

# AIR CONDITIONING AND REFRIGERATION Journal

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## Engineered Filter Frames for Clean Rooms

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A HEPA filter frame is one of the most critical components both in a clean room and in a nuclear / toxic application area and plays a major role in achieving the required parameters. Even then it is the most neglected component in the whole system. Most suppliers or contractors in the clean room industry think that they need not spend time, money and energy in making an “engineered” filter frame. They manage to achieve efficiency of the bank and in turn the class of cleanliness by using some sealant or tape around the HEPA filter or by employing a liquid-gel type seal. If users insist on an “engineered” dry / liquid type frame for class 100 and better application, the vendor will simply use imported components.

The only industry or organization in India which closely looks into the design of the frame is the nuclear industry. This may be because of the toxicity of the exhaust air which

is to be treated and passed through a HEPA filter bank before discharging to atmosphere through a stack. The HEPA filter bank is the main “engineered safety feature” (ESF) in nuclear installations.

## The Role of Nuclear Industry in the Development of HEPA Filter Frames for Clean rooms

In nuclear applications, proper embedment of the frame structure in a concrete shell is initially ensured. Integrity of the frames and perfect sealing of the filters with the frames is ensured during the design and execution. While efficiency of filters is 99.97% down to 0.3 micron, efficiency of the entire bank also, is expected to be around 99.95%. The integrity of the frame with a concrete shell on one side and a HEPA filter on the other side must therefore be close to 100%. This feature of a nuclear HEPA filter bank is wholly applicable to the banks of clean rooms as well.

Design of filter banks for nuclear application aims at quick removal of filters to minimise the man-rems (exposure to radio activity). This demands reasonable space between filters for the clamping mechanisms. While such space does not pose any problem in nuclear applications, it becomes a deterrent in clean room applications. Such space, termed as attic space in clean room terminology, is always a cause of concern for class 100 and better applications. HEPA filter banks used in the nuclear industry have therefore to be suitably modified for clean room application.

The evolution of HEPA filter frames from nuclear application to clean room application is shown in **Figures 1 to 6**.

The engineering up-gradation of a HEPA filter frame will be clear from **Table 1**.

**Table 1 : Progressive improvement in design of a HEPA filter frame**

<b>S.No.</b>	<b>Description</b>	<b>Attic w.r.t filter effective area</b>
1.0	Unused space in conventional nuclear HEPA filter bank.	24.1 %
2.0	Attic space in standard clean room application.	18.6 %
3.0	Attic space in a design (by BARC) meant for an international assignment.	8.6 %
4.0	Attic space in a design (by BARC) displayed at Clean Room India 2001 workshop organized by SSPL/DRDO, Delhi.	6.2 %



±0.25 mm.

### Material of Construction

All the embedment parts of a filter frame should have the same life as the building or structure. Therefore the embedment parts should be necessarily fabricated out of stainless steel material. The filter frame itself can be fabricated out of any material such as aluminium, mild steel duly powder coated or stainless steel. For class 100 and below, the material of construction should necessarily be either stainless steel or an extruded aluminium section, duly anodised.

