Concentratin of } ^{129}I \text{ at the upstream)}}{C_2 \text{ (Concentration of } ^{129}I \text{ at the downstream)}}$

(2) $\frac{C2}{Co} \times 100$

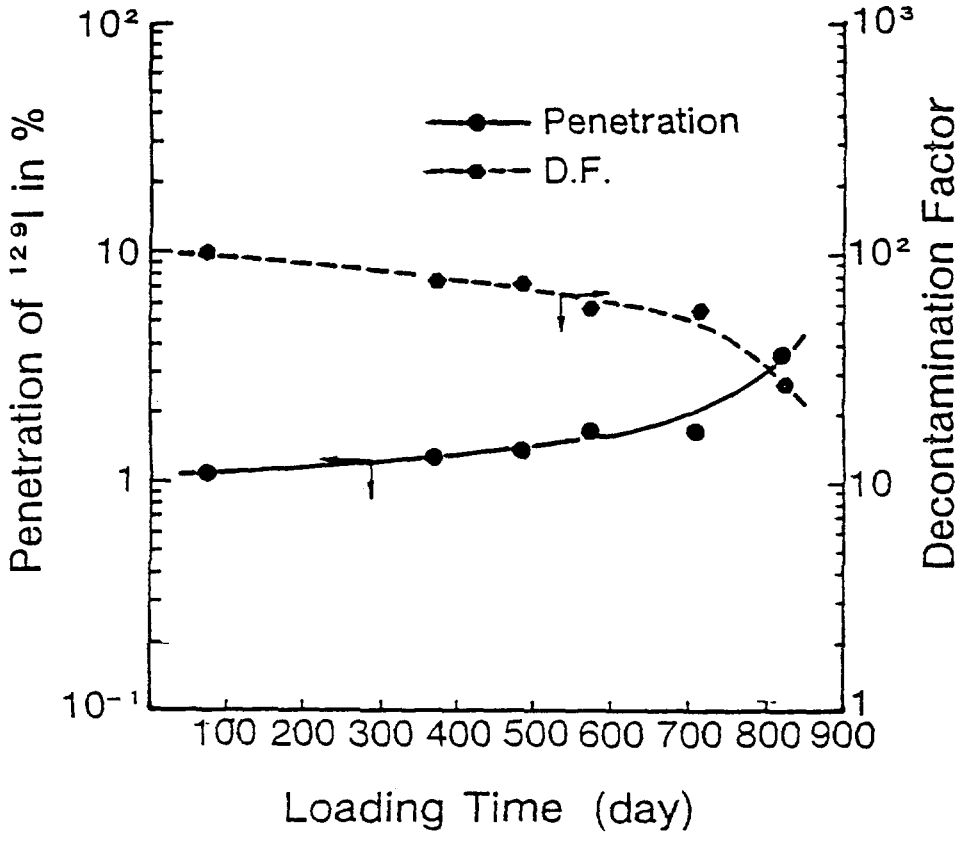


Fig-4. Penetration and Decontamination Factor of ^{129}I for AgX Filter as a Function of Loading Time

The decontamination factor and penetration ratio in Table-3 show the average values calculated at each campaign on the basis of ^{129}I concentration measured in the vessel off gas.

Fig.-4 shows both the decontamination factor and the penetration of ^{129}I as a function of loading time. The curve of decontamination factor shows a tendency to declease, which could be forecasting breakthrough of the AgX filter. Although the life of the AgX filters could not be definitely determined only by this result because of the variation of ^{129}I concentration in the off gas at upstream and the errors of sampling and measurements, we chose safety side for the plant operation and new filters were installed in March 1982, after study of this degrading trend. The average decontamination factor through the total loading period was about 70, so that about 98.6% of ^{129}I in the off gas was adsorbed on the AgX filters. Therefore the amount of iodine(^{129}I) exhausted after filtration is estimated less than 1% of the upstream.

The total amount of iodine(^{129}I) adsorbed on the AgX filters is estimated to be about 22 mci (which is about 140g of ^{129}I) which corresponds to the adsorption capacity of about 0.5 mg ^{129}I/g-AgX. This adsorption capacity is small compared with the methyl iodide adsorption capacity of 85 mg CH_3I/g-AgX specified by CTi-Nuclear Co., LTD. but this value achieves 10 times as much as the charcoal filter.

However, through over two years' adsorption test of AgX filter at the waste disposal facility, the following conclusions have been given.

