IN SITU CLEANABLE HEPA FILTER

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ABSTRACT

The HEPA filter system under development by the Westinghouse Savannah River Company at the DOE, Savannah River Site in Aiken South Carolina uses a filter constructed of steel particles which is cleaned by an in situ spray wash, and rapidly dried by the application of high vacuum. There has been a long recognized need for a HEPA filter assembly from which accumulated particulate can be removed and filter performance restored by an in situ means. The Defense Nuclear Facilities Safety Board [DNFSB] technical report DNFSB-TECH-23 (May, 1999) has documented the additional challenges of fire, elevated temperatures, wetting, filter strength, air leaks and aging.

Attempts using air backpulse to clean filters have failed due to wetting by atmospheric or process upsets. When challenged with liquid, glass paper media loses strength and fibrous metallic media plug. The SRS design is a major departure in that the filter is cleaned by application of liquid onto the dirty surface. Following the wash, the filter is dried and full flow restored by application of vacuum exceeding 57kPa (230" wc). High flow per unit area (263 $l/s/m^2$) has been demonstrated during extended operation at a vacuum of 40 kPa (160 inches wc). The design promises high value in use and long life.

WSRC has accumulated significant data using a Mott Corp. steel filter, and is concurrently testing alternative filter media.

Welded stainless construction reduces potential damage by heat and fire, eliminates failure prone sealant, and is impervious to damage by water, high pressure, and high vacuum. In situ cleaning reduces disposal cost, extends service life, reduces personnel exposure and labor cost, and provides the means to quantify and analyze collected radionuclides. The system comprises vertical filter tubes, spray wash nozzles, a liquid collection plenum, and a vacuum pump.

The one-micron test filter media is constructed of metal powder sintered to form a 1.2mm thick sheet and rolled into 51mm diameter tubes. The media behaves as a front surface filter collecting 99.97% of 0.3-micron particles on the surface of the tube wall as air is pulled through the wall.

Sintered metal filters are being tested for regenerability or cleanablity in simulated conditions found in a high level waste (HLW) tank ventilation system. The filters are being challenged using materials found in HLW tanks. HLW simulated salt, HLW simulated sludge and South Carolina road dust. Various cleaning solutions have been used to clean the filters in situ.

The SRS tanks are equipped with a ventilation system to maintain the tank contents at negative pressure of about 0.25 kPa (-1.0" water column) to prevent the release of radioactive material to the environment. This system is equipped with conventional disposable glass-fiber HEPA filter cartridges. Removal and disposal of these filters is not only costly, but subjects site personnel to radiation exposure and possible contamination.

A test apparatus was designed to simulate the ventilation system of a HLW tank with an in situ cleaning system. Test results indicate that the Mott sintered metal HEPA filter is suitable as an in situ cleanable or regenerable HEPA filter. Data indicates that high humidity or water does not effect the filter performance and the sintered metal HEPA filter is cleanable back to new filter performance by an in situ spray system. The in situ spray system allows the cleaning of the soiled HEPA filters to be accomplished without removing the filters from process. Thereby personnel radiation exposure associated with removal of contaminated filters and the high costs of filter replacement and disposal is reduced. The results of ongoing investigations indicate that an in situ cleanable HEPA filter system for radioactive and commercial use could be developed and manufactured.

INTRODUCTION

This paper describes a welded steel HEPA filter which uses liquid spray cleaning and vacuum drying. Development of the filter was initiated in order to eliminate personnel exposure, disposal cost, and short lifetime associated with systems commonly employed throughout the Department of Energy complex. In addition the design promises to resolve the issues of fire, elevated temperatures, wetting, filter strength, air leaks and aging documented in the May, 1999 DNFSB-TECH-23 report.

Historic HEPA filter development has emphasized low pressure drop and large surface area. As a result typical HEPA's use accordion folded fibrous media. Both glass and sintered steel fibrous media have been found to have low, i.e. 1.2 kPa, pressure drop in dry air, but are easily plugged when wetted. Because filter wetting is one of the major problems suffered by existing HEPA systems; the program sought to develop a filter that could tolerate liquid spray, and recover from the wash within a reasonable period of time. The successful application of liquid spray to clean the 'dirty' front face of a filter required a filter media which prevents the particulate from being buried within the body of the media and one containing a minimum of incursions in which particulate could become lodged. One-micron filter media produced by Mott Corporation appears to fulfill these requirements.

Filter Porosity

The Mott Corporation designates filter material based on nominal retention rating in a liquid phase media. The one-micron rating than refers to a liquid phase test wherein about 99% of one-micron particles are stopped by the filter media. Two-micron filters have larger pore size than do one-micron filters, but the numbers are only relative. Challenge tests using monodispersed 0.3 micron Poly Alpha Olefin (PAO) particles at SRS have shown that both one and two micron filters are able to stop 99.97% of 0.3 micron particles in air testing. It is common practice at

WSRC to refer to this as a DOP test in reference to dioctylphthalate smoke that was for years used as the standard test of HEPA filtration. The DOP terminology is used throughout this paper.

