Radial HEPA Filter Experiences At AWE

Grant Hall, Awe (UK)

ABSTRACT

Radial Flow HEPA Filters have been approved for use in the UK Nuclear Industry for nearly 40 years. A report is given on the experience of use of this type of filter at AWE.

INTRODUCTION

A filter development team at the Atomic Energy Agency (AEA) Harwell (United Kingdom) lead the approval and manufacture of radial flow filters for Nuclear use in the 1970's. These new cylindrical filters were developed with flow rates comparable with the available square filter units, whilst also being mindful of waste disposal into standard round 240 gallon oil drums.

Two distinct sets of filters were produced which were:-

- Plug In units for general abatement.
- Push Through units for process flow abatement.

These type of filter elements have given reliable and efficient service. The issues we have found are usually attributed to the filter housings and not the replaceable elements.

Photo 1 and 2. Plug and Push Through Filter Elements.

Plug In Filters.

The “Plug In” filters come in two styles, with either internal or external lip seals. The external lip seal units are used for remote change housings, which AWE does not have any experience of. However we have 95 manual change internal seal units, in use on our site. The measured efficiency obtained by hot dispersed oil particulate testing (hot DOP) range from 25,000 to 3,000 with an average measured Decontamination Factor (DF) of 11,600. With this unit the seal between the filter element and the housing is simply made by pushing the element onto a spigot within the housing, see fig 1 and photo 1, 3 & 4. This compares with the use of a compressible seal on square filters which require a constant axial pressure to maintain a seal.

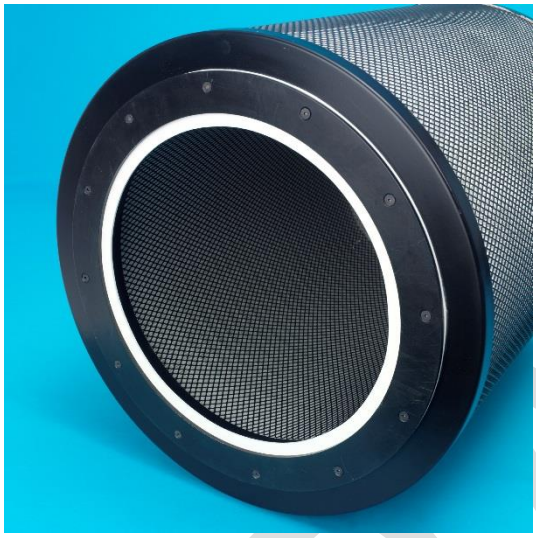

Photo 3. View Of Plug In Filter With An “Internal” Lip Seal.

The filter element can be purchased in Stainless Steel or with a Carbon Steel painted finger guard and polyurethane end caps. The paper is the standard AG1 approved Lydall AX3398 normally manufactured in their plant in France. This is identical to the Lydall paper manufactured in the US. Spacers are either bonded glass fibre string or strips of glass fibre paper. Standard flows available are 950, 470, 280, 160, 75 l/sec (2000, 1000, 500, 320 or 150 cfm). The dimensions of the largest 950 l/sec element has been sized to fit directly into a 240 gallon waste drum when over wrapped with two layers of PVC. Clean filter pressure losses are normally between 1” and 1.5” WG, which is comparable with the square filters.

Within the UK standard maximum claims within facility safety cases have been developed for different filter configurations. Due to the improved seal mechanisms of the Plug In filters types, over the standard square units, a higher decontamination factor for these types of filters is allowed for two independently testable stages in series. The allowable figure for two radial flow filters in series is a decontamination factor of 100,000 where we can only claim 10,000 for two square filters units in series.

The radial flow units are provided with standard “Safe-change” bagging arrangements, [1]. It is perceived that as these elements capture their dust internally, they will release less of their inventory to the downstream duct work when being changed, when compared to square units. However there is limited proof that this is achieved in reality.

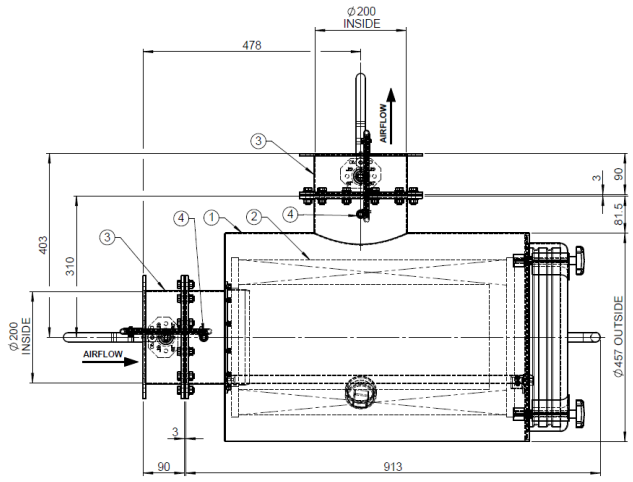

Fig 1, Plug In Filter On Housing Spigot.