1) When an AgX adsorbent is used in avessel off gas line under relative humidity conditions of 40% to 60%, and the NOx concentration of about 10 ppm, the influence of moisture and NOx on an adsorption efficiency will be negligible even after over two years' loading.

2) Decontamination factor of an AgX filter can be expected to be about 100 at the low off gas temperature of 50°C and at the low iodine concentration of 1.5×10^{-9} μci $^{129}I/cm^3$-air (which corresponds to 9.3×10^{-12} g $^{129}I/cm^3$-air).

4. Conclusion

Since the fission product iodine(^{129}I) was detected in the vessel off gas line at the beginning of the active test, the development of iodine removal techniques from the off gas has been taken during the active operation of Tokai reprocessing plant.

Consequently, it was confirmed that AgX filter was effective for the removal of airborne iodine(^{129}I) in the vessel off gas.

These iodine removal examinations have been continued over 4 years for the time being (Mar. 1982). Through these examinations, we have obtained such information as the iodine distribution in the plant, ^{129}I activity released into the vessel off gas, the iodine removal efficiencies of several adsorbents and so on, although there were the restrictions of sampling and analysis because of the plant scale test.

At present, the iodine(^{129}I) discharged to the atmosphere has been effectively controlled at a low level in Tokai reprocessing plant by means of the installation of AgX filters on the vessel ventilation system.

Reference

(1) BERG, R., SCHUTTELKOPE, H.,: Measurement of the Distribution of ^{129}I in and its Discharge from the Karlsruhe Reprocessing Plant, BNWL-TR-311 (1977).

(2) HENRICH, E., HUFNER, R. and SAHM, A.: Improved Procedures for Efficient Iodine Removal from Fuel Solutions in Reprocessing Plants, IAEA-SM-245/16 (1980).

(3) PENCE, D. T., DUCE, F. A. AND MAECK, W. J.: Metal Zeolite, Iodine Adsorption Studies, TID-4500 (1971).

(4) PENCE, D. T., DUCE, F. A. and MAECK, W. J.: Development in the Removal of Airborne Iodine Species with Metal-Substituted Zeolites, 12th AEC Air Cleaning Conference (1972).

(5) FUKUSHIMA, M., MIYAHARA, K., and MATSUMOTO, K.,: Iodine Removal from the Vessel off Gas in Tokai Reprocessing Plant, IAEA-SR-72/25 (1982).

THE DEVELOPMENT OF MOBILE FILTRATION UNITS FOR USE IN RADIOACTIVE FACILITIES

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Abstract

The design of a packaged transportable mobile high efficiency air filtration unit built to nuclear industry standards is described.

I Introduction

The concept of mobile HEPA filtration units has materialised at AWRE in order to achieve the following purposes.

1. To assist the decommissioning of facilities handling transuranics.

2. To up-grade the ventilation of buildings arising from, for example, a change in function.

3. To act as a back-up to give protection in emergency clean-up operations should the need arise.

In situ assembly and commissioning of HEPA filter installations for nuclear use is costly and labour intensive. Modification or extension of existing plants may be even more so because of the extensive precautions needed for work under controlled radioactive conditions. The advent of a transportable or mobile "packaged" HEPA filtration unit for use in radioactive facilities concentrates much of the work of assembly and commissioning at the factory. This may, depending on the quantities involved, enable a higher degree of standardisation in design and manufacture.

II Scope

The restriction in overall dimensions of a compact unit capable of movement into and out of laboratories and plant areas inevitably limits the airflow capacity. This may be overcome by the use of modular construction, eg fan module(s), filter module(s) and a control module could be coupled together to provide a filtration plant of large capacity. However the design aim of the present exercise was to maximise the capacity achievable in a single module, at the same time meeting the exacting requirements of engineered safeguards for the nuclear industry.