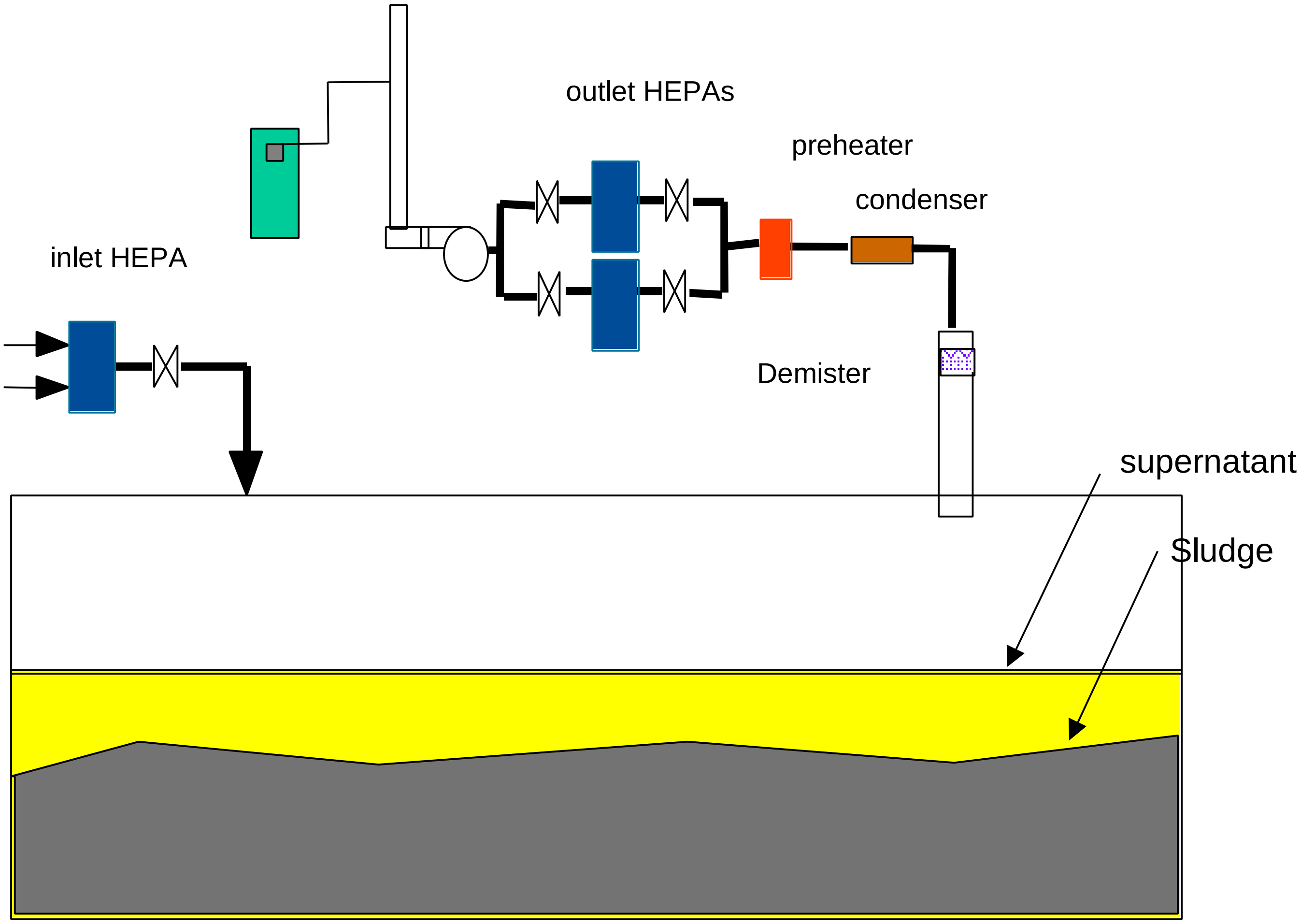
Earlier Work in the Field

The suppliers of commercially manufactured HEPA filters have been focused on the development of filters that generate a very low pressure drop while removing virtually all the particulate matter from the air stream. Use of low pressure drop reduces horsepower demand, and places low mechanical stress on the media and the HEPA support structure. As a consequence filters are commonly constructed with accordion folds or other such techniques designed to enlarge usable surface area in a compact assembly. Filter life is determined by the filter's continued ability to provide sufficient airflow, and its ability to prevent release of particulates to the atmosphere. The end of life for a HEPA filter constitutes a major expense due to manpower, personnel hazard, and long term storage (disposal) of the plugged or failed filter assembly.

For the past several years, personnel from SRS, Lawrence Livermore National Laboratory, and Oak Ridge National Laboratory have been investigating the use of cleanable or regenerable HEPA filters to replace conventional disposable HEPA filters. The results of these investigations indicate that commercially available technologies could be applied to develop and manufacture a filtering system that would meet the performance criteria of a conventional HEPA filter and is cleanable or regenerable in situ. In other words, when the performance of the filter drops below specified minimums, the air flow and the differential pressure across the filter could be restored to a clean filter status without being removed from the filter housing (in situ restoration) and with minimal labor. Studies and testing have been conducted to determine the feasibility of washing HEPA filters in situ after becoming plugged with the simulated but non radioactive version of wastes found in the high level waste (HLW) tanks at SRS.