Photo 4. 950 l/sec Plug In Housing (Change Bag Removed For Clarity)

With these plug in units the filter element is supported on two lower guide rails. Two issues with the guide rails have been reported by other UK sites. The first issue is with the radius at the front of the rail. Experience has shown that these rails need a large (~1") radius on the front of the rail, otherwise they may damage the filter element as they are inserted. See Photo 4 and 5 for "too sharp" rails. The UK sites have now changed their procurement specifications to include the minimum 1" specification on the rail radius. The second issue is that if the support rails are attached too near the housing spigot the filter element may not have enough clearance to actually be able to fit into the housing. This issue has been resolved by emphasising the minimum distance required in the procurement specifications.

Photos 5 and 6. Guide Rails With Insufficient Corner Rounding

Photo 7. EP2 Type Plug In Filter Housing (Note: Large radius on guide rails).

Push Though Filter Units.

The Push Through filters have been extensively used for “process” flows, such as glovebox and support fume-cupboard exhausts. The standard sizes used at AWE are 35 l/sec and 160 l/sec. In addition to their availability in Stainless Steel and Carbon Steel/Polyurethane they are also available with a plastic finger guard and polyurethane end caps to make them suitable for environments with raised acidic levels. These filters are not normally efficiency tested on the plant, however pre-installation Sodium Flame testing is performed. These filters when new consistently give a Sodium Flame efficiency result of >10,000. Normally efficiency failures are due to some of the Polyurethane moulding agent sticking and left attached to the seal. This excess moulding flash should be fully removed at the manufacturer. AWEs filter fitting teams have been trained to identify this (infrequent) issue during the filter pre-installation visual inspection checks [2].

Other UK sites have reported that they have received “Push Through” filter housings where the extract pipe transition has not been completely smooth, and has therefore damaged the filter element seal when inserted. The minimum radius for this join has been specified as 10mm on our procurement specification [3].

Of interest, there are eight different styles of filter housings, each with their own advantages and disadvantages. The eight different styles are described in the AWE “Push Through Filter Housing Design Guide” [4].

Style A This style is designated to the original design produced by AEA Harwell in the 1970’s, see fig 3. Although this style works well, as can be seen from the diagram when

changing the filter element, if the process flow is left running the flow will bypass the old and new filter element. This issue was solved by extending the inlet portion of the housing, Style B – see fig 4, which isolates the flow until the replacement filter is in position. However this second design does fully block the extract at times and makes element positioning within the housing very important. If the filter is in the incorrect position it can isolate the extract. Several measures have been introduced to try to obtain correct initial filter positioning. The more complicated solutions use “filter position pusher devices”. However one of the simplest methods is to weld spacers to the end plate which simply pushes the filter into the correct position. Vertical filter housings also need a device to prevent the filter element slipping down over time, which has been observed in this type of filter element, see photo 8.

