IMPROVED HEPA FILTER/BARRIER TECHNIQUE FOR WASTE HANDLING AND PROCESSING

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Abstract

Safety in waste handling operations can be significantly improved and waste packaging efficiency can be increased by inserting flexible, lightweight, high capacity HEPA filters into the walls of plastic sheet barriers. This HEPA filter/barrier technology can be adapted to a wide variety of applications: disposable waste bags, single or multiple use glovebag assemblies, flexible glovebox wall elements, protective environment for sensitive equipment, and room partitions. These filtered barriers have many potential uses in fields such as radioactive waste processing, HVAC filter changeout, vapor or grit blasting, asbestos cleanup, and other applications where improved operational safety and waste volume reduction are important. The applications can result in significant cost savings, improved operational reliability and safety, and total waste volume reduction. This technology was developed at the Argonne National Laboratory-West (ANL-W) in 1993 and has been used at ANL-W since then at the TRU Waste Characterization Chamber Gloveboxes.

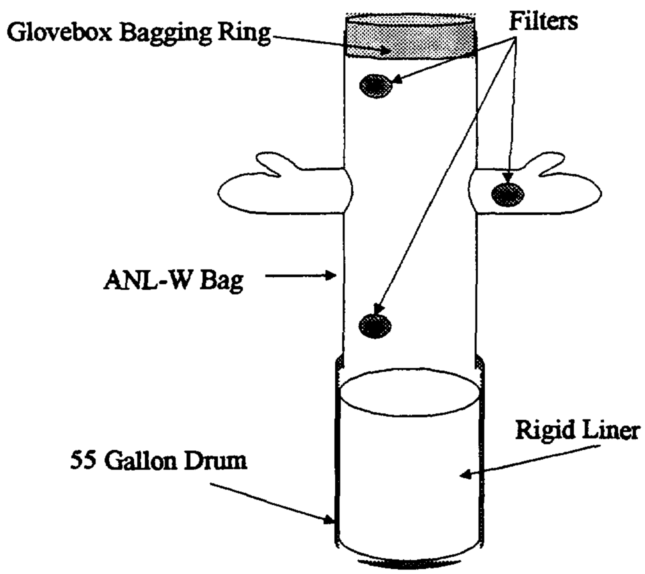
I. Introduction

The HEPA filter/barrier technology described in this paper was initially developed, in 1993, when a need for higher flow capacity HEPA filtration was identified during pre-operational testing of a glovebox bagout procedure at the Argonne National Laboratory-West (ANL-W) located at the Idaho National Engineering and Environmental Laboratory (INEEL). The ANL-W Waste Characterization Area (WCA) utilizes gloveboxes to open 55-gallon Plutonium contaminated waste drums for sampling and analysis. The procedure for bagging out a 55-gallon drum was part of the operational testing of the WCA prior to its commissioning for handling contaminated waste. The bags are used to contain contaminants while radioactive waste is transferred from the Plutonium glovebox into the drums. A step in the procedure involved the rapid deflation of the drum's containment waste bag prior to installing the drum lid. The deflation flowpath was through a rigid snap-in filter, which proved to have inadequate capacity. To increase the deflation rate, operators pushed on the bag, which resulted in a bag breach at the filter. The solution to this problem required a higher capacity, low physical profile, HEPA filter which could be incorporated into the containment waste bag. The low profile was necessary to allow the filter to fit between the top of the 90 mil rigid drum liner and the drum lid. Resolution to the problem was obtained by bonding a 3M 2040 face mask filter to the waste bag. Figure 1 depicts the configuration used at ANL-W.

The new filter has approximately 100 times the flow capacity of the previous filter and permits rapid deflation of the containment waste bag. This improved bagout system has been used at the ANL-W WCA for several hundred bagouts to safely separate the 55-gallon waste drums from the bagout rings on the bottom of the glovebox without any problems and is still in use today.

FIGURE 1

Argonne National Laboratories-West Bag with Filters Installed



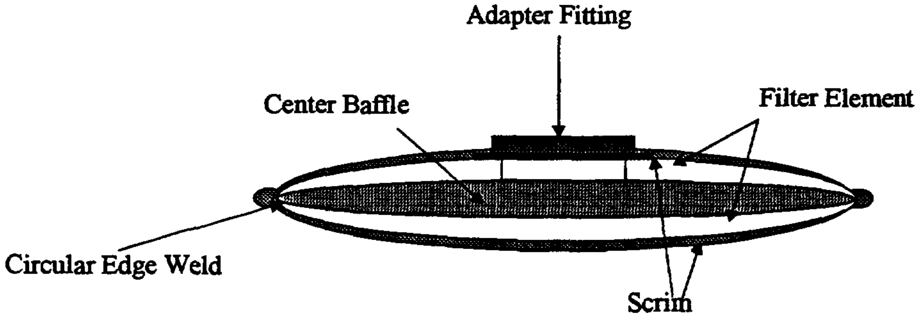
II. Technology Basis

Safety respirator mask manufacturers including 3M, North Safety, and US Safety are using polypropylene blown microfibers (BMF) to produce small, flexible, rugged, and high capacity HEPA filters, as depicted in Figure 2.