SRS Waste Tank HEPA Requirements

The HLW tanks hold approximately 4914 m^3 (1.3 million gallons) of high level radioactive waste (figure 1). The tanks are located outdoors and are equipped with a ventilation system to maintain the tank contents at about 0.25 kPa negative pressure . The negative pressure prevents the release of radioactive material to the environment, make up air is pulled into the tank through an input HEPA. The ventilation systems of these tanks are equipped with conventional disposable glass-fiber HEPA filters. Routine removal, replacement, and disposal of these filters is required as a results of filter pluggage, wetting, and excess radioactivity due to particulate buildup. During the filter change out, site personnel are subjected to radiation exposure and the used filters contribute to an ever-growing waste disposal problem.
HEPA filters must exhibit a particle removal efficiency of 99.97% when challenged by thermally generated monodispersed smoke particles with a diameter of 0.3 microns. Process HEPA filters at SRS are required to pass an in-place leak test per site requirements before being placed into service, and periodically after they have been placed into service. DOP tested connectors are designed into each HEPA installation to facilitate the routine in-place DOP test per National and Site Standards.



High Level Waste Tank Ventilation System

Fig. 1

Test Apparatus

The Savannah River Technology Center (SRTC) located at SRS designed and constructed a test apparatus to closely simulate the conditions found on a HLW tank and allow for testing to be conducted on two filters at once (figure 2). The test apparatus was designed such that one filter could be cleaned while the other remain in testing. The apparatus operated continuously (24 hours a day, 7 days a week) with the test filters filtering the entrained particles from the air stream until the filter plugged. These particles are believed to be responsible for plugging the existing HEPA filters in the HLW tanks. The apparatus was designed for approximately 9.4 l/s of filtered air to flow into a waste tank filled with approximately 113 liters of heated (60 °C) simulated HLW solution. The simulated solution was agitated while the filtered air traveled through the headspace of the tank, simulating the flow path of the HLW tank ventilation system. From the tank the airflow split, with approximately 4.2 l/s of air passing through each test filter. A separate vacuum pump was used to pull the air through each filter. The primary components of the test apparatus includes the simulated waste tank, two filter housings, two vacuum pumps, data acquisition system and an in situ filter cleaning system. The filter housings contain four evenly spaced spray nozzles that distribute the cleaning solution through a positive displacement pump over the entire filter surface.

Testing was initially conducted on two (one-micron) sintered metal filters one filter was constructed of fibrous material and the second was constructed using small particles bonded into a 1.2 mm thick sheet via sintering. The fibrous filter plugged when wetted by the spray wash cycle. The fibrous filter could not be recovered using high vacuum, and is not discussed further in this report. On the other hand the second filter (particle construction) was easily dried with the application of vacuum exceeding 57kPa. The successful in situ cleanable filter was a sintered metal Mott filter, which was provided by Mott Corporation, located in Farmington, Connecticut. The 1-micron filter was constructed using 316L stainless steel particles, sintered into a 51 mm diameter by 102 mm long tube with a filter medium thickness of 1.2 mm. The filtration area of the test Mott Filter is 161.3 cm^2. The filter has a pressure drop of approximately 40 kPa with 4.2 l/s of airflow.

The following three materials were used to challenge the filter. The materials simulate the waste found in the HLW tanks and atmospheric dust:

- Simulated HLW Salt
- Simulated HLW Sludge
- South Carolina Road Dust

The simulated solutions did not contain radioactive materials and only one solution was in the waste tank at a time. However, the tank was empty while testing with the SC road dust. The dust was used to simulate atmospheric dust found around SRS. The SC dust consisted of topsoil taken from a garden in Aiken County. The soil was dried in an oven to remove the moisture and particles larger than 75 microns were sifted out, giving a large distribution of particle sizes to challenge the filter. Testing was conducted first with simulated HLW salt. Further testing was done with a concentrated salt solution, which was created by evaporating off water to create dry salt in the tank. At the end of the salt test, the solution was removed from the tank and the simulated HLW sludge was then added to the tank. The water was also evaporated from the sludge to create a dry sludge tank.