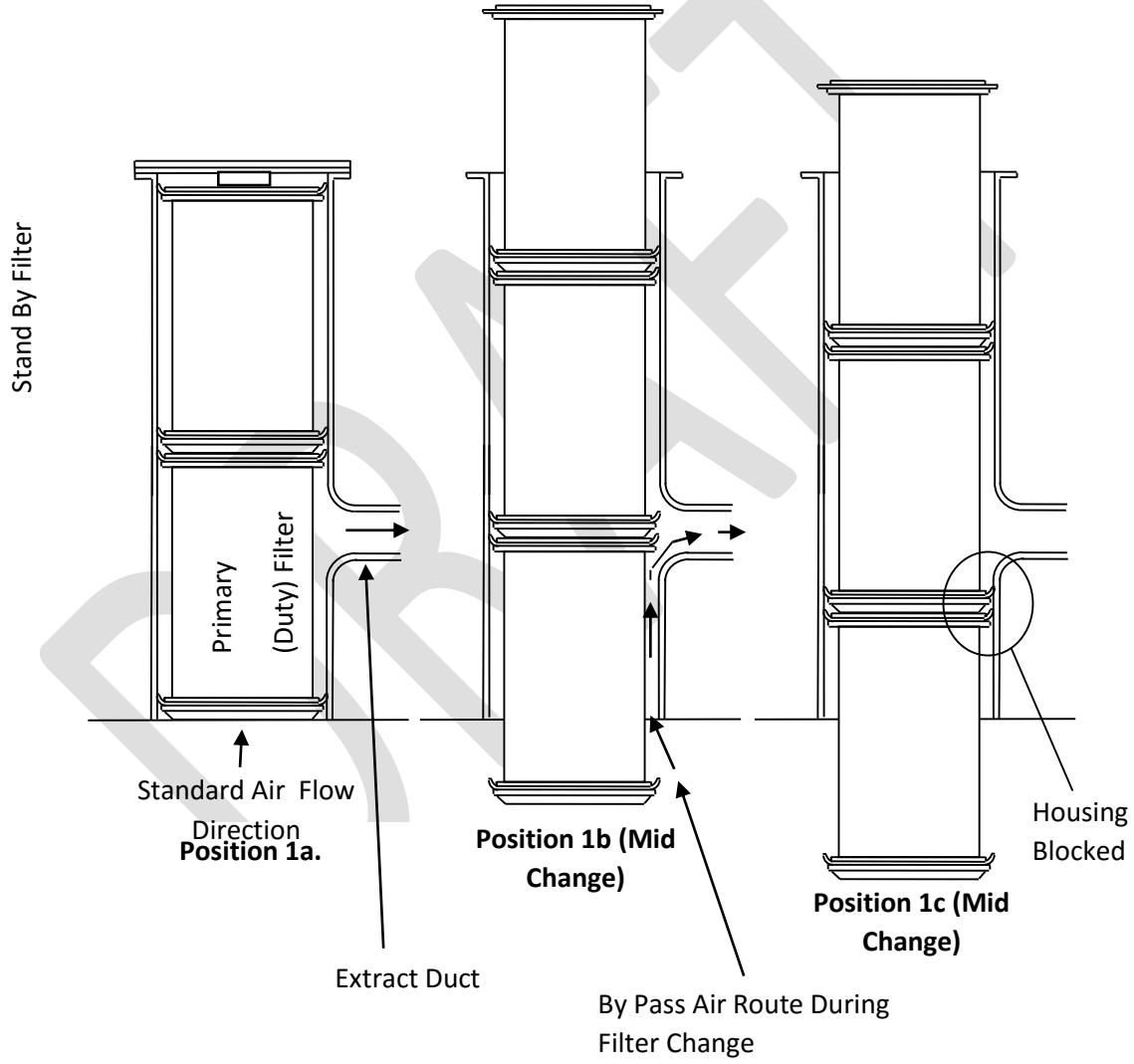

Fig 3, Style A, Push Through Filter Housing.

