NUCLEAR INDUSTRY GUIDANCE

NNVF Discussion Document - Guidance on “safe change” filter housing design.

Issue 01

VMG DD003

June 2015

Foreword

This document has been issued as a National Nuclear Ventilation Forum discussion document aimed at formulating best practice within the UK Nuclear Industry for possible adoption by the Nuclear Site License holding companies. As such it may contain ideas and comments which may not reflect the consensus opinions of the NNVF attendees and should not be relied on as a source of information or used for contractual agreements. Any one who uses information from this document will therefore do so at their own risk.

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Acknowledgments: The following companies are acknowledged for their contributions in writing this document and supplying photographs. AWE Plc, Sellafield Ltd, EDF, MC Air Filtration, Emcel and Cam Fil Farr.

Current at Date of issue. 4 June 2015

RECORD OF REVISIONS

Document Issue	Revision Date	Changes Made
Issue 01	June 2015	First Issue

CONTENTS

1. INTRODUCTION

This paper has been written by the UK National Nuclear Ventilation Forum filter subcommittee. This sub group has expert members from the UK Nuclear licence sites and UK filtration supply chain. The document has been written to provide some education on the meaning of “safe change” when applied to filter housings. As such it may contain ideas and comments which may not reflect the consensus opinions of the NNVF attendees and should not be relied on as a source of information or used for contractual agreements. Anyone who uses information from this document will therefore do so at their own risk.

There are many misconceptions regarding the meaning of the word “safe change” when applied to filter housing design. This document has been written to detail what “safe change” means in practice for filter housing design and looks at safe for whom. This document also examines the practical application in mobile fan/filter units for decommissioning.

This document should give the reader enough knowledge to recognise possible contamination migration during filter changing and to dispel the myth surrounding the phrase “safe change”.

2. EARLY FILTER CONFIGURATIONS

To understand how the term “safe change” was coined we first need to examine some of the early less “safe” filter configurations.

Two popular filter configurations of the 1960’s were the Ladder Rack and the walk in Active Filter Room. To change these filters man entry to the ladder rack plenum or Active Filter Room is made wearing pressurised suits or suitable RPE. When changing the filters the filter is simple removed from the wall of filters or housing and a clean unit inserted. The filter change operative and the “clean” side of the housing/filter could easily become contaminated. Therefore from a safety view these were not safe change for the filter changing team or the down stream ductwork.

Note: Ladder Rack systems were still being installed in the 1980’s. However these were for low activity applications, hence with reduced risk when changing

Fig 1. Ladder Rack Style Filter Housing (Filters Shown To The Left).

Fig 2. Modern Ladder Rack Design.

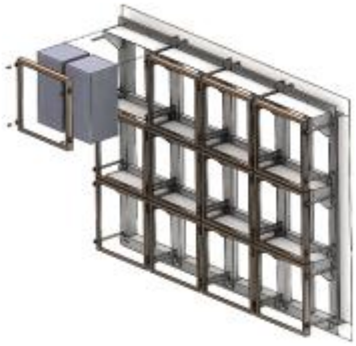
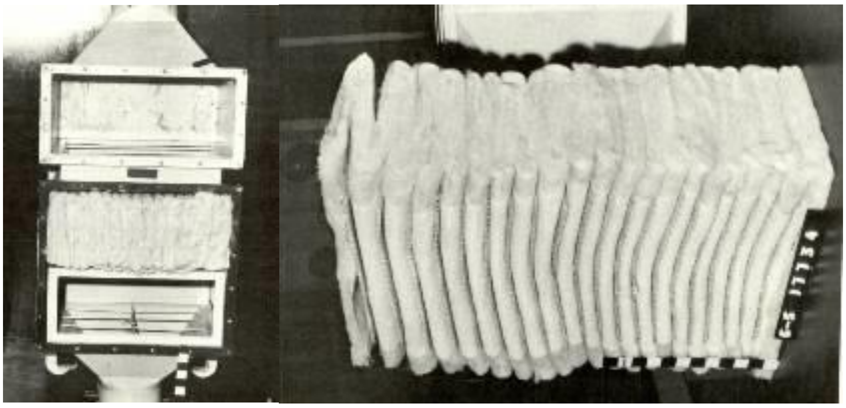


Fig 3. 1960's Non Safe Change Housing In Exclusion Area.

Fig 3. Shows the "walk in" style of filter plant room, where the filter is simply withdrawn into the room with no protection as the whole room was classified as a dirty area.

The non-safe change housing in the 1950's normally were of the "re-packable" design. Basically the filter wadding was made up larger than the filter housing and compressed into the housing, so it made its own seals. The obvious problem here is as the wadding is removed the particulate would mostly sit on the top of the wadding and may become airborne as it is pulled out the housing.

Fig 4. Re-packable non safe change housing and new wadding.



3. THE ROLE OF CHEMICAL FILTERS IN FILTER HOUSING DESIGN.

Chemical filters were developed during both world wars to counter the effects of gas attacks. It is documented by the DOE that the US Army Chemical Corps supplied filters to the Manhattan Project nuclear weapon programme. There are many simularities with filter housings for chemical and Nuclear protection. Its difficult to say where improvements in housing design came from. However the important factor is that the effort applied improved the technology available for both industries.

Safe Change Systems within the Nuclear Industry tend to be used to keep contaminants from getting out of an area or building however, systems can also be used where contaminants are trying to be kept out or from gaining entry into an area/building. Examples could be in an extract system from a process plant or alternatively on a ventilation inlet or recirculation system to a critical control room.

Military Chemical, Biological, Radiological, Nuclear (CBRN) applications tend to operate safe change systems in a way that protects occupants of certain environments such as those within armoured vehicles, ships, bunkers and buildings. Systems exists within vehicles that use the Push through style of filter to eject contaminated filters from within the clean area into the contaminated zone. Of course with vehicles that are challenged by CBRN agents the immediate reaction is to withdraw to a clean zone before changing filters. Once at this clean zone the whole vehicle can be decontaminated and then filters changed using protective suits etc.

However, clearly this process is not possible for building protection and in this instance buildings are more likely to have two systems set up in parallel to allow one to be changed while the second is offering protection to the environment. Isolation of each system is achieved in the same way as for Nuclear type applications with the use of dampers. Changing of such filters can be complex and extremely cumbersome since building CBRN filters tend to be significantly larger than those for vehicles.

In Marine applications it is rare that the traditional bagging system is used when changing of filters. Systems are available that simply cap off the contaminated filter before withdrawal and change. This type of process leaves opportunities for cross contamination between clean and dirty sides of a ventilation system.

It should be noted that for CBRN applications the large majority of filters tend to be built as a combination of both HEPA and Carbon since protection is usually required for both chemical & biological agents.

4. BAG CHANGE HOUSINGS

Ozonair produced a round “safe change” housing in the late 1950’s. These were still being installed in the 1980’s relatively unchanged. Fig 4 shows a filter in position with the bag removed for clarity. The handwheels on the lower part of the housing lift the filter up to seal on its top surface. The change bag is on the clean side of the housing. So technically as the dirty filter is withdrawn into the bag the clean side of the housing could becomes contaminated. However this was a good improvement from the previous housing designs.

Fig 5. Ozonair Filter Housing.