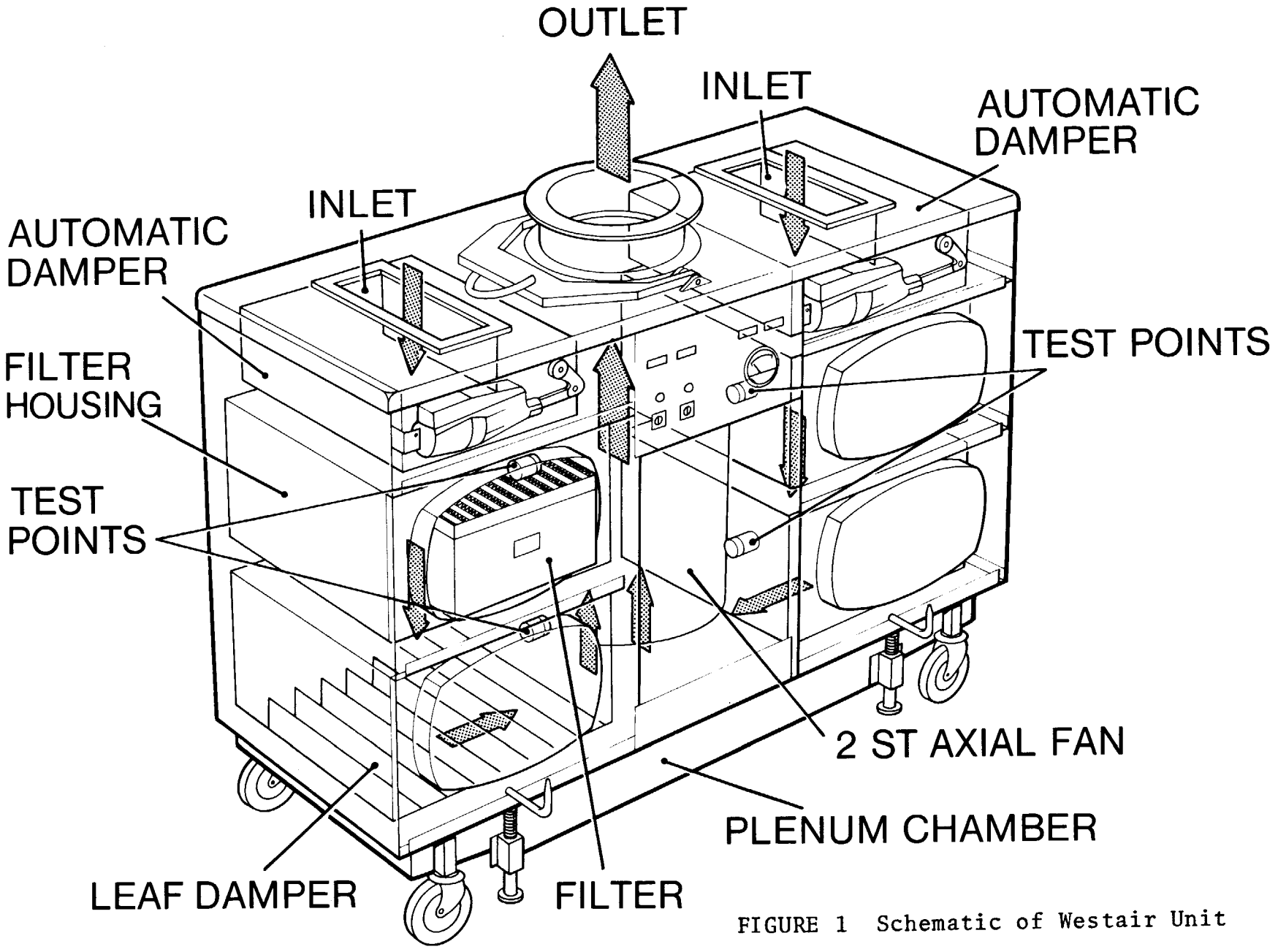

FIGURE 1 Schematic of Westair Unit

III Function

The functional specification therefore devolved to a requirement for a single trolley mounted unit as follows:

Dimensions: height - 1980 mm maximum (6'6")
width - 915 mm maximum (3'0")
length - 1830-2745 mm (6'0"-9'0")
(minimum achievable within this range)

Airflow: variable up to 6800 $m^3 h^{-1}$ (4000 cfm)

Filtration: 2 stage HEPA, each stage 99.99% efficient by sodium flame test (BS 3928 : 1969)

In addition to these general requirements there were other special features to be included, viz:

bag change filter housings

automatic shut off inlet dampers

high integrity leak tight enclosure

manual flow control dampers

high temperature HEPA filters

facilities for in-place testing

single crane lifting point

fork lift transportability

fixed jacks for immobilisation

fully swivelling castors

IV Development

Two basic arrangements were chosen for further evaluation. One of these is shown in Figures 1 and 2. Air enters downwards through two electrically actuated tight shut-off dampers at either end of the top of the unit. It then passes downward through two stages of HEPA filters, and an adjustable leaf damper into a plenum chamber at the base of the unit. The air is then extracted upwards from the centre of the plenum by a two stage axial fan and discharged vertically upwards from the centre of the top.