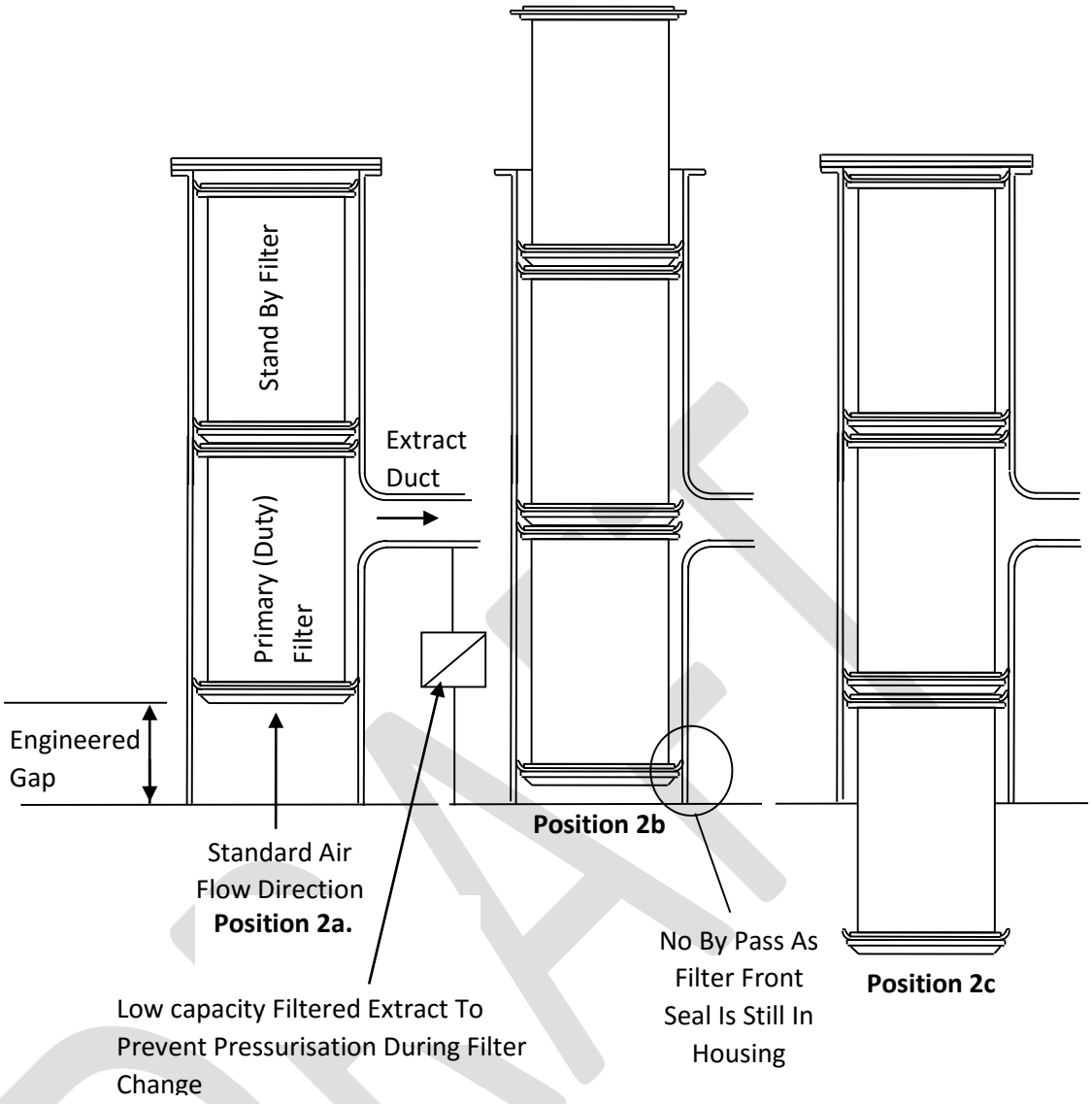

Fig 4, Style B, Push Through Filter Housing.

Photo 8. Style A Housing (The device to prevent the filter moving down the housing can be seen through the window). Note: This is a coated glovebox with the filter housing internally coated)

One of the clearest issues with Style A and B is that the replacement filter element may be 15 years old or older before coming into service. This issue is resolved by Styles C and D, which are similar to A and B but only contain one filter element. However, filter changing will open up the extract to the laboratory, so extra precautions are needed here. Either a bag or a filter changing tube can be used.

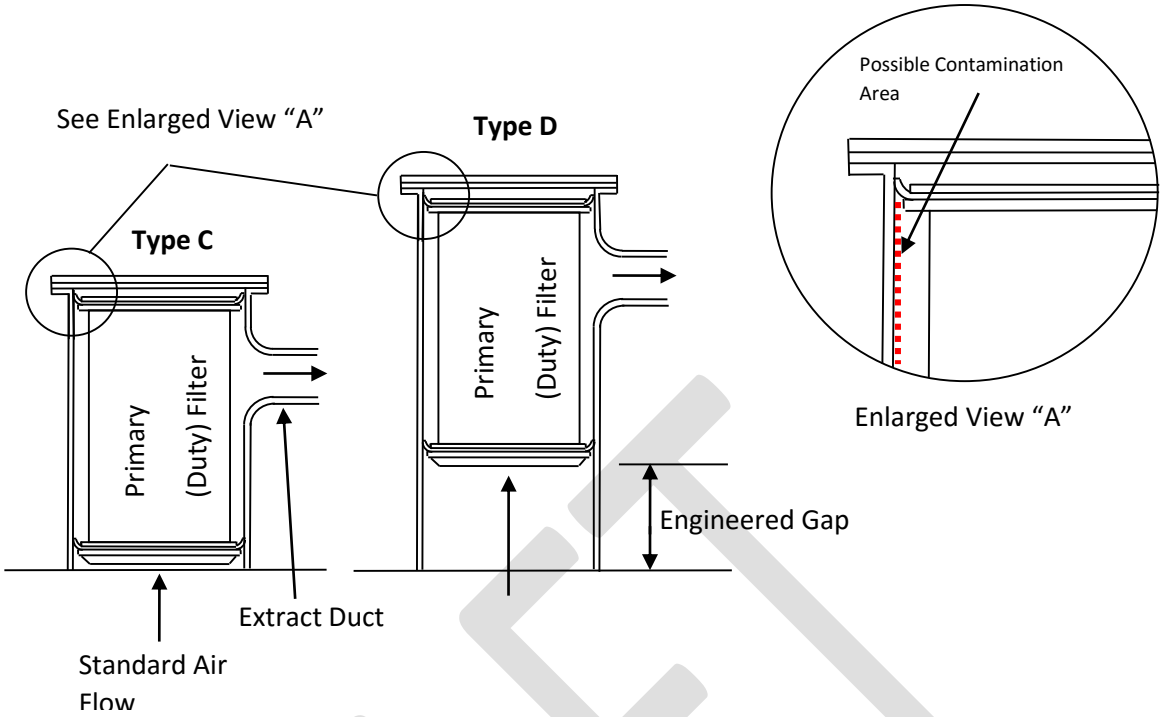

Fig 5, Style C and D, Push Through Filter Housing.