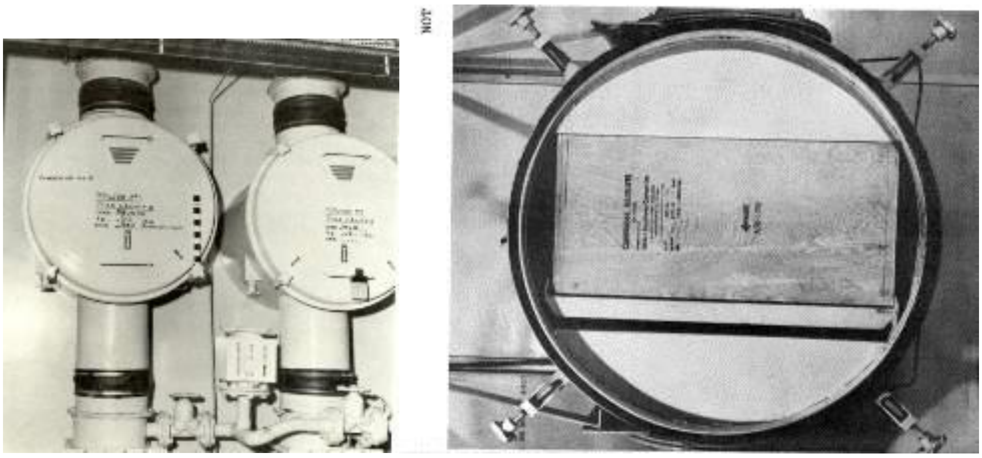
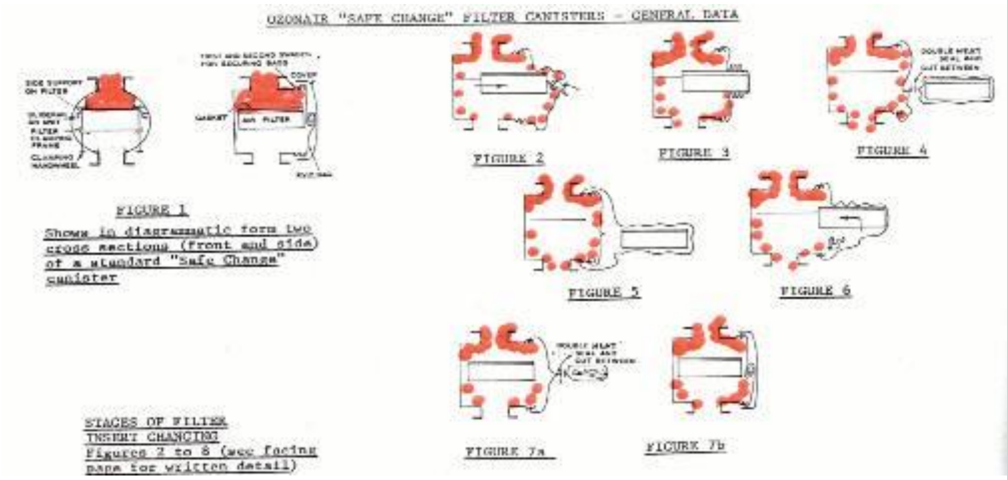


Fig 6. Original Filter Change Sequence With Added Red Markings For Contamination Movement.



From these early configurations the square bodied “safe change” filter housing was developed which is generally used today. The old filter could be removed from the housing into a PVC bag and then a new filter put into the housing using a second new PVC bag, and inserted into the housing. As with the round design in most circumstances this is “safe change” for the filter change team.

Fig 7. Modern “Safe Change” Housing with filter support table. Note the air flow is horizontal.

Fig 8a and b. Modern Multi Bank “Safe Change” Filter Housings With Pre-Filters (Top) and HEPA Filter arrangement at the bottom.

There are several different styles of “safe change” housings ready to accept standard square filters. The most common application is to have the flow going from top to bottom to help “retain” any particulate in the filters as they are changed. In addition, using filters in this configuration will mean that the seal face of the filters is uppermost such that they are not damaged or dragged upon installation. However, as the filters are changed particulate can spread around the change bag and onto the “clean” faces of the filter housing. If we have the down stream “clean” ductwork below the filter, loose contamination will settle on the “clean” side. Therefore this type of housing, although may protect the operative from the filter during change out, may not be considered as “safe change” for the down stream ductwork.

The housing needs to be isolated from the headers either side during filter change as you would not want the facility flow running through the housing when the filter is removed. This may be designed as a complete system isolation where all filter may be changed without airflow passing through or systems may be designed such that individual housings may be isolated so that other filters within the bank arrangement may continue to operate albeit with a slightly increased flow rate until all are brought back on line. On plant dampers are normally found above and beneath each housing. Also very often the depression within the ventilation duct will be too great to be able to use the change bag effectively if only one isolation valve was fitted. Because the isolation dampers either side of the housing are normally a little leaky a small filtered air in-bleed is provided. This inflow can be adjusted so it balances with the leakage of the isolation dampers and will provide a small depression in the housing. It can therefore easily be seen that any contamination which makes its way to the clean side of the housing during a filter change will either be carried into the clean side of the duct during a change or when the ventilation is restored.

These types of housing are used for atmospheric abatement filtration and normally would be very lightly loaded with contamination, with the majority of any particulate arising from the processes being stopped by local process filtration. Therefore this very minor carry over of particulate is not normally a problem, although an allowance should be made in the plant design for particulate carry over during changing. What is important is the overall Decontamination Factor the housing provides over its life time. The subject of the required facility Decontamination Factors is fairly complex and therefore can't be discussed in any great detail in this general document.

In practice the post filter atmospheric discharges are carefully measured. These measurements have shown over many years that the discharges can be kept within the discharge limits set by the Enviromental agencies when the plant is operated correctly.

These types of change methods are often more accurately described as "Bag In Bag Out". This description does not give the illusion of providing any safety for the down stream ductwork.

5. SQUARE TYPE SAFE CHANGE FILTER HOUSINGS

The square type arrangement preceded the now more common Circular type filters but can still be found in many Nuclear sites across the UK and Europe. The movement towards the Circular type housings and filters was driven by the more consistent sealing of the circular filter and by the suitability to dispose of the circular filter without the need for dismantling or cutting up.

The picture below, see fig 9, shows a typical Prefilter and HEPA filter housing with safe change bag in place for the prefilter but removed on the HEPA filter for clarity. The HEPA filter has seals fitted to the upstream face that seat onto an internal flange within the main housing. The middle picture shows the eccentric "Cam Bar" arrangement that is used to lift the filter into place and compress the seals within the housing. This arrangement allows the filters to be inserted into the housing without dragging or damaging the seals and the eccentric bars control the amount of compression on the seals to be set. In the example shown the flow of air is from top to bottom of the unit although it is also possible to mount similar types of units such that horizontal flows can be accommodated.

Collection of the particulate is on the top of the filter and within the pleats of the material and so there is potential for this to be disturbed during filter change and thereby contaminant the clean side of the housing however, unlike the circular filter there is no need to jerk the filter off its spigot and so opportunity for disturbing particulate is limited.

Past experience has led to seals becoming over compressed due to oversized filters being fitted or filters becoming stuck to the seal face of the housing due to seals being used that have not properly been cured. In such instances it has been particularly difficult to withdraw the filters through the safe change bags.

Due to the weight of HEPA filters (particularly Type II) some systems employ a support table or platform to withdraw the HEPA filter onto however, this can make changing of the filter more complex.

Fig 9. Square Safe Change.

6. CIRCULAR PLUG IN SAFE CHANGE FILTER HOUSINGS

Fig 10 Modern "Safe Change" Plug In Filter Housing.

Fig 10 shows a plug in filter being removed from its filter housing, with the change bag not in place for clarity. The filter seals onto a round spigot, which can be seen at the back of the housing on the left. Here the flow of air is normally from inside of the filter to the outside. As the filter is changed this helps to keep any loose particulate off the clean side of the housing.

The circular plug in filter was developed by AEA Technology during the 1970's and aims to provide a more reliable sealing arrangement to the proceeding square filter, while also being directly disposable into a waste drum without size reduction.

This type of housing suffers from the same problem of potential contamination carry over during a change as the square safe change filter housing. However where the flow is from the inside to the outside for the filter element the geometry lends itself better to retain any loose particulate.