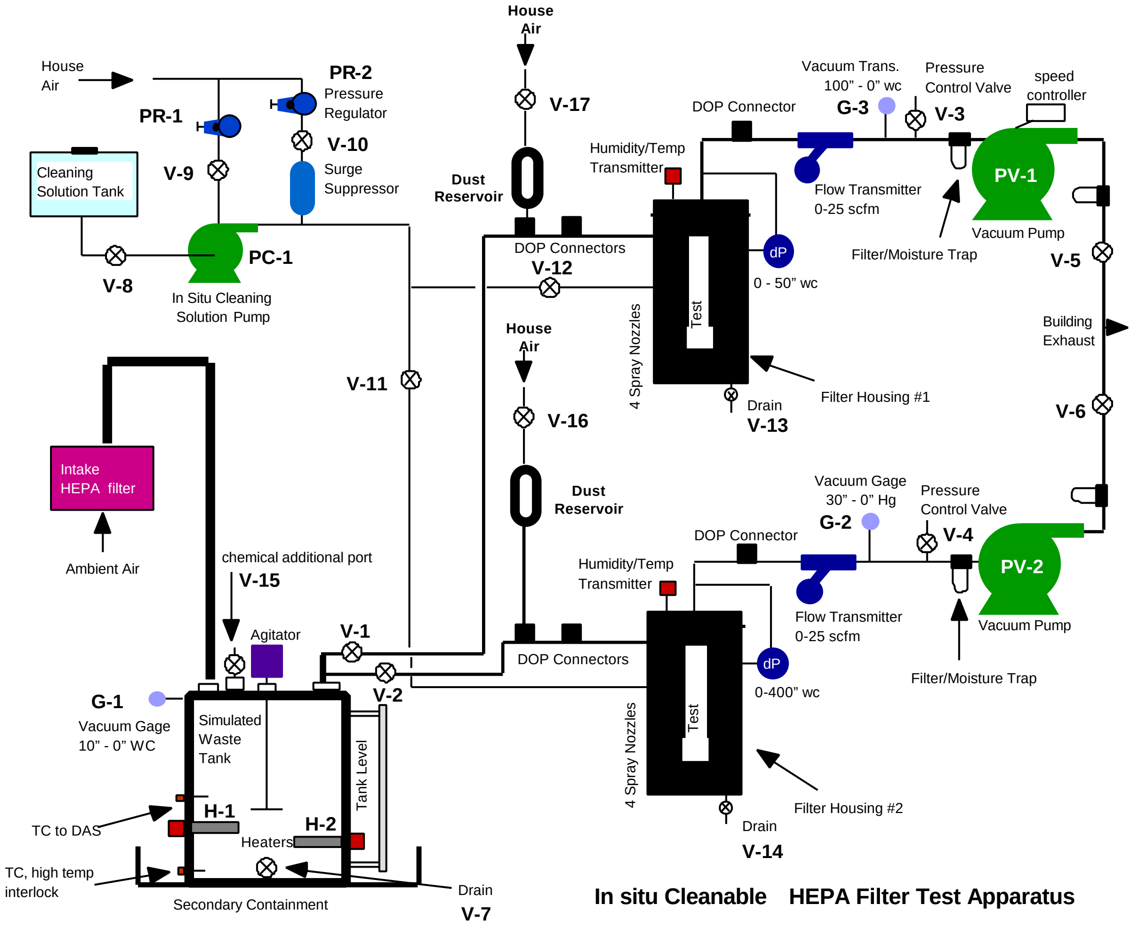
The scale waste tank was operated with approximately 711 mm (113 liters) of simulated HLW salt or sludge in the tank. During the dry salt and dry sludge test, the tank level was maintained at approximately 457 mm. Simulants were vigorously agitated in the waste tank while a temperature of approximately 60 °C was maintained. When required, water was added to the waste tank to account for evaporation. The simulated waste tank operated under a small vacuum, (approximately 0.25 kPa) which is normal operating pressure in the HLW tanks.

At the end of the sludge test, the tank was emptied and cleaned out. The SC road dust was added to the dust reservoir, which was connected to the DOP test connector port as shown in Figure 2. The dust was slowly injected into the 4.2 l/s -air stream using a small purge of house air.

Vacuum pumps pulled approximately 4.2 l/s of air through the clean test filters. Variable speed controllers and pressure control valves were used to obtain 4.2 l/s of airflow with a clean filter. Once the variable speed and pressure control valves were set for a given filter, the settings were not changed for the duration of the test.

The data from the experiment was recorded by the data acquisition system (DAS) using calibrated instrumentation. Data that were recorded by the DAS includes differential pressure (DP) and flow across the filters, humidity and temperature in the filter housings, and the temperature of the simulated waste tank.

Actual recorded and or observed data reported in this paper was accumulated as a result of test work conducted on the test apparatus (figure 2). As a result of the positive results obtained, the next stage of the program is the construction and testing of a 236- l/s skid mounted system that after successful validation will be placed into radioactive service.