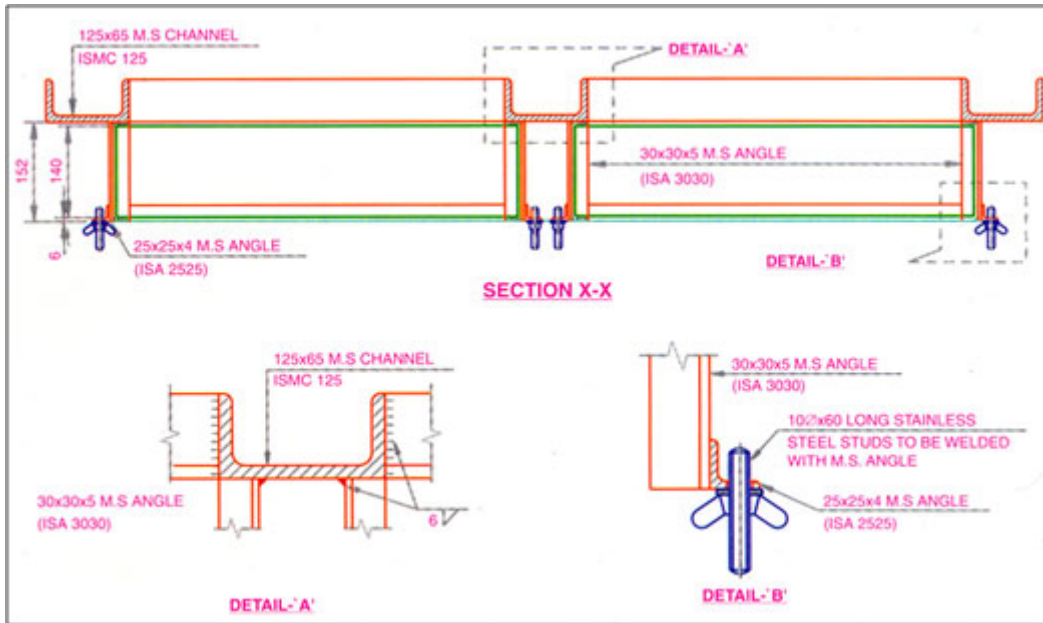


Figure 2 : Sectional details of conventional nuclear HEPA filter bank (vertical)

[Click to view the clear picture](#)

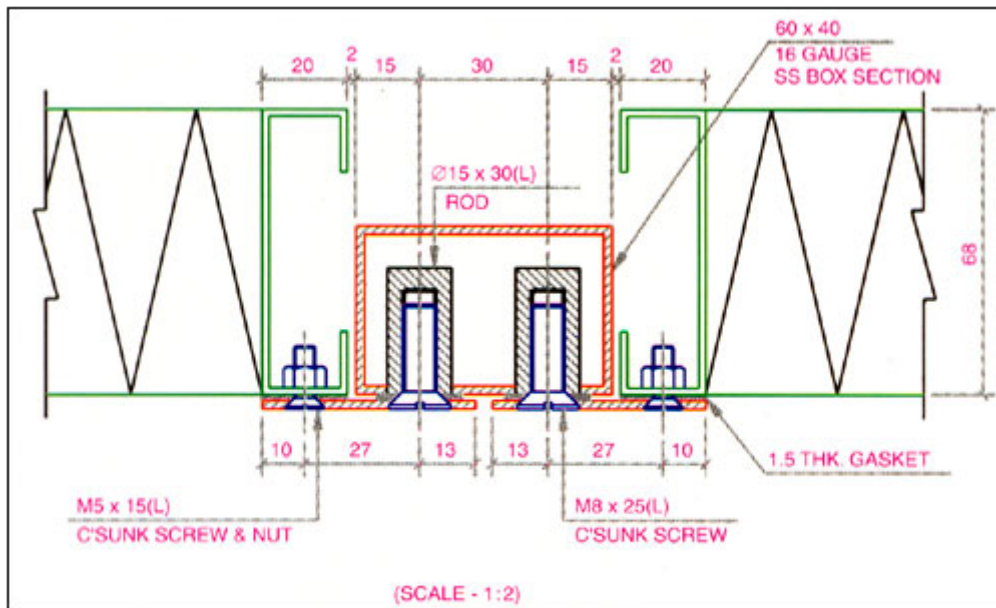


Figure 3 : Sectional details of standard clean room HEPA filter bank (ceiling)

## **BARC-Designed-Frame for Display at "Clean Room India 2001" Workshop**

A filter frame was designed and fabricated by BARC, mainly for clean room application but with certain changes, it can be employed for nuclear and toxic application as well. This frame was designed for achieving class 100 and better cleanliness level and was installed in a clean room tent which was displayed at the workshop "Clean Room India 2001" at Delhi, organized by SSPL / DRDO. The filters were supplied by Filter Manufacturing Industries, Calcutta. Details of the set-up are as under:

**1 Clean room tent** - 1225 (L) x 1225 (W) x 2100 (H) mm dimensions

### **2 HEPA Filter**

Quantity - 4 Nos.