There is a style of multiple filter "Plug In" housing, the EP2, which has multiple plug in filters. This style was originally introduced with all the filter flow coming into the centre of the filters and radially flowing outwards, identical to the single housings. The inlet and outlet were both from the top. However in some installations this original design has been modified, to save space the air first enters the inner diameter of the first filter and then flows radially inwards through the second filter, i.e. the flow direction through the second filter is the wrong way to normal to save space. However by the time the air stream has reached the second filter it is practically particulate free so this compromise is not normally a problem, although the variety of derivatives may start to become confusing to some building operatives. There may be good reason why the standard filter housing design has been modified, i.e. design flows may have changed and the now built plant room is not big enough. Any modifications normally introduce other issues so great care and thought need to be applied to changes. With the modified EP2 combining two filter stages, the mixing distances for DOP, etc. cant be fully achieved. The use of 'quick mix' injection for DOP does not reduce the mixing distance to zero, so many of the 'alternative arrangements' are not fully compliant and leave the operators with a problem of proving that there efficiency testing results are sufficiently accurate.

With this housing the filter slide back on two rails before it is lifted onto the back spigot. There have been reports of the rails having sharp edges so damaging the filter as it is inserted. Because of this problem these rails need to be nicely rounded. See fig 11 for poorly rounder guide rails.

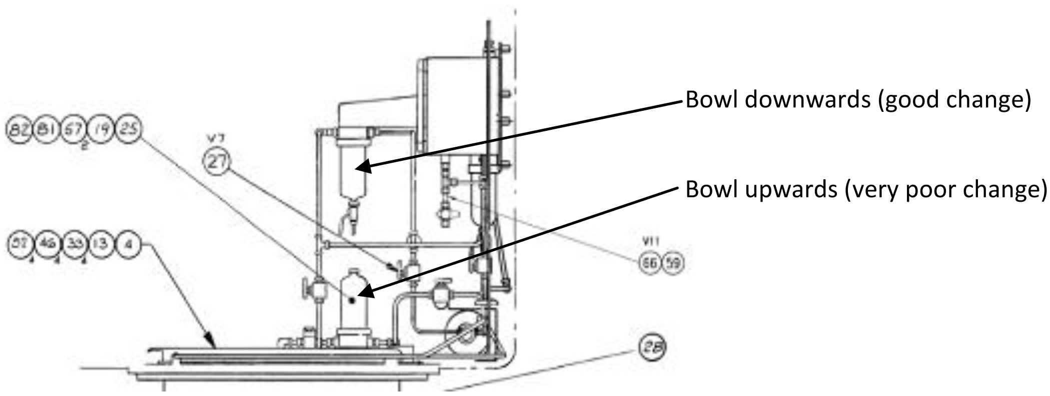
Fig 11. Guide Rails With Insufficient Corner Rounding.

When this “Plug In” filter is changed from a horizontal to a vertical orientation the amount of particulate retention will change.

With sintered metallic liquid process filters, which are basically the same shape as their larger air filter cousins, the elements can be mounted with the removable bowl on top of the mounting spigot or below, see fig 12 and 13. Note; Pall Europe now advise that all filter elements should be exclusively mounted with the bowl downwards. With the upper filter housing in the sketch at fig 12 the element can be pulled off the housing spigot with the particulate collected in the removable element retained in the element. However with the lower filter housing in fig 12, when the filter element is removed the particulate collected has a high chance of dripping onto the clean side of the filter housing, which is unexpectedly what is actually found in practice. This would effectively render this micron particulate removal filter useless. The same should be true for its larger air filter cousin to some extent. The liquid plug in filter has been further developed to enable a bowl upwards configuration by adding a weir to the filter element for remote change applications. However this still wont be as effective as the bowl downwards configuration.

Fig 12. Standard Liquid Plug In Filter

Fig 13. Sketch Of Poor Liquid Plug In Filter Installation



7. BAG CHANGE TECHNIQUES.

When bagging in/out filters through the change bag there are several popular techniques to separate the filter from the housing. The technique for bagging out final stage filters is normally different than for bagging out components from active glovebox lines. The reason for this is that the filters bag is on the clean side of the filter housing and so should be contaminated to many orders less than the average glovebox, except for the push through wall mounted types. Also the change out bags for filters are normally much larger than used for gloveboxes, although this is not always the case.

The bags are either cut with scissors/knife or using a hot wire. It is believed that the hot wire will seal in any loose contamination.

A popular method in the UK is to swan neck the bag and then cut and tape the loose ends. The filters needs to be rotated to form the swan neck and is sometimes lowered onto a lower filter change table and simply rotated, see fig 14 or just simply rotated. Some of the air around the filter may be pushed back into the clean side of the housing.

Fig 14. Swan Necking At Bag Out.

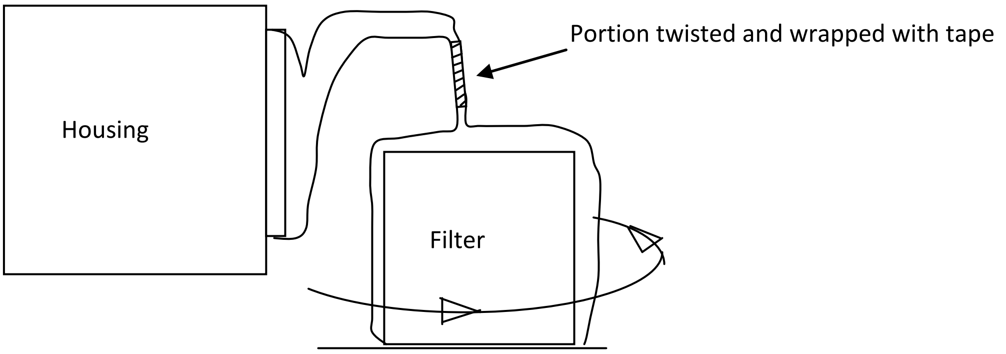


Fig 15. Swan Necking.

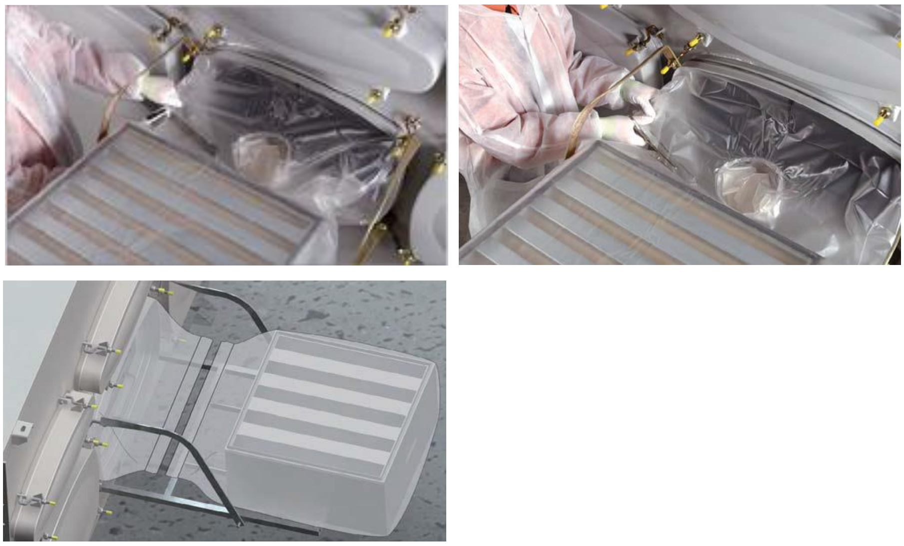
Cable ties or Steel banding is also commonly used. These are positioned to neck the bag down and the bag cut between the ties/bands.

Bag welding techniques are also available for filter changes which are identical to that used for more hazardous glovebox work.

Fig 16. Bands applied to a change bag before separation.

Fig 17. Cable Ties And Scissors.

Fig 18. Camfil Bag Welding Method (Weld, Cut and Seperation).