Insitu Cleanable HEPA Filter
Test Apparatus

Fig. 2

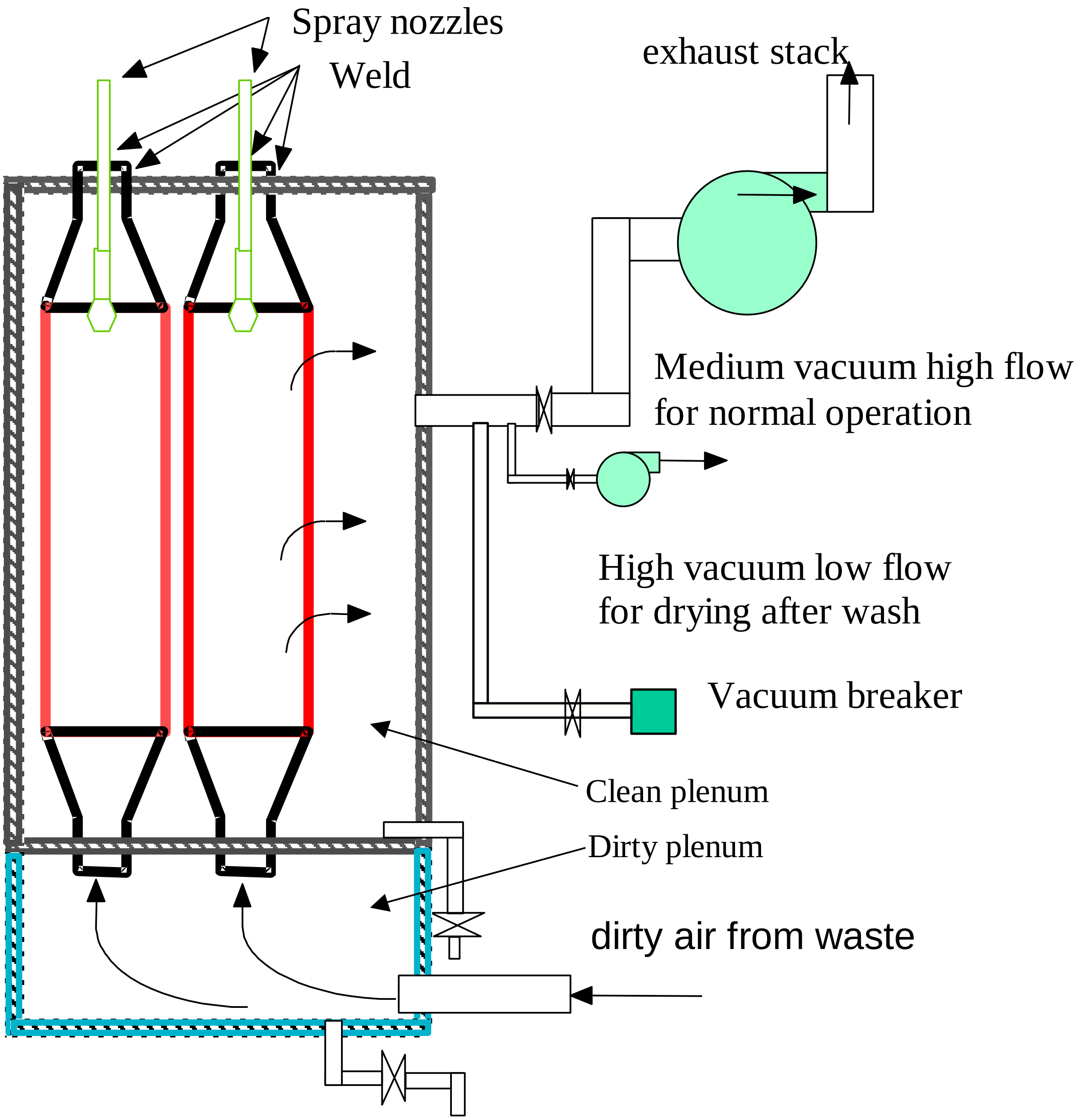
500 cfm System

Following the success of the small scale demonstration, Mott Corporation and WSRC with funding from FETC began development of a 500 cfm (236 l/s) system which is planned for radioactive service in 2001. To this end Mott has installed a test HEPA at their Connecticut facility. The new system is testing a 610mm long, 76mm diameter filter element.

As currently conceived air will be drawn into the open bottom of each filter element and be pulled through the filter wall by vacuum applied to the clean plenum (figure 3). Multiple vertical tubes will be welded into an arrangement resembling a tube and sheet heat exchanger. Water condensing from the process will not pass through the filter wall, but will be collected in the dirty plenum. Tests at SRS have shown that water will not pass the filters until applied vacuum exceeds about 230" wc (57kPa). During normal operation a vacuum breaker may be employed in order to guarantee that contaminated liquid cannot inadvertently be pulled through the filter into the clean plenum. It is assumed that during radioactive operations this liquid will be contaminated with dissolved and perhaps undissolved particulate matter. During testing, the 60ºC simulant tank generated high condensation rate. As a result, liquid accumulated in the 'dirty' plenum and eventually filled it to the point where the liquid was in contact with the bottom of the filter element. During normal operation it is expected that an overflow trap from the dirty plenum will return contaminated liquid to the waste tank. During the wash cycle the trap's valve will be closed in order to collect the wash solution for analysis.

Alternative High Vacuum Pump

Pumps which supply both high flow and high vacuum are available, however an alternative concept is to use two pumps as illustrated on figure 3. The 'low flow high vacuum pump' would only be valved into service during the recovery period following the wash cycle.



Washable HEPA Layout

Fig. 3

Horsepower requirement

The cylindrical steel filter elements are able to withstand full 100 kPa vacuum as compared to the 1.2 kPa limit normally applied to glass fiber filters. As a result the metal filter may be operated at much higher flow per unit area than the glass. During SRS testing normal air flow was 263 $l/s/m^2$ (0.36 cfm/in^2) at 40 kPa (160”wc) vacuum. Flow through typical glass filters is about 15 $l/s/m^2$ (0.02 cfm/in^2 at 1.2 kPa.(5”wc).

Air flow rate through the metal filter media is proportional to the applied pressure, and total flow is proportional to the filter area. The metal filter offers the option of a small package at the cost of increased vacuum and horsepower or a larger package using less vacuum and horsepower. A 40 kPa system will require about 25 hp (18.5kW)to deliver 236 l/s (500 cfm) through 6, 610mm (24”) long 76mm(3”) dia elements. A 20 kPa system will require about 15 hp (11kW) to deliver the same flow through 12 tubes, etc. As a practical matter conversion to the washable filter will require replacement of the vacuum pump and the piping between the pump and the clean plenum.