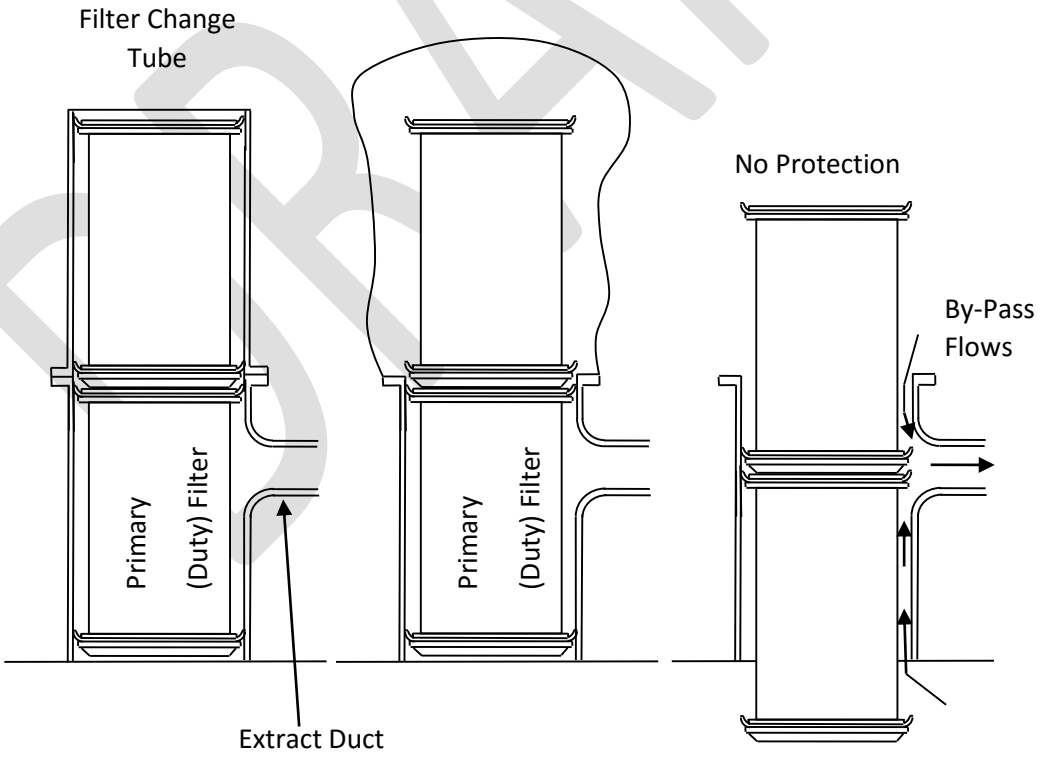

Fig 6, Style C and D Housings During A Filter Change.

Styles E and F are standard wall change units. Here the spent filter is pushed into a change bag. Style E has the issue of a bypass during filter change and style F has the issue that spacers need to be loaded between the filters so the spent filter is pushed far enough down so it can be grabbed by an operator at the bag end. The more experienced reader will have noticed that unusually the change bag is on the dirty side of the housing, where normally you would expect it on the cleaner side. For this reason these styles will only be suitable for lightly contaminated installations.