8. CANISTER FILTERS

Although there are normally no claims that canister filters are safe change, they do offer some safety advantages. Techniques have been developed for changing canister filters using ventilated enclosures or change bags. The main advantage for this type of filter is that normally during a filter change there is little likelihood of particulate migration to the down stream ductwork, so they achieve a good safety rating from a down stream ductwork view, although they have a poor safe change rating for the person performing the change and contamination spread to the laboratory. For some of the smaller canister filters there is a large selection of end fittings available. The standard 25 l/sec has 4 end flange designs, so it would be good practice to double check that you have the correct replacement filter derivative before removing the old one.

Fig 19 Picture shows a 5Ltr/s Process HEPA Filter

9. FILTERS WHICH ARE SAFE TO ENTER INTO THE WASTE STREAM.

Under certain circumstances the holdup with a HEPA filter can require it to enter the intermediate level waste stream. In short, for the current low level RA waste stream the filter can enter the waste route as a double wrapped package. For intermediate level waste the disposal route requires the filters to fit into the standard oil drum. Where standard square 609 x 609 filters are disposed of this will require their size reduction to allow for this disposal route. Unfortunately size reducing a HEPA filter which is contaminated to an extent where it is classified as intermediately level waste is not a risk free operation. To lessen this size reduction hazard a split 609 x 609 unit has been manufactured, which in operation acts similar to the standard filter, but each half of the filter can be directly disposed of within the standard oil drum package. In this way we now have a filter which is "safe" to enter the intermediate level waste stream.

Fig 20. Split 609 x 609 unit for "Safe" Intermediate Level Waste disposal (fitted with split pre-filters).

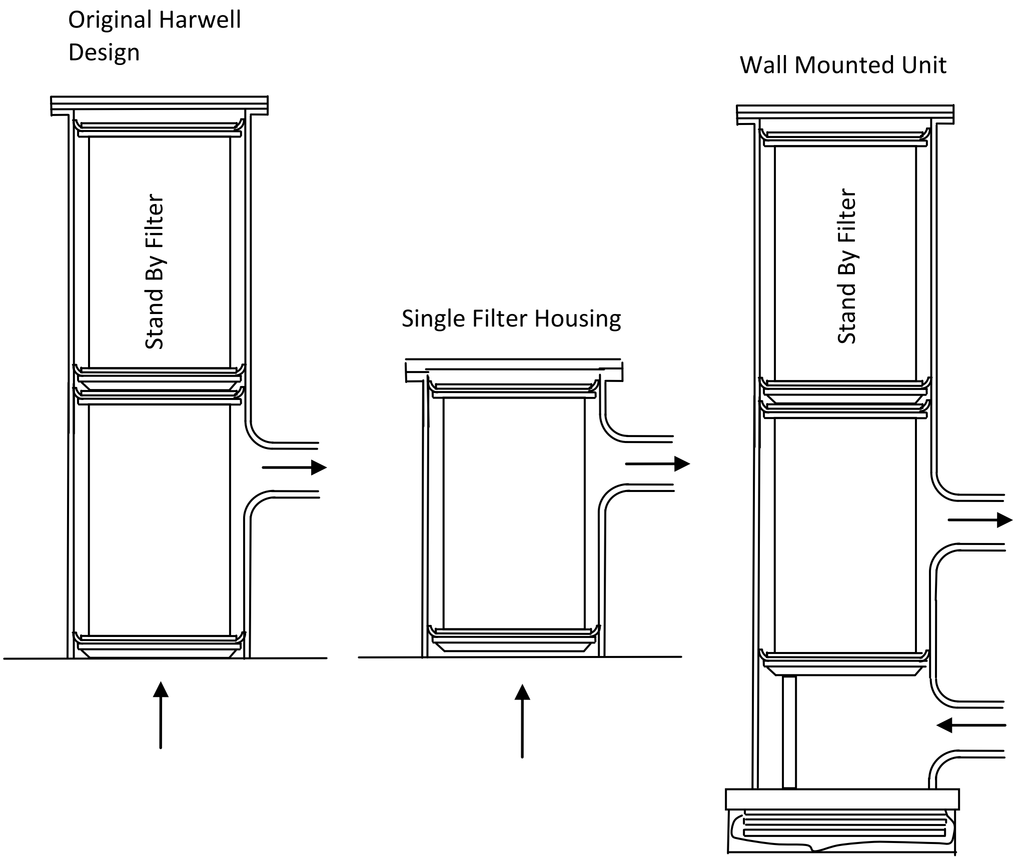
10.PUSH THROUGH FILTER HOUSINGS USING RADIAL FLOW FILTERS.

There are several different types of push through filter housings and push through filters. The main distinction in these filters is between the designs which have basically radial or axial flow. This section will look at the advantages and disadvantages of radial flow push through filters, with the next section looking at axial flow push through filters, which are often called “Push Push” filters.

Radial flow push through filters are normally used to accommodate gas process flows. As with the other filters we will first look at the hazard to the operator and then the hazard to the down stream ductwork. The radial push through filters come in standard sizes ranging from 12.5 l/sec to 160 l/sec.

Fig 21. Photo Of Radial Push Through Filters.

Fig 22. Radial push through filter housing types.

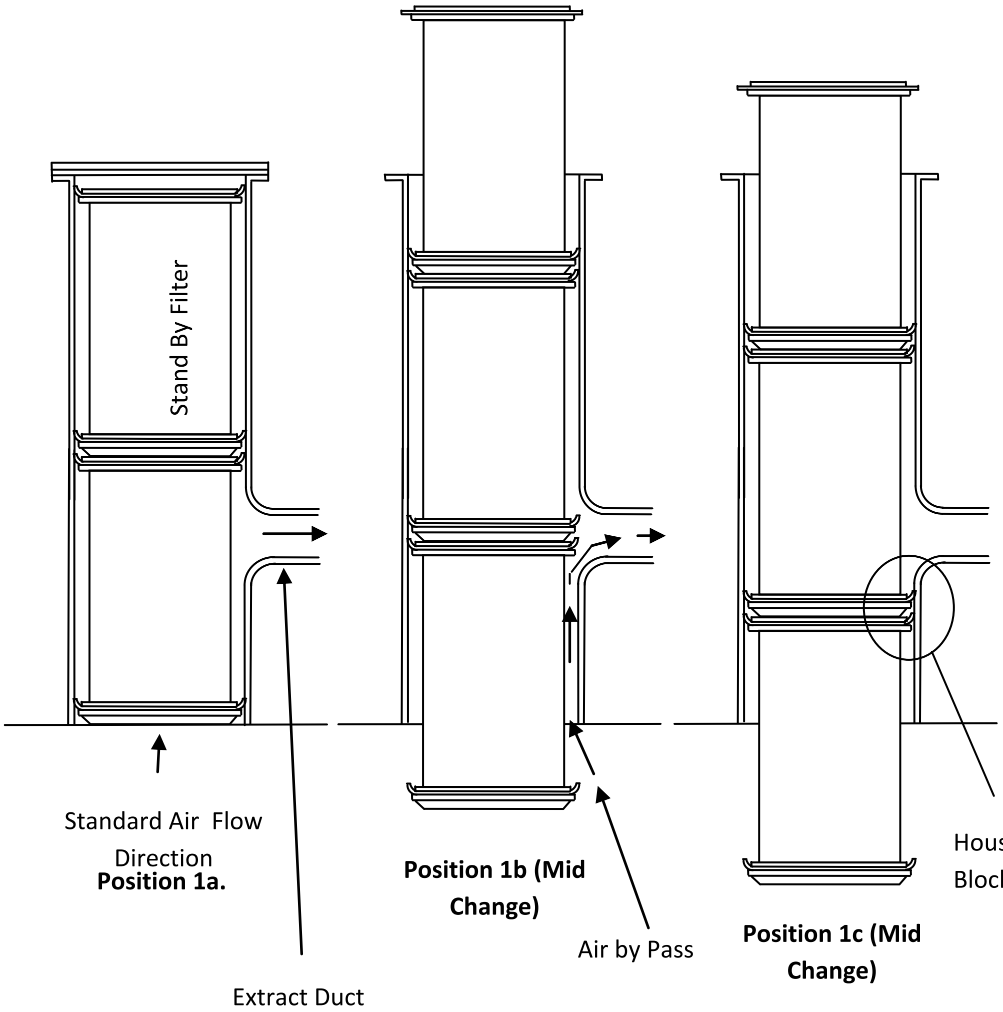


With these types of filters there are three basic types which vary the hazard to the downstream ductwork and filter change team. We have the original "Harwell" design, the modified one filter element housing and the wall mounted design. With the original design the maintenance man is protected from particulate release by the "Stand By" Filter. However with this design it was recognised that the "Stand By" filter may be 20 years old before it is put into service. The truncated single filter housing version was then developed. To protect the maintenance crew either the new filter is placed in a special filter changing tube or a bag placed over the housing. During filter changing there is the risk that the ventilation duct will be exposed to the laboratory as the secondary filter is pushed through if precautions are not taken. This could risk tripping the ventilation system. The third type of housing is the wall mounted unit where the filter is displaced into a catch bag. However with all these systems the risk to the maintenance crew from contamination spread are minor with no problems reported on the sites where these types of filter housings are installed.