The 3M and US Safety filters rely on electrostatics to enhance filtering with charged fiber filters, while the North system relies on mechanical filtering. These filters are ideal for filter mask applications because they are relatively inexpensive, reliable, and simple to manufacture.

FIGURE 2

TYPICAL CIRCULAR FLEXIBLE BREATHING AIR MASK FILTER (FILTER SECTIONED FOR CLARITY)



BMF Filter Media

BMF filter media is made by spray forming a thin mat of polypropylene fibers into large sheets of filter media in a manner similar to the way paint is sprayed from a paint gun onto a flat surface. This media has excellent wet strength and won't support the growth of mold, mildew, fungus or bacteria. The cloth-like non-woven fabric is similar to the material used in the garment industry to make polypropylene athletic garments. Like athletic garments, this filter technology can be expanded by tailoring the mat material or by selectively layering the mat with other media to include enhanced features that are available by layering or bonding the BMF with special materials that adsorb, absorb, or chemically react with vapors, mists, or gasses.

A filter can be made by layering as many of the filter media mats as desired to meet the required filtering efficiencies. Because the filter media is made in large rolls, like regular cloth, the size of the filter is easily adaptable within reasonable limits to meet the needs of the application. Each filter is usually covered with a scrim, or cover material, most often a BMF material, to protect it from abrasion and provide some additional structural integrity. The resulting filters are rugged, flexible, and easily sized to meet any application.

III. Technology Development

The high flow capacity, flexible, and rugged HEPA filters are practical for many applications in a number of industries. The BMF fabrication process can be tailored to produce a variety of media that are suitable for specific services such as air filters, waste containment box liners, filter vented waste bags, and clean room environment barriers.

The initial application of the filter/barrier technology at ANL-W directly thermal heat sealed the filter into polyethylene glovebags. Thermal impulse heat sealing is the preferred method to join BMF HEPA filters to polyethylene plastic barrier material because it produces a permanently welded high integrity joint that is flexible and tough with a much longer life than an adhesive joint. The thermal heat sealing joint provides improved operational safety because it can flex around corners that could tear barrier material from rigid filters.

Containment bags with BMF filters could increase the loading of Pu238 contaminated radioactive waste in 55-gallon drums destined for shipment to the Waste Isolation Pilot Plant (WIPP). A result of this would be decreased costs associated with packaging and shipping. Some waste packaging is limited by the ability of the bag filters to diffuse hydrogen and keep the concentration below the lower explosive limit. Specialized, inert, or controlled flowing gas environments can be established inside barriers while maintaining filtered inlets and outlets.

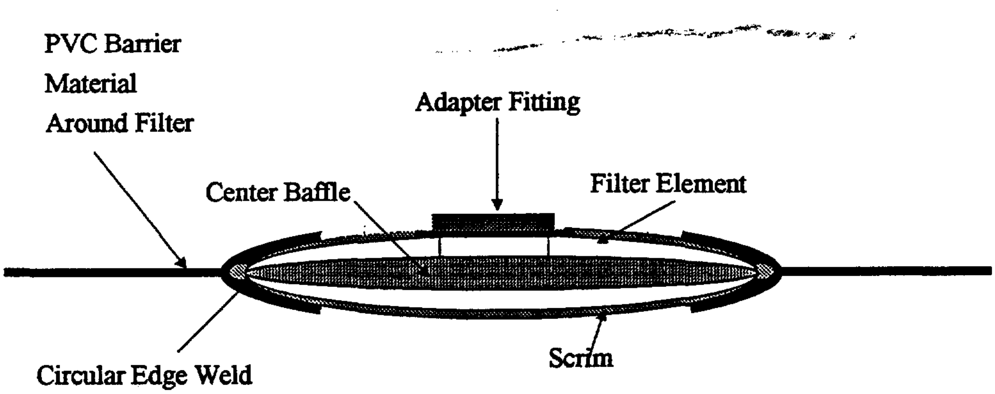
Inserting the high flow capacity HEPA filter into an otherwise airtight barrier allows the barrier to breathe quickly and adjust to pressure changes. The time needed to deflate a sealed containment bag can be significantly reduced and sudden pressure changes or reversals will not cause loss of containment.