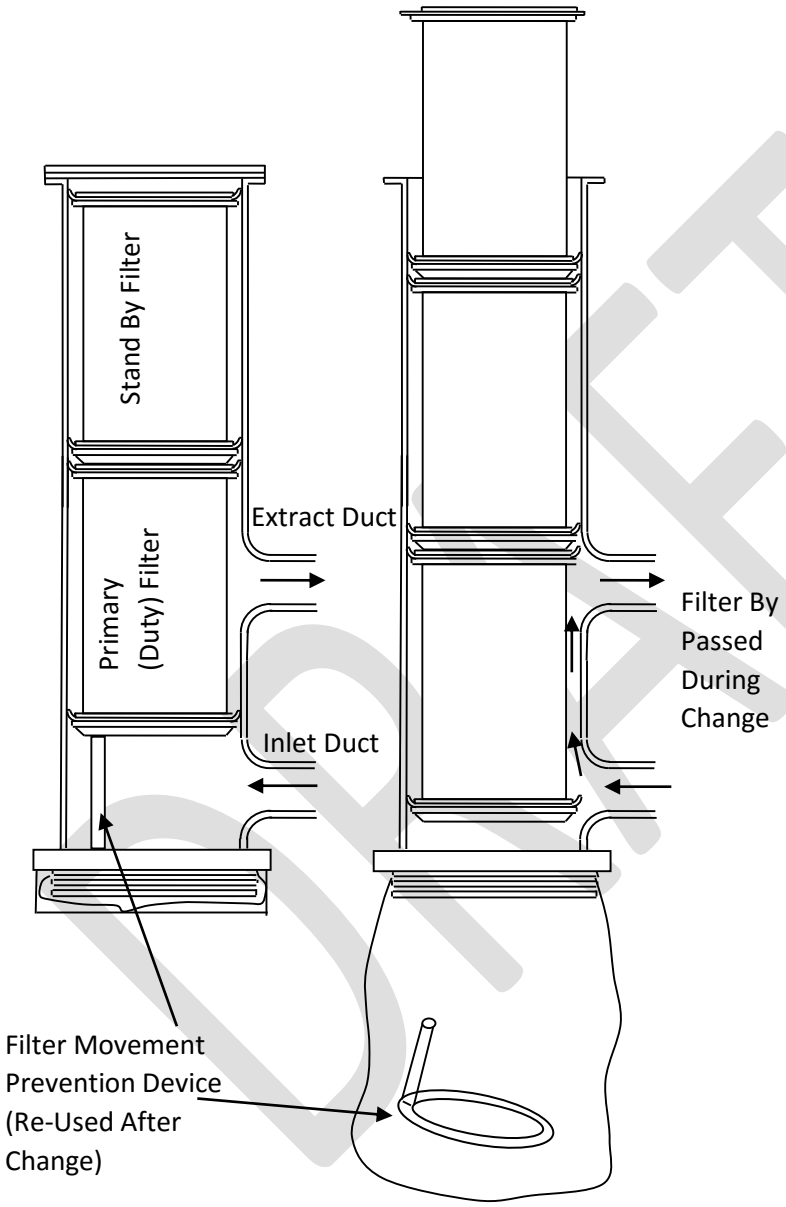

Fig 7, Style E Housings During A Filter Change.