Wash Cycle

After the filter becomes plugged with particulate or when the radioactivity from the accumulated particulate approaches area limits, the in situ cleaning system will be initiated. The sintered metal is cleaned via spraying the inlet side of the filter with pure water and/or nitric acid followed by pure water. The Mott filter does not require back flushing to remove particulate. The cleaning liquid and flushed particulate is accumulated in the dirty plenum located below the vertically mounted filters. The residual solution may be collected for radionuclide analysis and the solution may be neutralized with sodium hydroxide to enable return to the waste tank. If the filter is in a 100% wetted condition no air will pass until vacuum exceeds about 57 kPa. As the vacuum exceeds a 57 kPa the residual water on the surface of the filter is pulled through the wall of the filter and vaporizes. Normal ‘clean filter’ airflow is re-established within five minutes, and the flow and vacuum (DP across the filter area) return to normal ‘clean’ values.

Vacuum Drying

Vacuum drying eliminates the need to use heated air to dry the filter after water wash. The vacuum drying sequence provides restoration to full flow in about five minutes. Front face collection, no pleating and high strength tubular form assures that most particulate matter can be removed without backflow. Energizing the vacuum blower after the water rinse cycle results in zero airflow. However as the vacuum increases above 57 kPa, air flow begins to increase. Apparently the high vacuum applied to the film of water causes the water to be pulled into the filter wall where it is vaporized. As the water is thus removed the airflow increases and the pressure drop across the filter decreases to normal clean flow conditions.

Dissolved radioactive material

When vacuum exceeds about 57 kPa it appears that the surface tension of the water is overcome and the water is pulled through the filter wall. Concern that water could contain a quantity of dissolved material such as cesium 137 has led us to a design which will use a vacuum breaker to limits applied vacuum during normal operation, but allow vacuum to maximize to as great as 100 kPa during the vacuum drying phase.

Front surface filter

The one-micron metallic powder formed Mott Corporation filter appears to behave as a front surface filter stopping 99.97% of 0.3-micron particles. It is constructed of 1.2 mm thick sheet rolled into a 76 mm diameter tube (figure 4). Whereas fibrous filter construction owes its collection ability to adsorption over large surface area provided by the glass or metallic fibers, powdered metallurgy appears to stop most particulate matter at the surface of the filter.