In order to obtain the maximum possible airflow rate through the unit the European mini-pleat design of high capacity HEPA filter was used. These have a nominal rating of 3000 $m^3 h^{-1}$ at 25 mm wg and meet UK nuclear industry high temperature rating requirements for non combustible HEPA filters.

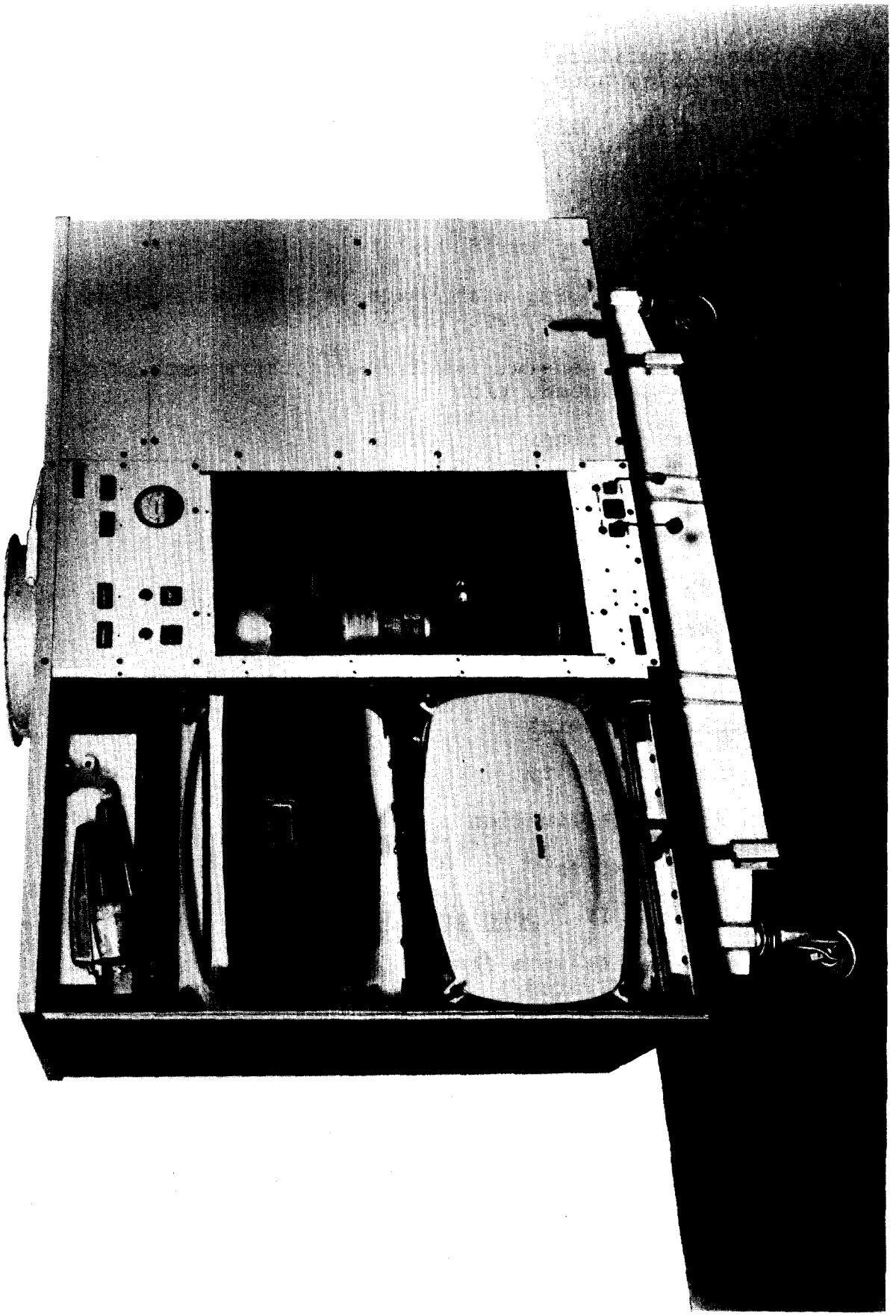

FIGURE 2 View of Westair Unit

V Assessment

After detailed engineering design, two prototype units were constructed. After acceptance tests these units now provide extract filtration in a fabrication workshop handling uranium metal. Experience gained in assembly and testing of the units together with practical operating experience in a typical working environment is providing design feed-back essential for future machines of this type.