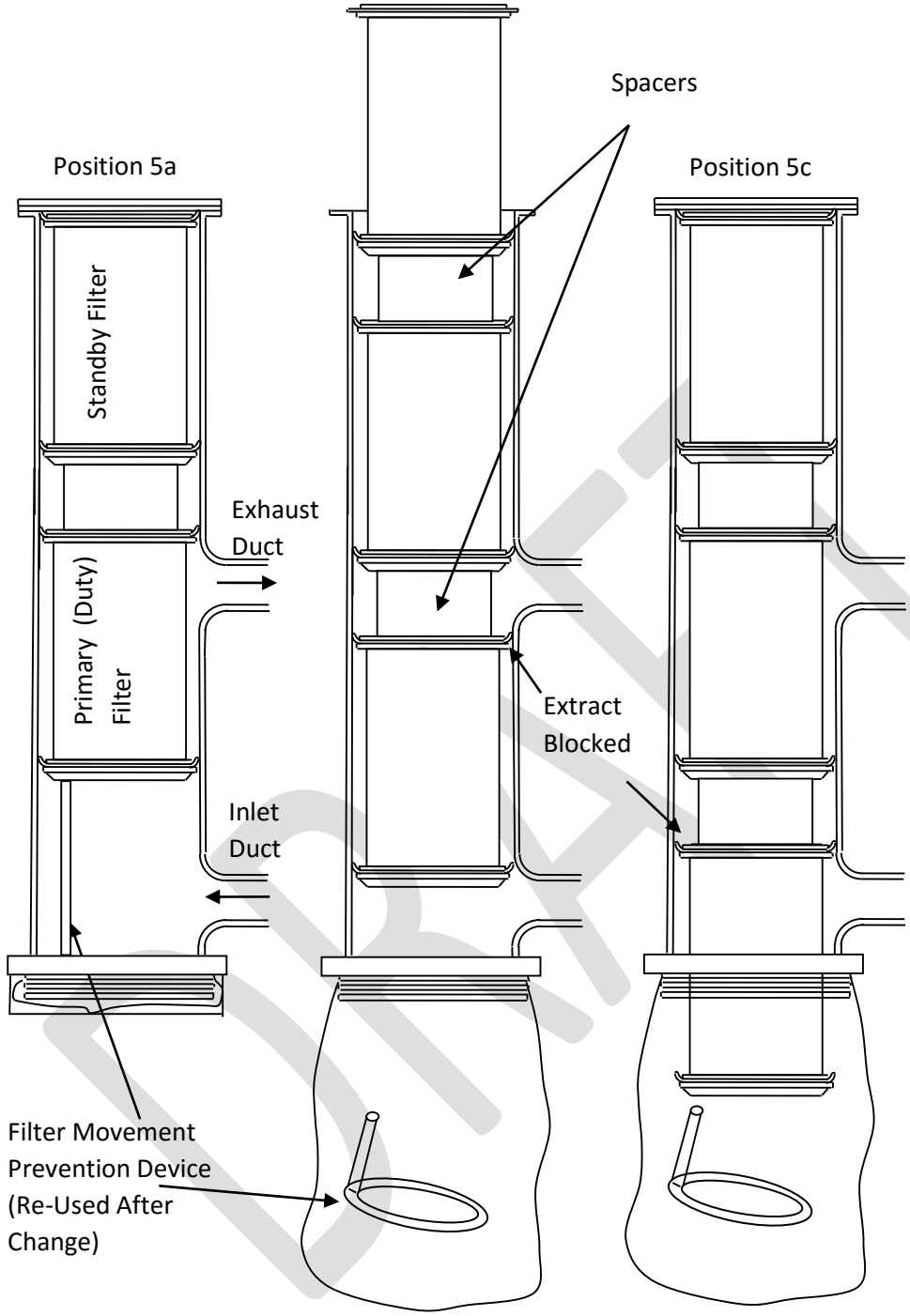

Fig 8 and Photo 9, Style F Housings During A Filter Change.

Style G tries to overcome the change bag issue with remote filter housings. Here the filter housing is sealed to a support glovebox. When the filter needs to be changed the sealing plate is removed and ejected into the glovebox. In a recent application the support sealing plate needed to have some acid resistance, so was manufactured from mild steel and fluorocarbon coated, but subsequently weighed about 11 lb. This was deemed to be too heavy to be safely used. The plate was re-manufactured from uPVC, see photo 8, but had trouble sealing due to its flexibility. Finally the seal was changed for a softer thinner unit to be able to meet the leak rate requirement.