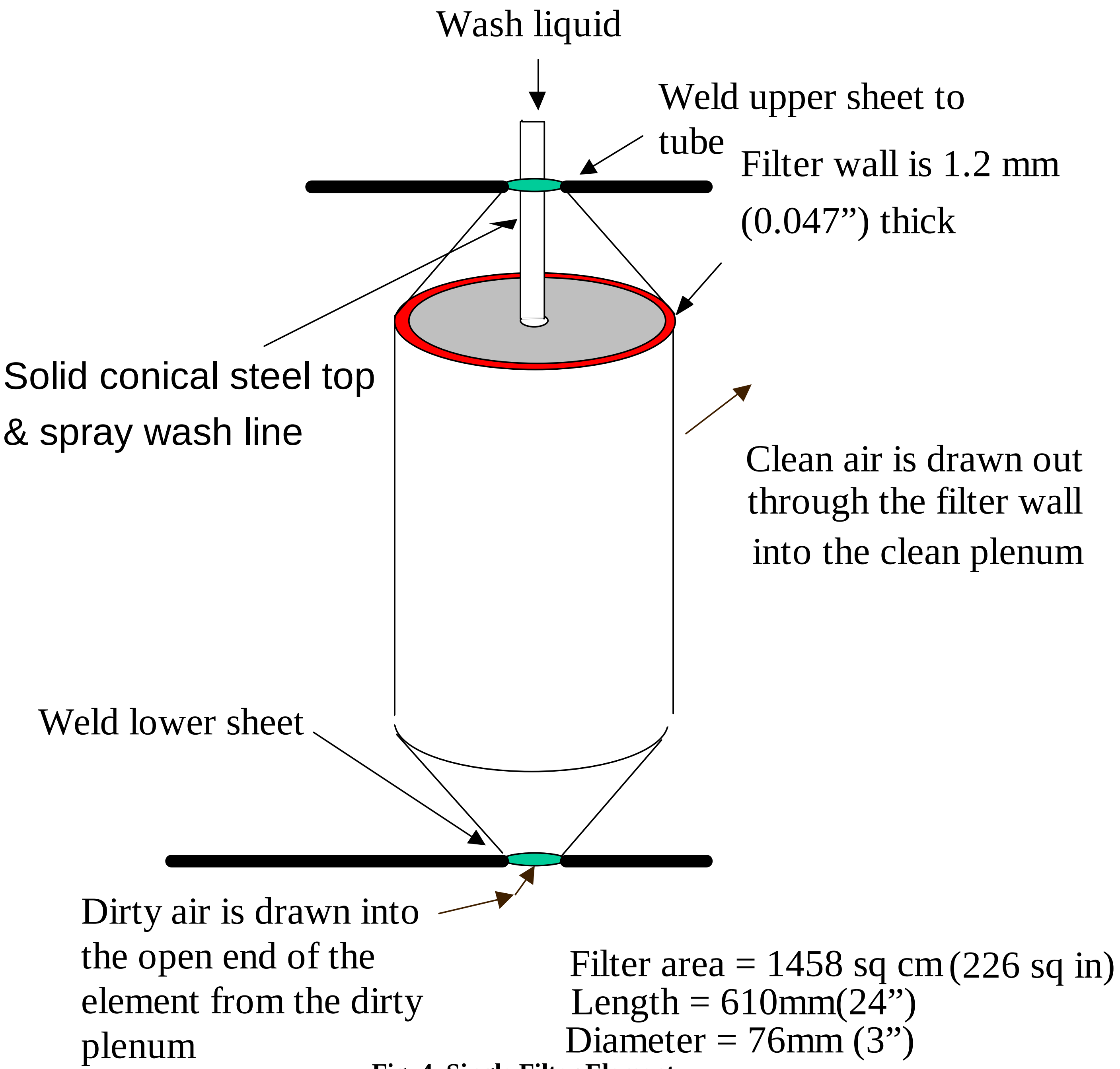


Fig. 4. Single Filter Element

Test apparatus results:

The spray wash cycles conducted at SRTC demonstrated the ability to return a totally plugged filter to ‘clean’ performance. Since the spray is applied to the dirty side of the filter we conclude that most if not all of the material resides on the front surface.

Radionuclide Evaluation

An emerging issue for HLW Tank Farm operations is the unknown quantity and identification of radionuclide and other particulates that may be accumulated on the HEPA filter. Since there exists no practical way of determining buildup of alpha and beta emitters, release of these radionuclide to the environment from a catastrophic HEPA filter failure has become a concern. The application of the in situ cleanable filter could potentially prevent buildup of alpha and beta emitters. The filter could be washed in situ to remove particulate matter build up and analyze the wash water to measure buildup verses operating time, and predict the result of a catastrophic failure. Once the accumulation rate is confirmed the filter could be procedurally washed to prevent excessive build-up. The in situ cleanable filter could potentially be used in other related applications such as recovering valuable material that may collect on a glove box HEPA filter.

Fire Resistance

Current design concept for the system emphases welded metal construction that will eliminate components prone to fail under fire or other high temperature conditions. Heavy smoke and smoke borne particulate may of course plug the filter, but given that the filter will be designed to withstand full (100. kPa vacuum (29.9” mercury); the plugged condition will not cause filter breakthrough.

Fire suppression system testing will not harm the filter media.

Condensers, demisters, re-heaters

The SRS waste tanks purge air exhaust systems currently include a condenser, demister, and re-heater for the purpose of preventing wetting of the HEPA filter. Test data suggests that the successful implementation of the metal filter will allow construction of an off gas system that does not require condenser, demister, or re-heater.

Assembly

An important consideration for the design of a new HEPA system is the issue of radioactive integrity. Seals used to support the filter media should at least equal the lifetime of the media. The use of welding to seal and assemble the sintered steel media is therefor quite an attractive feature. Given the potentially long life of the steel HEPA it should be practical to build the filters into the housing as an integral unit such that the housing and filters would be disposed of as a unit.

TEST RESULTS at SRTC

The first filter performance test on the sintered metal filter was a standard in-place leak test of HEPA filters per national standards. The filter passed the test with 99.99% removal efficiency. However, the DOP material partially plugged the sintered metal filter. Soaking the filter in methanol followed by air-drying, cleaned the filter. The test engineer indicated that the quantity of DOP material used to challenge the small filter far exceeded the amount needed for a 4.2 l/s filter.

The sintered metal filter was then tested with water in the simulated waste tank to determine if the filter could operate in a high humidity environment without plugging due to high moisture in the air stream. The water was agitated and heated to approximately 60 ° C with the humidity in the filter housings at approximately 100% and water standing in the bottom of the filter housings. The high moisture content of the air had little or no effect on the operation of the filter.

The performance of the sintered metal filter was than tested with a simulated salt solution in the test apparatus waste tank. The water was evaporated off the salt to simulate conditions found in the HLW dry tanks such as HLW Tank 9. During this time the waste tank agitator speed was increased to accelerate filter plugging by increasing the generation of droplets and particulates carried-over to the filter. With dry salt in the simulated waste tank, a hostile environment was created and the filter plugged (20% or more decrease in flow) in approximately 24 hours. The short plugging time is believed to be due to dusting from the salt cake, however no buildup of salt particles could be seen on the surface of the filter by visual inspection. The sintered metal filter was cleaned in situ using nano pure water five times during the 160-hour dry salt run. Each time the airflow and dP across the filter recovered to full clean flow. After the second cleaning cycle, the filter was plugged completely and the vacuum pump continued to operate deadheaded for 50 hours with vacuum as high as 99.5 kPa on the suction side of the filter. This allowed for the small salt particles to be pulled into the filter's flow channels, potentially making it more difficult to clean the filter. After cleaning the filter in situ, the airflow and filter DP recovered immediately.

The sintered metal filter was then tested using only simulated HLW sludge in the waste tank. The sludge simulates conditions found in HLW sludge tanks such as Tank 12. After approximately 600 hours of operation, the filter had not plugged. The filter was not impacted by the simulated HLW sludge until the water was allowed to evaporate off the sludge in the waste tank, creating a dry sludge. The dry sludge allowed particulate matter to be entrained easily in the air stream, creating a environment where the filter would plugged rapidly. Unlike the simulated salt, the sludge was quite visible on the surface of the filter. During initial in situ cleaning of the sludge; water, hot water and hot detergent water failed to clean the simulated HLW sludge off the filter. 10% nitric acid was found to do a good job of cleaning the sludge off the filter. The airflow and dP across the filter was restored to normal. Approximately 11.3 liters of 10% nitric acid and 11.3 liters of rinse water were used to clean the filter insitu.