Type - Mini pleat HEPA filter

Size - 610 x 610 x 68mm

Manufacturer - FMI Calcutta

Velocity - 90 FPM

Flow - 360 CFM

Special features of HEPA filters:

- Improved filter casing surface flatness of  $\pm 0.4$  mm.
- Casing width 15 mm only resulting in increased cross sectional area of filter paper 580x580mm.
- No wastage of effective filter paper area due to adhesive i.e. effective filter paper area for air flow remains 580x580mm

### **3 Material of construction of tent**

Filter casing - Extruded aluminium section

Filter frame - Stainless steel

Duct plenum - Anodized aluminium

Tent partitions - PVC

### **4 Fan details**

Flow - 1500 CFM (approx.)

Static pressure - 40 mm of w.g.

### **5 Salient Features of tent**

- Stainless steel HEPA filter frame in 2x2 configuration.

- The above frame size can be extended to the required number of filters based on actual room size.
- Machined filter seating surface.
- Reduced clamping force (approx. 20 to 30% of normal clamping force).
- Simplified filter holding and clamping arrangement.
- Reduced attic area due to the improved design and close fabrication tolerances in filter frame and HEPA filter.
- Only 6 mm more blocked area with respect to size of a HEPA filter i.e. area covered per filter is only 616x616 mm for a typical filter of size 610x610 mm.
- With respect to air flow the blocked area is only 18mm wide strip all around filter where-as for earlier and present design being followed, it varies from 40 to 80 mm wide strip all around HEPA filter.
- Reduced attic results in improved airflow pattern with induction of very small quantity of secondary air.
- For given parameters due to reduced attic, it results in better class of cleanliness.
- Reduced pressure drop with separatorless mini pleat HEPA filter.
- Reduced power consumption due to use of mini pleat HEPA filters.
- Resulting in a saving in electricity bill.

## **6 Details of particle counter & measurements**

Make - Air Techniques Industrial, USA.