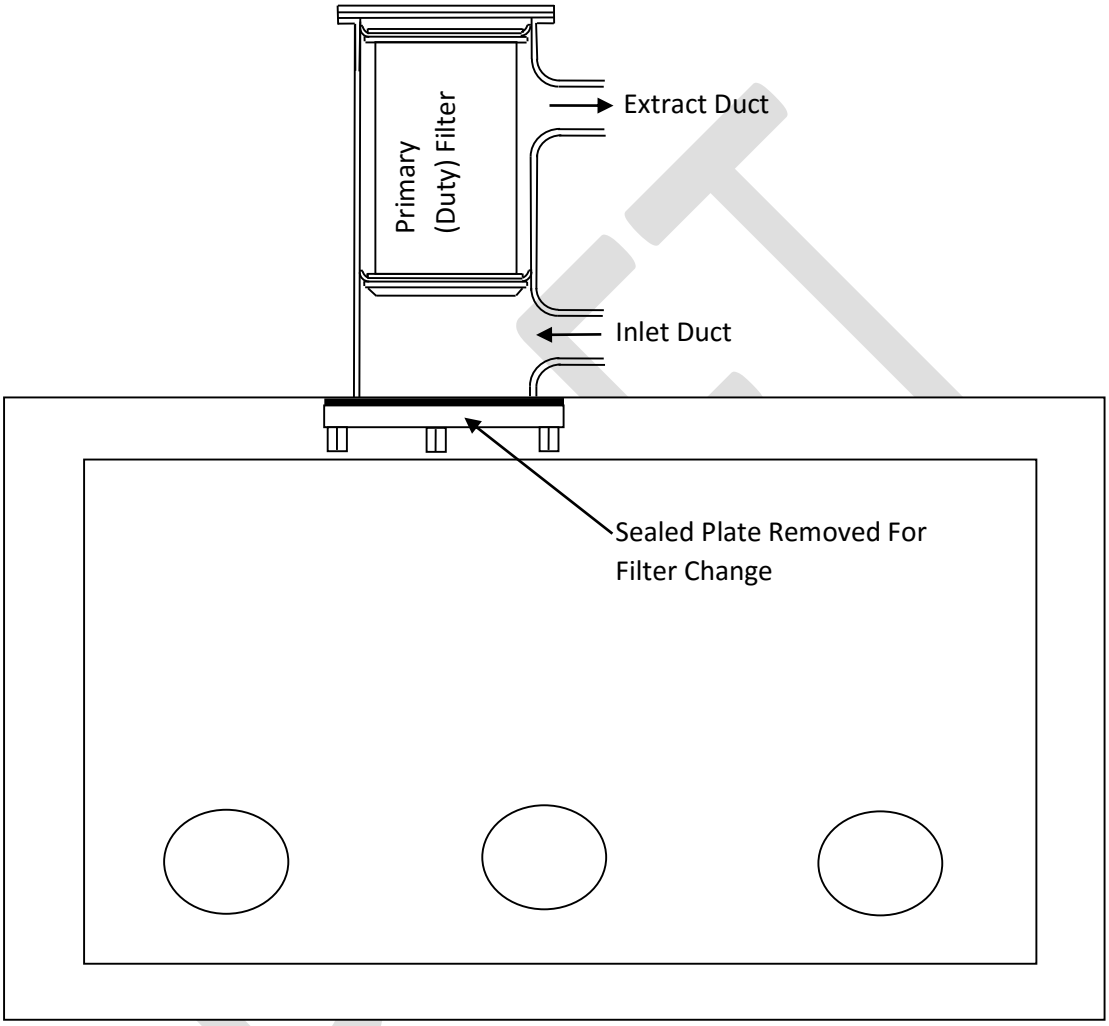

Fig 8 Style G Housings

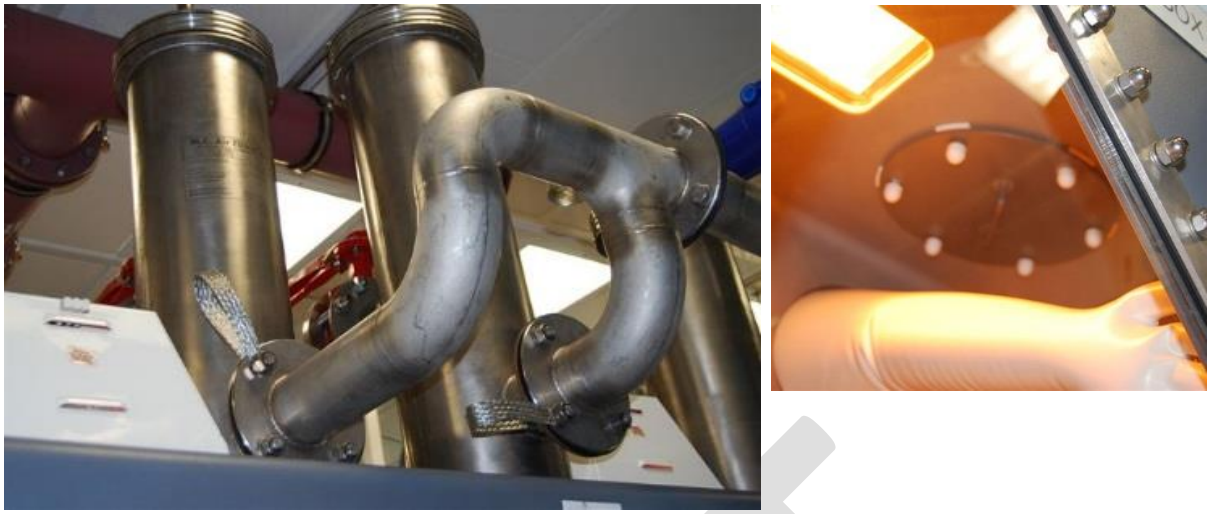

Photo 10 and 11. Style G Housing (Insert to the right is the view from inside the glovebox). Note: The inlet pipes are at the front with the extract pipe isolation valve just visible at the rear.

The Push Through system has proved to be a good solution for glovebox extracts.

All these Push Through housing styles are regarded as “safe change” for the maintenance team. As can be seen there are different degrees of possible contamination carry over to the “clean” downstream pipework during filter changing.

Even small modifications to such a simple housing design often brings other unexpected issues which need to be fully resolved before they can be used in active service. Therefore filter changing under simulated active conditions is always advisable on any modified design.

References.

01. NNVF Discussion Document “Guidance On Safe Change Filter Housing Design”, National Nuclear Ventilation Forum (UK), 2015, Published on Nuclearinst.com.
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03. Engineering Standard Specification - Filter Housing For Circular Push-Through HEPA Filter Inserts 12.5 To 160 Litres/Second Capacity, G Hall, 2014. AWE Internal Document.
04. Engineering Guidance, Circular Push-Through HEPA Filter Housings, G Hall, 2014. AWE Internal Document.

Acknowledgements

Photos 1, 2, 3, 4 and 7 kindly supplied by M C Air Filtration (UK)