VI Acknowledgements

The contribution of Messrs Westair to the engineering and production of the prototype filtration units is gratefully acknowledged.

DISCUSSION

BURCHSTED: There are two filter trains in parallel in this unit, with a single filter per stage in each train. How do you achieve 4,000 cfm? What is the pressure drop across each stage?

DYMENT: High capacity HEPAs are used. These are rated at 3,000 m^3 h^{-1} at 25 mm w.g. We use them slightly uprated to achieve 4,000 cfm total flow. With clean filters, the total flow with no external flow resistance is about 5,000 cfm. The axial fan is rated at 4,000 cfm with a head of 8" w.g.

JOHNSON, J.S.: What is the noise level of the portable system.

DYMENT: As depicted, the noise level 1 m from the unit is 98 dBA. Addition of a cylindrical pod silencer, 4 ft. long x 2 ft. diameter, to the outlet reduces this to 78 dBA, which is considered acceptable for most situations.

MOELLER: Have you considered providing emergency power for operation of your mobile unit?

DYMENT: We have considered it. Provisions of emergency supplies would depend on the outcome of hazards analysis for the actual task involved.

HIGH-EFFICIENCY CHARCOAL AIR FILTER WITH COMBUSTIBLE FRAME

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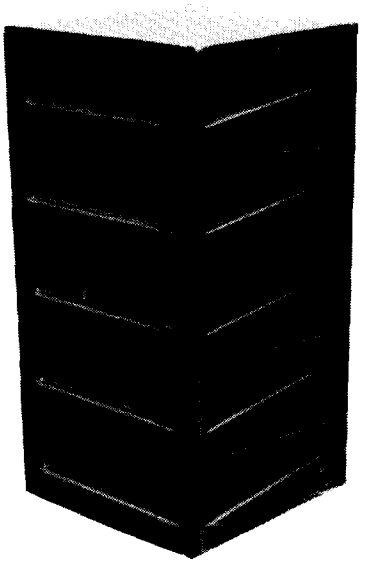

A high-efficiency charcoal filter (adsorber) with a combustible polystyrene frame has been developed by Charcoal Service Corporation, Bath, North Carolina. The combustible frame design allows the adsorber to be disposed of by incineration, eliminating the need for burial. This development came at the request of facilities using carcinogenic, noxious, or toxic gasses and vapors for a more easily disposed high-efficiency adsorber.

The new plastic frame adsorber exhibits mechanical efficiencies of 99.9+% when tested with Freon F-11 to meet all current standards and specifications. The adsorber can be filled with any sorbent, including the 12x30 mesh Whetlerized sorbent.

The Chemical Industry Institute of Technology (CIIT) in the Research Triangle Park, North Carolina, has tested the adsorber exhaustively in actual working conditions, and has then incinerated them. The results have demonstrated that the incinerable adsorber will fill a need for a more easily disposed adsorber. In addition, the adsorber is easier to handle (change-out) because it weighs 20-30% less than conventional steel framed adsorbers and is less likely to tear plastic change-out bags.

The plastic adsorber is available in three standard sizes, as follows:

SIZE(INCHES)	FLOW RATE (CFM)	RESIDENCE TIME (SEC.)	ΔP (IN. W.G.)	APPROX. FILLED WEIGHT(LBS.)
24x24x16	1,000	0.125	1.45	120
24x24x11 1/2	1,000	0.083	0.80	90
24x12x11 1/2	500	0.083	0.80	45

DISCUSSION

ETTINGER: What is the cost difference between the disposable unit and the traditional unit?

EDWARDS: The initial cost is approximately the same as a comparable stainless steel sorber. However, the cost benefit comes from the difference in the cost in incineration vs burial or surface storage.

JOHNSON, J.S.: Are the adsorbers available in various sizes and flow rates?

EDWARDS: Yes, there are three sizes available: 24H x 12W x 12D, 24H x 24W x 12D, and 24H x 24W x 16D, all dimensions in inches. The last size will provide 1,000 cfm at 0.125 sec. residence time. If a contaminant requires 0.25 sec. residence time, then two sorbers in series are used. For "common" gases (i.e., those easily adsorbed) the 24 x 24 x 12 unit will provide adequate filtration at the 1,000 cfm flow rate. The half-size unit was made for a special application of one of our customers, and would not, otherwise, have been developed.