The risk to the down stream ductwork is a little more complex. The risk can be explained from the sketches of the changing process for each type of element, fig 16.

During the Filter Element change it is apparent that if the glovebox inlet flow and process gasses are not stopped, potentially dirty gas will be passed directly to the extract duct when the filter insert is bypassed when the seal of the used and secondary filters are passed by the extract duct. This may lead to some contamination entering the extract duct, although it should be noted that HEPA filters are not absolute and will let through 0.02% of the challenge at the most penetrating particle size for a 99.98% filter during their normal use, i.e. the downstream duct will not be guaranteed as contamination free. It should also be noted that the extract is Blocked for part of the change. These effects can be seen in Figure 23. Also during the last part of the filter change the primary containment will be slightly pressurised as the used filter is pushed in. This blockage situation is normally overcome by providing Run and Standby filter housings or by using a small filtered bypass line to provide some ventilation for filter changing.

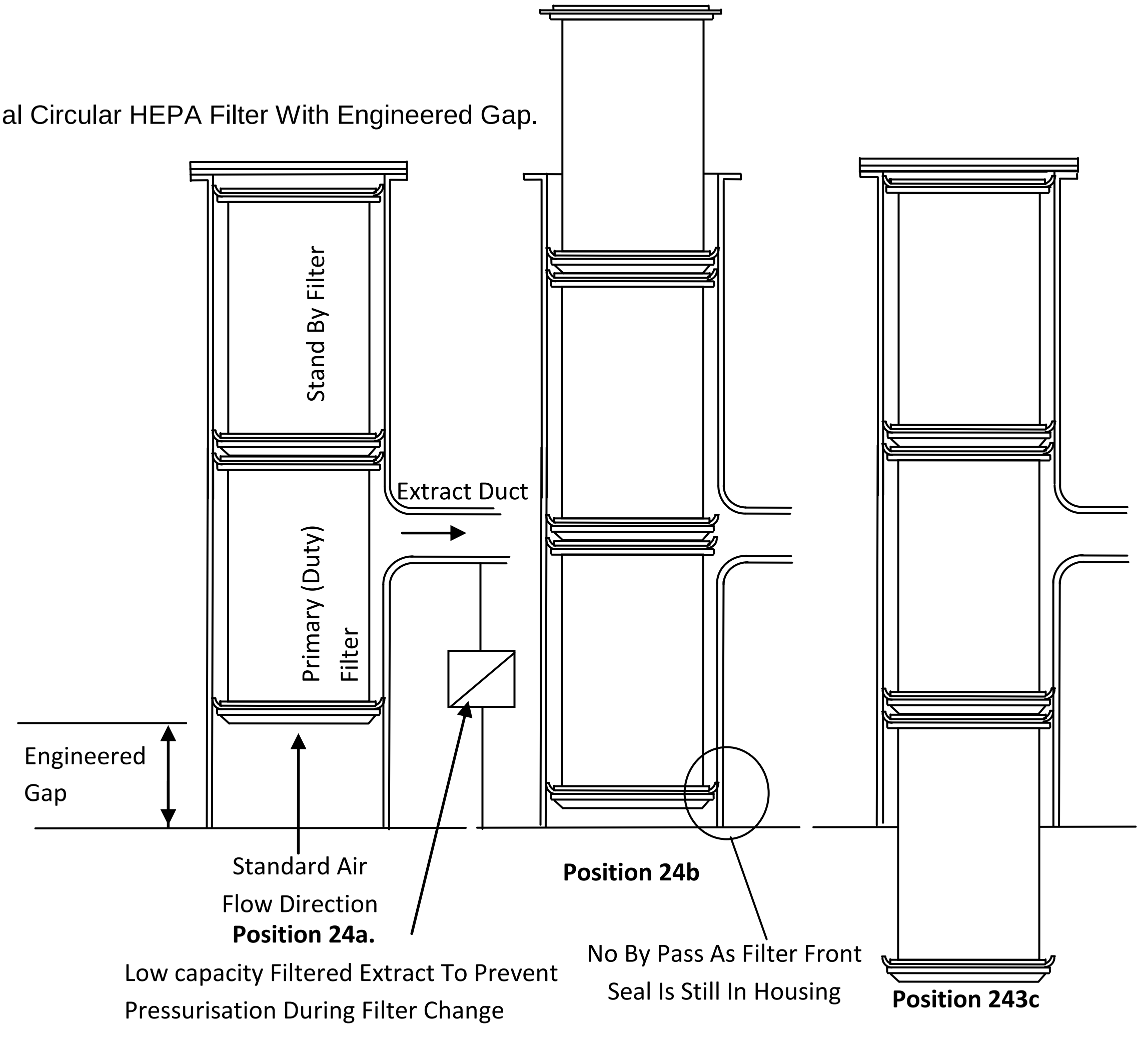
Fig 23. Original Standard Harwell Push Through Filter Housing Design.(Type A)



With a derivative of the standard original Harwell push-through filter housing the design has been slightly modified giving an “Engineered Gap” between the primary filter and the containment, see fig 24. This prevents the “passing” of the filter element during a change, see fig 17 position 17b, however the “Engineered Gap” means the filter can not be tipped/rotated to release the seal to allow it to be removed from the housing, see fig 24 position 24c. This is only a problem where the extract needs to be isolated from the containment, which is usual where Run and Standby housings are provided, in such cases a filtered relief in-bleed needs to be fitted into the rear of the housing to stop a vacuum being formed behind the filter.