IV. Technical Challenges

A fabrication limitation is that polypropylene filters will only heat seal to polyethylene or polypropylene sheeting. Direct bonding of a polypropylene filter into a polyethylene barrier by a thermal impulse heat seal is the preferred method of barrier construction. The two materials are similar enough in chemical structure that a satisfactory weld can be achieved with appropriate equipment. This method of direct plastic welding has not been achieved for filter attachment to PVC or polyurethane sheets. Attempts at radio frequency and ultrasonic welding methods have been unsuccessful. PVC and polyurethane require other methods which can include physical attachment within a pocket through the combination of heat sealing and adhesive bonding. This method, currently used at ANL-W because of their use of PVC bags, is shown in Figure 3.

FIGURE 3

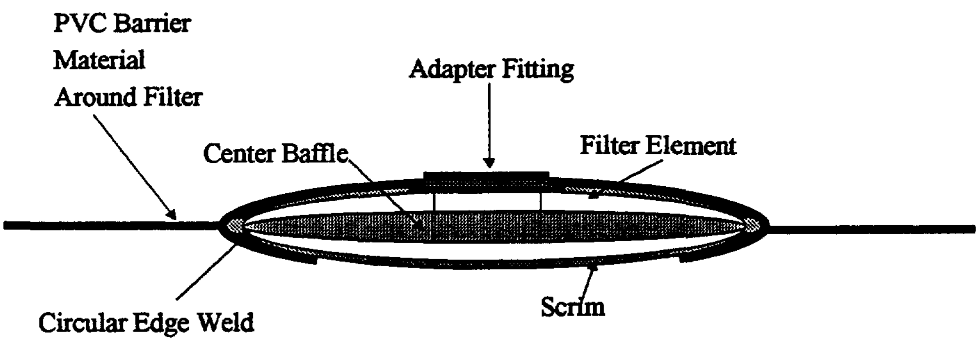
CONTINUOUS VENTING PVC POCKET AROUND FILTER (FILTER SECTIONED FOR CLARITY)



A similar pocketing technique, as shown in Figure 4, can be made airtight by sealing the barrier material to the flange of the adapter fitting. With this method, a vacuum or blower system could be attached to the adapter fitting for a more controlled air flow through the filter. In addition, special fittings or tape can cover the outlet of the adapter fitting to seal the bag.

FIGURE 4

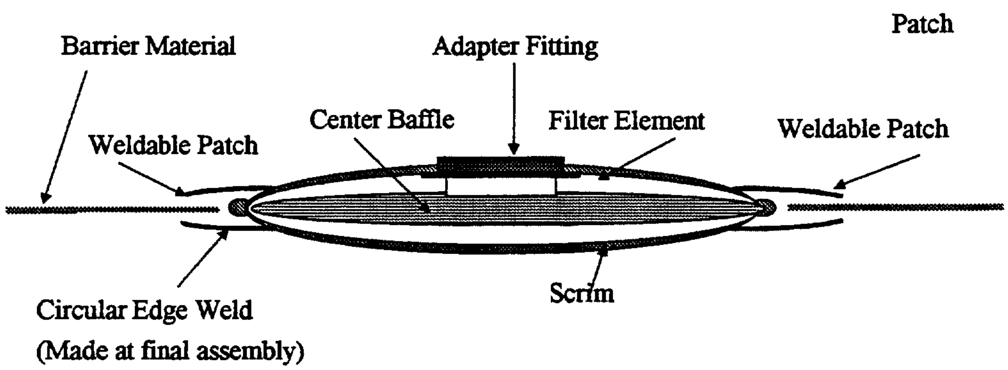
AIRTIGHT SEALABLE PVC POCKET AROUND FILTER (FILTER SECTIONED FOR CLARITY)



Another option is to create a patch assembly, as shown in Figure 5, that relies on housing the filter in a scrim material that is weldable to the barrier material.

FIGURE 5

CIRCULAR PATCH WELDABLE FILTER
(FILTER SECTIONED FOR CLARITY)



V. Operational Variations

Different mounting configurations of a filter to a barrier can provide a variety of operational capabilities. Possibilities include:

- Airtight mounting of a single filter in a bag type barrier with an integral outlet fitting so the only exit from the filter is through the outlet, creating an airtight barrier. This barrier can then be used for deflating and sealing compressible waste. The waste would be sealed inside the bag with a linear heat seal (Seal-A-Meal type) and then the air would be vacuumed from the bag without spreading contaminants.

- Airtight mounting of two filters with outlet fittings on opposite sides of the volume enclosing barrier to create a microenvironment in which experiments could be performed with controlled atmospheric conditions. Both the inlet and outlet would be filtered to prevent introduction or escape of undesired products or contaminants. This is an ideal construction for contagious disease testing on mice or other biological testing systems.