To determine if a cleaning solution could be used for more than one cleaning cycle, used nitric acid was used to clean the sintered metal filter between 500 to 600 hours of operation time. Data shows that the airflow across the filter continued to degrade while using this recycled dirty cleaning solution for the in situ cleaning. Therefore, using a cleaning solution for more than one cleaning cycle is not recommended.

The final test was conducted using South Carolina road dust to challenge the sintered metal filter. The SC road dust simulates the atmospheric dust in-leakage that may occur on the HLW tanks. The dust was placed into a dust reservoir and slowly injected into the air stream using a small purge of house air. The filter was plugged three times using SC road dust. Each time the airflow and DP across the filter recovered. The filter was cleaned in situ with 10% nitric acid and rinsed with water. The last in situ cleaning was conducted using 10% nitric acid, rinsed with water, 10% NaOH and rinsed with water. Unlike the simulated salt, the SC road dust was quite visible on the surface of the filter. Even with all visible dust in the filter housing and on the surface of the filter, the filter did not deadhead during a heavy loading of the filter from 275 hours to 600 hours of operation. The sintered metal Mott filter has operated in a controlled but very hostile environment using simulated HLW salt and sludge and SC road dust. The filter had been plugged and cleaned in situ many times with the airflow and dP across the filter recovering after each cleaning.

CONCLUSIONS

SRTC plus continuing Mott test results indicate that an in situ cleanable or regenerable HEPA filter system is feasible using sintered metal as the filter media. The sintered metal Mott filter was tested in a simulated but hostile environment where the filters would plug rapidly with HLW simulated salts, simulated HLW sludge or South Carolina road dust. After plugging in the simulated conditions, the Mott filter was easily cleaned and recovered to approximately the original dP and airflow even after numerous in situ cleaning cycles. The sintered metal filter passed the standard In-place leak test of HEPA filters and high humidity and water had little or no effect on its performance. Test data indicates promising results and shows that the sintered metal filter is suitable as an in situ cleanable HEPA filter for ventilation systems and could potentially be used to recover precious metals from filtration processes.

The unique features of the filter system are:

1. Filter media can be constructed using various metals such as 316SS
2. Sintered stainless steel tolerates much higher temperatures than standard HEPA assemblies
3. All welded construction eliminates sealing requirements
4. Filter is designed to operate at pressure drop of up to 40 kPa, and is not damaged after extended periods at a vacuum approaching one atmosphere.
5. Easily withstands full vacuum of 100 kPa (one atmosphere)
6. High pressure drop due to accidental loading will not cause filter breakthrough
7. Particulates accumulate on the surface (not within mass) of the filter media
8. Smooth (not pleated) surface of filter is easily washed
9. Accumulated particulate is flushed off of the dirty surface by spraying the dirty side of the filter with water or other cleaning solution
10. Filter media is not damaged by flooding with liquid

11. The clean wet surface of the media is dried when high vacuum from the ventilation pump atomizes the residual water and pulls it through the filter media where it is vaporized by the high vacuum.
12. Drying time required is about 5 minutes from plugged to full flow
13. Washing in-situ eliminates the need to replace HEPA
14. Service life is expected to be extremely long
15. Eventually vibration or stress corrosion may induce filter failure in the form of cracking as opposed to the catastrophic destruction assumed for conventional HEPAs
16. Disposal cost per year are extremely small
17. Effluent of the cleaning cycle is available for analysis
18. Cleaning process generates a minimum of waste
19. Cleaning frequency can be used to minimize the quantity of assumed radionuclide release due to an accident scenario
20. The 1.2mm (0.047 inch) thick media is formed into 76mm diameter tubes. Tube diameter may be optimized to a larger or smaller size.
21. Filter media is constructed of varying micron diameter spheres of metal which are bonded by sintering.
22. Multiple filter tubes are suspended vertically from the ceiling of the chamber
23. High vacuum side of the system can use relatively small diameter piping
24. Requires increased horsepower per l/s to compensate for the pressure drop
25. Special pump is required to deliver high vacuum at high flow
26. Process vacuum on the process side of the filter is unchanged from that present with a conventional HEPA system.
27. Use of a vacuum breaker on the process side of the filter to protect process in the event of HEPA failure
28. System can be applied to extract valuable airborne particulates
29. Uses a minimum number of components or manipulations.
30. The filter section footprint is approximately equal to that of a standard glass (paper) HEPA per cubic foot per minute air flow
31. Shelf life should be virtually unlimited since there are no elastomer seals and the filter media should not degrade.

Cost Savings

Cost saving is proportional to the average life of the system being replaced. We don't know the life expectancy of the in situ cleanable HEPA, but assume it to be in excess of 10 years. Cradle to grave cost for the 11,000 filters used per year in the DOE defense complex has been estimated at $40 million per year. Metal filters would generate maximum savings when used to replace high use and special problem applications such as the SRS Consolidated Incinerator Facility (CIF), Idaho Calcine Facility, and SRS glass melters with high off gas temperature.