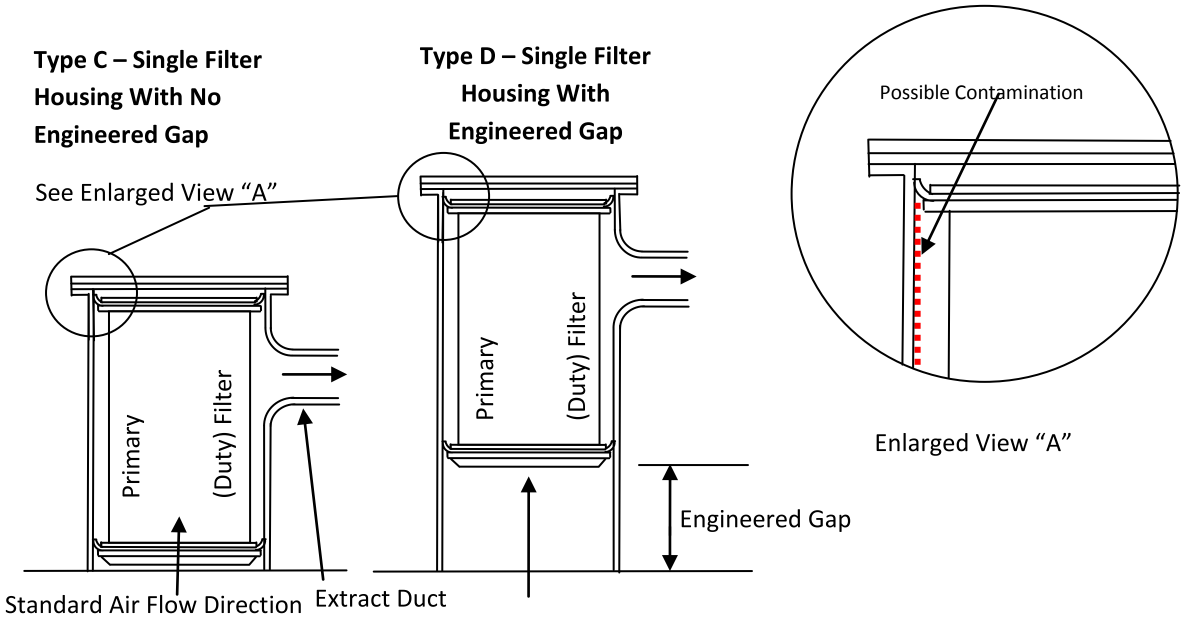
Where there is a single extract on the containment the “Engineered Gap” will lead to a greater pressurisation of the containment when the sealed filter end is passing through the lower portion of the filter housing during a filter change. Based on a 35 l/sec filter of 200mm dia and 300mm length the filter displacement will be approximately 9.5 litres with the pressurisation relative to the glovebox volume. In some designs a low capacity filtered extract line is provided to prevent pressurisation of the glovebox during filter changes.

Fig 24. Radial Circular HEPA Filter With Engineered Gap.



As detailed earlier the HEPA filters are not absolute protectors and a very small amount of activity may be expected to pass the element. If these particles settle near the upper seal and the standby filter is pushed too far into the housing or a slightly shorter filter fitted, this may expose a ring of contamination. It can thus be seen that filter positioning is more important with single filter designs then with dual filter units, see fig 25. However monitoring of actual in-service extract systems show that the extract ductwork remains very clean and not the problem it was once expected to be.

Fig 25. Single Filter Radial Flow Circular Filter Housings



A further development of the push through housing design is the remote wall mounted unit where the old primary filter is posted into a filter change bag, see fig 26. With the standard wall mounted design the filter seals are by-passed during a filter change as the extract is placed less than a filter length from the inlet. Increasing the distance between the extract and inlet will then cause the primary filter to be delivered further away from the bagging ring, see fig 27. It has been found that the compromise to make this non by-pass design operational is to introduce spacers between the secondary and primary filters, with the added waste disposal during a change. In some cases the spacer has been bonded directly to the rear of the Filter Element so it is not forgotten during a change. Serious thought should be given to the number of filter changes needed to be made over the facilities life and multiple canister filters considered, although most filter changes are initiated through penetration test failure (Note: Normally Push Through Filter Housings are not in situ tested). Both of the standard wall mounted units suffer from problems associated with having a standby filter which may be very old when put into use. It would be possible to use a single filter wall mounted unit. However in practice these are not normally used.

It should be noted that the wall mounted push through filter housing is the only "safe change" design which has the change bag on the "dirty" side of the housing.

Fig 26 Standard Radial Flow Circular Wall Mounted Push Through Filter Housing.