- Open face mounting of small filters without fittings provide continuous venting of gasses generated inside the barrier. This is ideal for packaging that needs to vent radiolyticly generated hydrogen to prevent the buildup of explosive levels of gasses.

- Large panel mounted filters in walls or ceilings provide excellent protection from overpressure conditions. The sudden starting or stopping of a large air-circulating fan would not collapse a barrier that was made of this type of material. Such a barrier could zone a large contaminated area into smaller easier cleaned zones for individual reclamation.

- Panel or frame mounted filters could provide low flow resistance and pre-filters for HEPA or other filters that are subjected to high loading from dust or other contaminants. The pre-filters would reduce the complexity of changeout of the HEPA filter and if the design of the containment was amenable, the pre-filter could be collapsed and bagged out from inside of the containment with much greater ease than the main filter.

- Custom bags with special inlet and outlet HEPA filters could protect temperature or dust sensitive electronics or other items that require clean cooling air to be blown across the equipment. The bag filtered inlets and outlets would be strategically placed to direct the airflow across the normal equipment cooling paths.

VI. Applications in Diverse Fields

Potential exists for application of the filter/barrier technology in other than the nuclear waste handling arena. Possibilities include:

- Medical isolation tents could be created to isolate patients to control contagious diseases. The filtered air inlet and outlet panels would filter air with the rest of the room or the tent could be sealed from the outside environment with specially purified and filtered atmospheres. This could be used to provide unique care conditions for a patient with special susceptibilities.

- Microenvironments for biological or medical experimentation could be created with specially filtered bags. The experimental environment could be controlled and after the test all the contents could be left in the bag and the entire experiment could be destroyed by incineration or rendered harmless by autoclaving.

- Biological hazardous waste containment could be evacuated by attaching a vacuum to the outlet of the filter for volume reduction and later destroyed by incineration or autoclaving.

- A sand, grit, or other particle blasting tent could be created to house the blast nozzle on applications where the byproducts are contained for ease of cleanup or safety.

- Containment for dry ice pellet blast cleaning of contaminated parts could be created that would result in the CO2 evaporating and only the material removed from the part remaining inside the bag. This would be especially valuable for processes like lead cleanup where the blasting byproducts are hazardous.

- Protective packaging could be made for sensitive electronic equipment. In this application, special bags could be made with filtered inlet and outlets that are located at the same place the equipment normally draws and discharges air. This could be used for heavy construction, farming, or military equipment where the outside environment is not controllable.

- Pressure equalization barrier to withstand changes in pressure across the barrier could be created. An example is a series of barriers within a large area that creates smaller chambers where smaller areas can be decontaminated individually. The smaller areas remain isolated so they do not become recontaminated as the cleaning process is completed.

- Gloveboxes with HEPA filtered flow-through ventilation systems could be created. They would normally rely on negative internal pressure to prevent contaminating the outside areas. This method could minimize the possibility of contaminating the outside environment if pressure inside the box becomes positive.

VII. Nuclear Waste Industry Benefits

This technology is being evaluated for use in packaging waste to ship to WIPP. Some radioactive waste forms are shipped to WIPP in sealed 55-gallon drums that have been fitted with HEPA drum vent filters in the lids to vent H_2 that might have been generated by radiolytic decomposition of hydrogenous materials.

The amount of radioactive waste that can be shipped in each drum is severely limited unless the plastic barriers inside the drums are also vented. H_2 diffusivity of the drum and bag vent filters must be adequate to prevent the buildup of the H_2 inside the drum from reaching an explosive level. The HEPA filters installed in plastic bags with this technology have a high enough diffusivity that they can eliminate the waste loading restrictions that are imposed because of H_2 buildup. It is feasible that a 20% increase in waste loading could be achieved. This would result in significant cost savings in shipping and storing WIPP waste.

VIII. Summary

The filter/barrier technology allows the creation of an inexpensive, readily available, and disposable HEPA filtered containment barrier which can be used in a variety of applications where contamination control and waste volume reduction are concerns. Enhanced safety, significant cost reductions, operational simplification, and convenience can be achieved through the use of this technology.

IX. Acknowledgments

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The original application of this technology was conceived and developed by Paul A. Pinson, who was granted US Patent No. 5.720,789 on February 24, 1998 titled "METHOD FOR CONTAMINATION CONTROL AND BARRIER APPARATUS WITH FILTER FOR CONTAINING WASTE MATERIALS THAT INCLUDE DANGEROUS PARTICULATE MATTER." The rights for this patent were assigned to Lockheed Martin Idaho Technologies Company, Idaho Falls, ID.