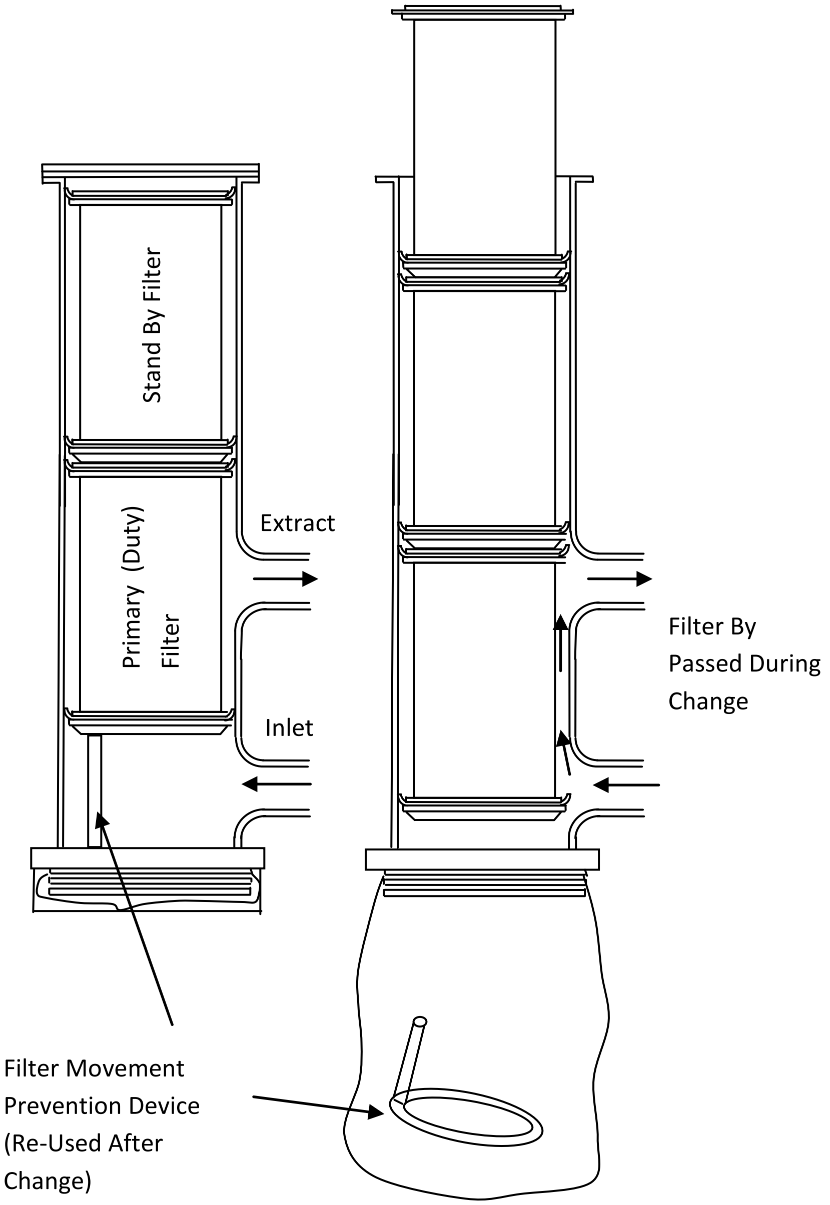


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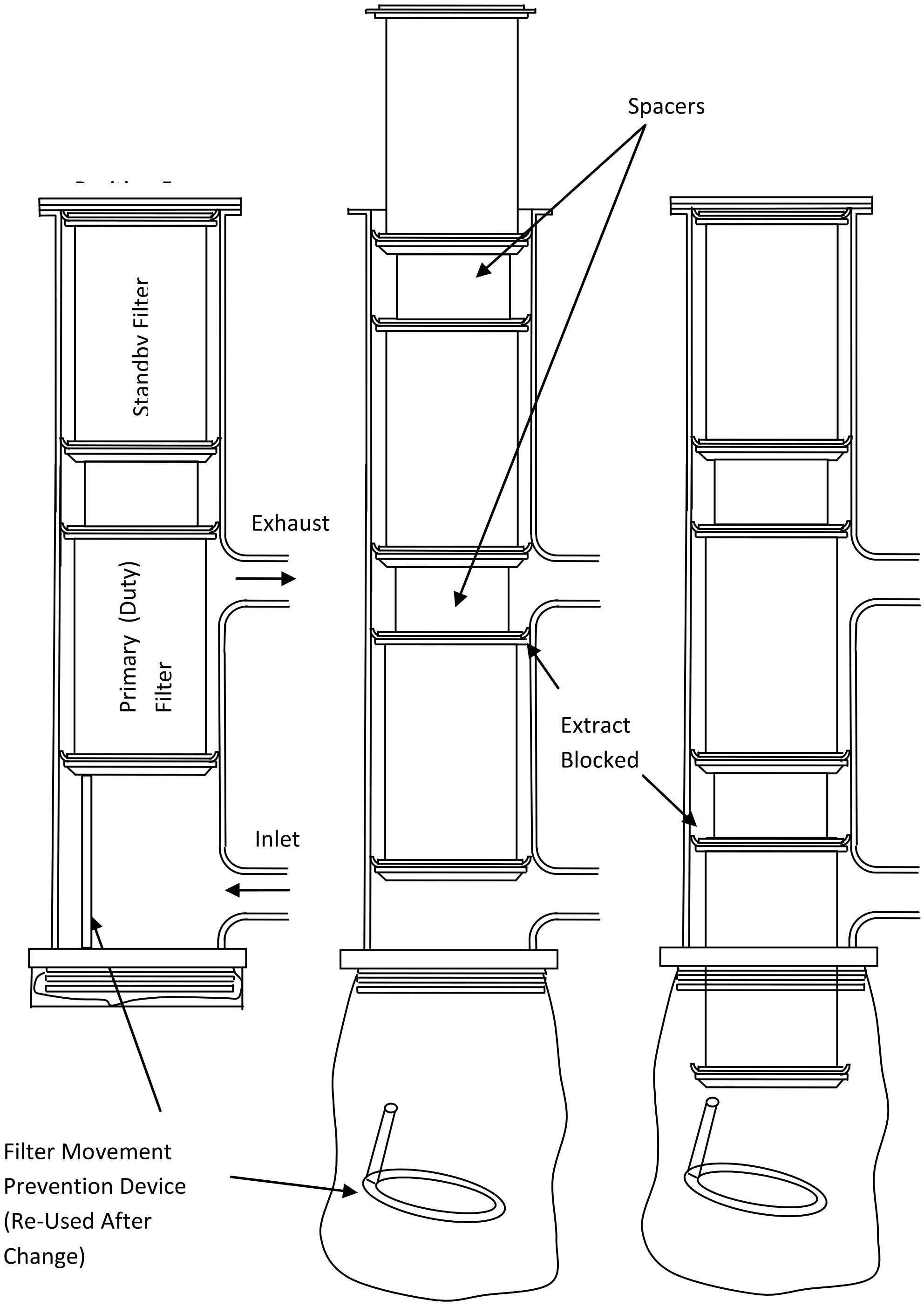
Fig 27 Radial Flow Circular Push Through Filter Housing With Extended Distance Between Inlet And Extract Ducts.



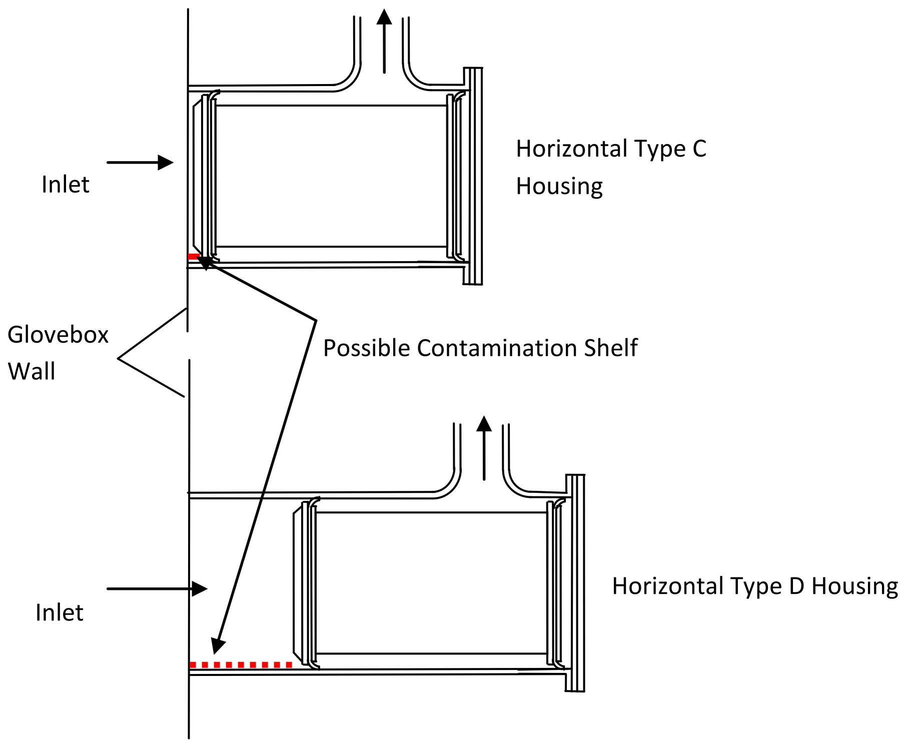
There is not always a choice due to space constraints if the filter housings can be vertical or horizontal. However there are some technical issues which must be understood with both designs. With vertical filter housings, if the filter is not properly vertically constrained it has been known for the filter insert to slowly creep down and start to extend into the glovebox, thus no longer providing any filtration, see the mid position filter element in Fig 23. This problem would not normally occur in horizontal units.

Both types of housing have been known to have Filter Elements incorrectly positioned within the housing. This could lead to the housing being blocked by the end of the Filter Element or for the element to be bypassed. Therefore all designs need a means to ensure the Filter Elements are placed in the correct position in the housing and that they stay there.

With horizontal housings as particulate is disturbed and settles within a Glovebox the highest dust levels will be on horizontal surfaces, when compared with a vertical surface. Thus if there is any horizontal shelf at the front of the filter housing particulate will be collected here which could be wiped under the front filter seal when changing, see fig 28. Obviously here the original Harwell design has the shortest horizontal shelf but may also suffer from by-pass problems.

Theoretically if the housing and Filter Element have been incorrectly toleranced in a horizontal design, the Filter Element could settle leading to a passing above the Filter Element. However the Housing and Filter Elements tolerances as normally defined have not led to any problems of this type being reported.

Fig 28. Horizontal Filter Housings



11.“PUSH PUSH” CIRCULAR FILTERS.

Circular filters which have an axial flow direction can be mounted so the flow passes through two sets of filter packs. These have been termed “push push” filters, and are more common in the Pharmaceutical then the UK Nuclear Industry, see fig 29.

Fig 29. Photo of a Push Push filter element.

Fig 30 Example of a Push - Push Housing.

Fig 31. A Push Push Filter Assembly In Operation.

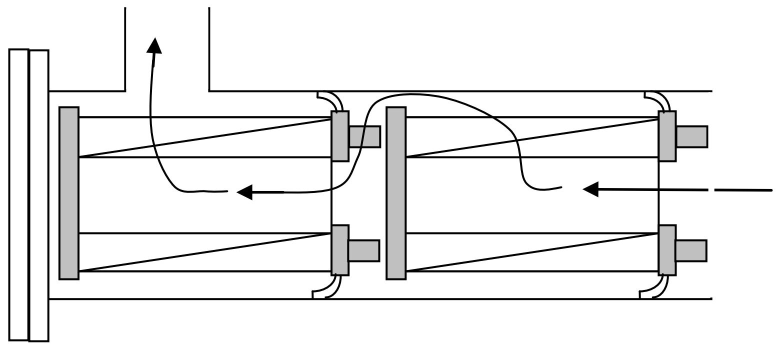
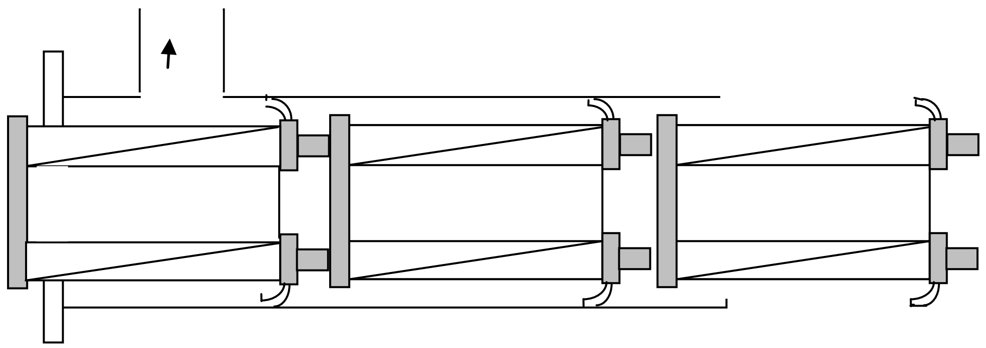


Fig 32. A Push Push Filter Element Change.



There is little experience of “Push Push” filters in the UK Nuclear industry, so this section has not been written from lessons learner, but only from a desk based analysis.

The obvious advantage of these filters is that the housing could contain two stages of series filtration. These filters are normally manufactured to a H14 standard, therefore giving a very high decontamination factor. The down side would be the higher pressure loss when compared with a single filter.

When changing these filters the containment the housing is attached to would not suffer the pressurisation which the standard radial circular filter gives with its sealed rear end. The maintenance person would be exposed to the containment via one or two stages of filtration, depending on the housing configuration during the change.

As the rear of the housing is opened, to insert another filter, the extract line is exposed to the laboratory. If the extract has been designed to shut down on loss of depression, this may cause the extract fan to trip off or cause a change over of the fans set. What may be required is the filter housing to be isolated during a filter change.

Filter positioning should be as important as with the radial circular filters. Therefore provision to hold the filters in the correct position will need to be seriously considered.

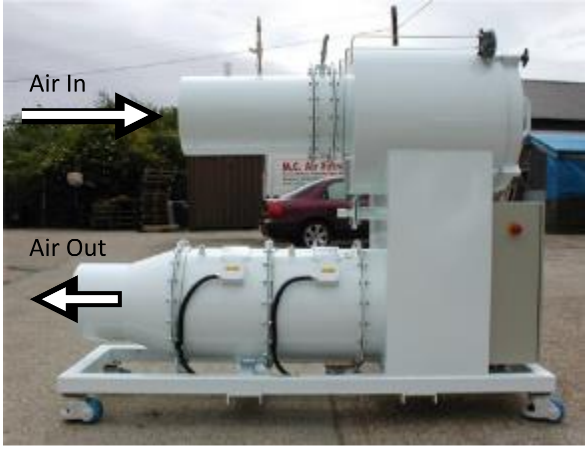
There are obvious advantages and disadvantages over the radial flow filters. The Push Push filters look to be better suited to reverse purge primary extract type applications on air boxes over Radial Filters as two serial filters can be in operation together.

12. COMPARISON OF FILTER CHANGING IN HEPA FILTERED TEMPORARY AIR MOVERS.

With modern mobile HEPA filter air movers the HEPA filter housings can either be “safe change” or bolt together non-safe change, see fig 33 for a photo of a modern safe change unit.

At AWE these units are normally used downstream of a tested HEPA filter, and so should remain relatively contamination free.

Fig 33. Nuclear Standard “Safe Change” 950 l/sec Plug In Mini Mobile Fan and Filtration Unit.



The “safe change” unit normally does no afford the filter change team much of an improvement in safety as the clean side of the housing is exposed to the dirty side of the filter during a change. The monitoring access is normally difficult due to the size of the units. Any contamination which is moved to the clean side of the housing during the change will be blown out of the unit when it is next started up. Due to the size of these units it is not normally practical to move them inside an enclosure for filter changing and monitoring. People also have the mis-conception that these units are “safe change” for the environment and the filter change team, leading to less precautions being taken than may be required.

For the non-safe change industrial units, fig 34, the air mover needs to be disassembled within a suitable enclosure, should some contamination become airborne during the filter change process. Once disassembled the inner faces of the filter housing can be fully monitored and cleaned. If the contamination levels after this process are low enough the filtration unit can be removed from the enclosure for use on the next task.

Fig 34. Standard industrial air mover with square filter.

These two cases of a circular plug in filter or a square filter are not ideal. Operators of this type of equipment need to control the amount of activity reaching these air movers if they are to be re-used. Given they both have high particulate arrestance efficiencies, then in theory all the RA reaching them should get caught in their filters. The use of a terminal filter before the air mover will keep contamination levels at the second stage filter to a level where they can be safely changed using RPE. There is therefore in practice very little contamination spread problems if terminal HEPA filters are used.

13.ACTUAL CONTAMINATION RELEASES DURING FILTER CHANGING

There has been very little research into how much particulate is actually release during a filter change. It is expected that there are many contributing factors which will determine the potential for a release, some of the major factors will be:- housing/filter design, volume of free particulate, mobility of particulate, care taken during the change, etc…..

There have been reports of spikes in facility discharges during filter changing, but very little evidence on the magnitude of these "spikes" has been collected to give any credence or validity to their actual significance.

From a discussion with building operators who managed the non-safe change filter design in Fig 3 it was hope that a rough estimate of particulate release could be made. However these filters were in a pressurised suit area where loose contamination was expected. The management regimes were concentrated on contamination levels at the pressurised suit entry area, looking to limit the spread of contamination to the other building rooms. The highest contamination levels from the surveys found were around the Electrostatic Precipitation filters which required to be opened up and washed down from time to time.

Several "clean room" managers were interviewed to see if they had the answer. However as they understood the situation particulate would be released when changing filters. Therefore precautions were taken to limit the spread of particulates into the clean areas using flexible tents and PVC sheeting where possible. No measurements of the particulate levels released were taken. The filters are simply very carefully removed, replaced and clean up measures applied. Only after the full clean up measures have been applied is the clean room counted for particulate.

14.CONCLUSION

There are many different styles of filter housings and the amount of protection a “safe change” system will offer the down stream ductwork and filter change crew will vary enormously.

This paper only looks at the filter housing styles from a contamination perspective. In areas of high radiation the doses received by the filter change teams may be excessively high if a full “safe change” procedure is followed. Therefore in high radiation areas the full safe change method may not be followed. Alternatively high radiation filters may need to be changed on radiation levels and not on dust blockage or efficiency.

When we consider the safety of a filter housing design we need to consider:-
A, The possibility of particulate escaping from the housing during a change.
B, The possibility of the clean side of the housing becoming contaminated during a change and migrating to the downstream ductwork.
C, Any size reduction of the filter required to allow it to enter the waste stream.
D, The radiation levels the filter change crew will be exposed to when changing the filter.

Abatement of the process arisings is a full topic on its own. Generally facilities are designed to contain the majority of the loose contamination within the process containments with the later stage atmospheric discharge filters being very lightly loaded. Therefore the choice of filter housings can only be determined though an analysis of the process flow sheets, hazards, discharge limits and site standards.

The designer must understand how the plant will be operated and maintained. From a close analysis of what will happen to the contamination on the filters as they are changed we can see if the design will meet the intent of the abatement system. In hindsight it is clear that the intent of using a vertically mounted liquid “plug in” filter (bowl upwards) will cause down stream problems after filter changing. Unfortunately this type of issue would likely not be picked up during commissioning. The advice on how these filters are used is now changed so they are mounted with the filter below the housing. It is only though questioning how operation and maintenance will affect the plant can the design be improved and the correct equipment developed and installed. The significant design information must be passed to the operators and maintainers of the plant to ensure it can be used safely. This information exchange is especially true where standard filter designs have been modified so slightly different change procedures or ancillary support equipment is required.

It is therefore up to all of us to assess our hazards and question if we have the correct equipment available for the task. As can be seen from this simple analysis of what “safe change” means, with some thought and reflection on operating experience we can better understand the tools at our disposal and the tasks which they are suitable to perform.