Model - Met One-228

Sampling volume - 0.1cft

Sampling time - 1 minute

No. of locations - 9

Elevation - Three different levels

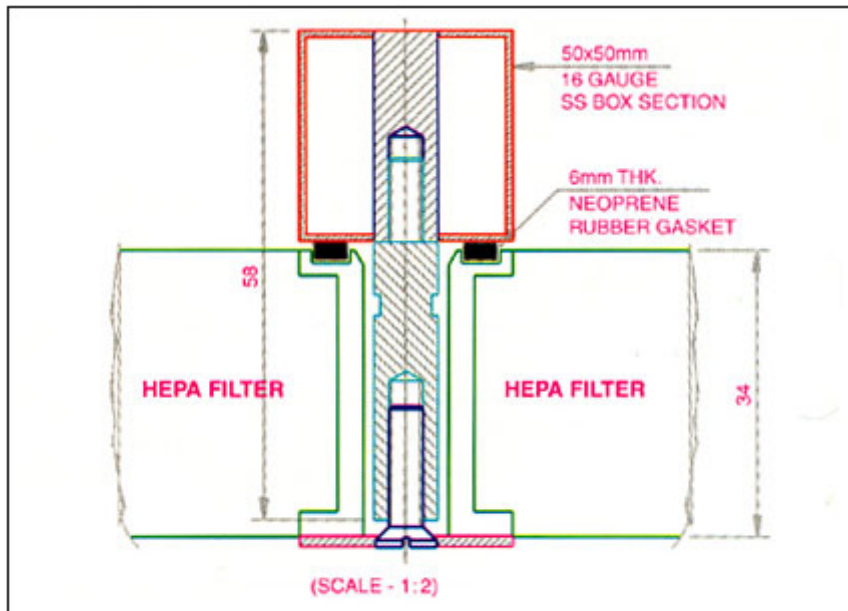


Figure 4 : Sectional details of a design meant for an international assignment

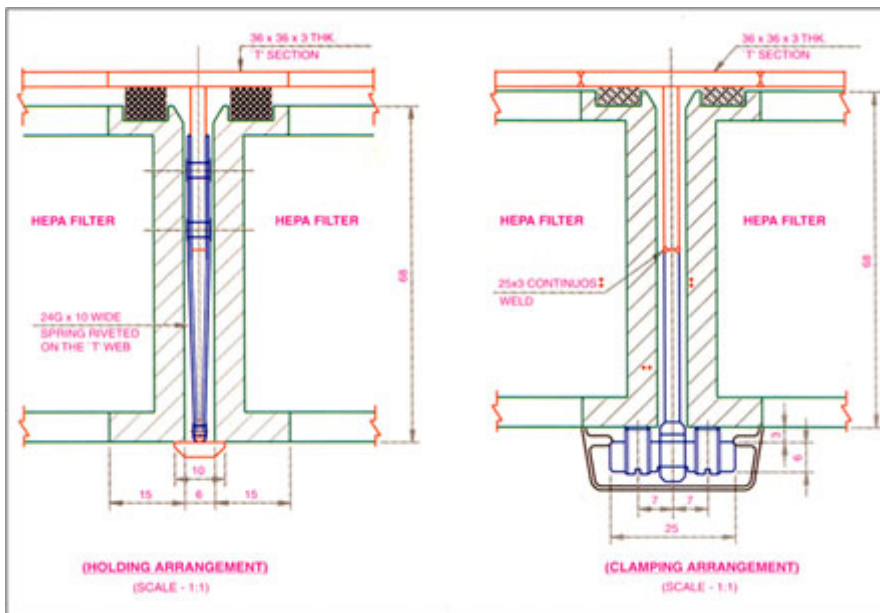


Figure 5 : Sectional details of the filter frame displayed at Clean Room India - 2001

[Click to view the clear picture](#)

## 7 Test results

The details of the particle count carried out on 12/04/2001 at SSPL/DRDO, Delhi is shown in **Tables 2 and 3**.

### Pre lunch readings

- Back ground particle counts 7.0 lakh particles down to 0.5 micron
- The details of sample locations are as indicated in **Figure 7** (The figure is indicative only for 2x2 filter configurations)

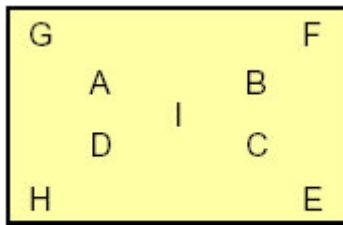


Figure 7

Table 2 : Particle counts inside the clean area

S.No.	Level	Particle Size	Particle count / Cu ft volume at various locations as per Figure 7								
			A	B	C	D	E	F	G	H	I
1	Near filter	0.5 micron	0	0	0	0	0	0	20	30	800
2	1.5 ft. below filter	0.5 micron	0	0	0	0	0	0	20	10	890
3	5 ft. below filter	0.5 micron	170	160	140	190	140	150	140	180	1060

Table 3 : Particle counts inside the clean area after re-clamping

S.No.	Level	Particle Size	Particle count / Cu ft volume at various locations as per Figure 7								
			A	B	C	D	E	F	G	H	I
1	Near filter	0.5 micron	0	10	0	20	0	0	40	40	260
2	Working level	0.5 micron	20	0	10	0	0	0	30	10	80
3	Close to floor	0.5 micron	140	120	140	180	120	190	150	130	320

It is clear from **Table 2** that the count at location "I" i.e. at the junction of all the 4 filters was high. Therefore clamping was redone and second set of particle counts was taken in post-lunch session. The counts are as per **Table 3**.

### Post lunch readings

- Back ground particle counts 7.5 lakh particle down to 0.5 micron
- The sample locations are same as for pre-lunch readings.

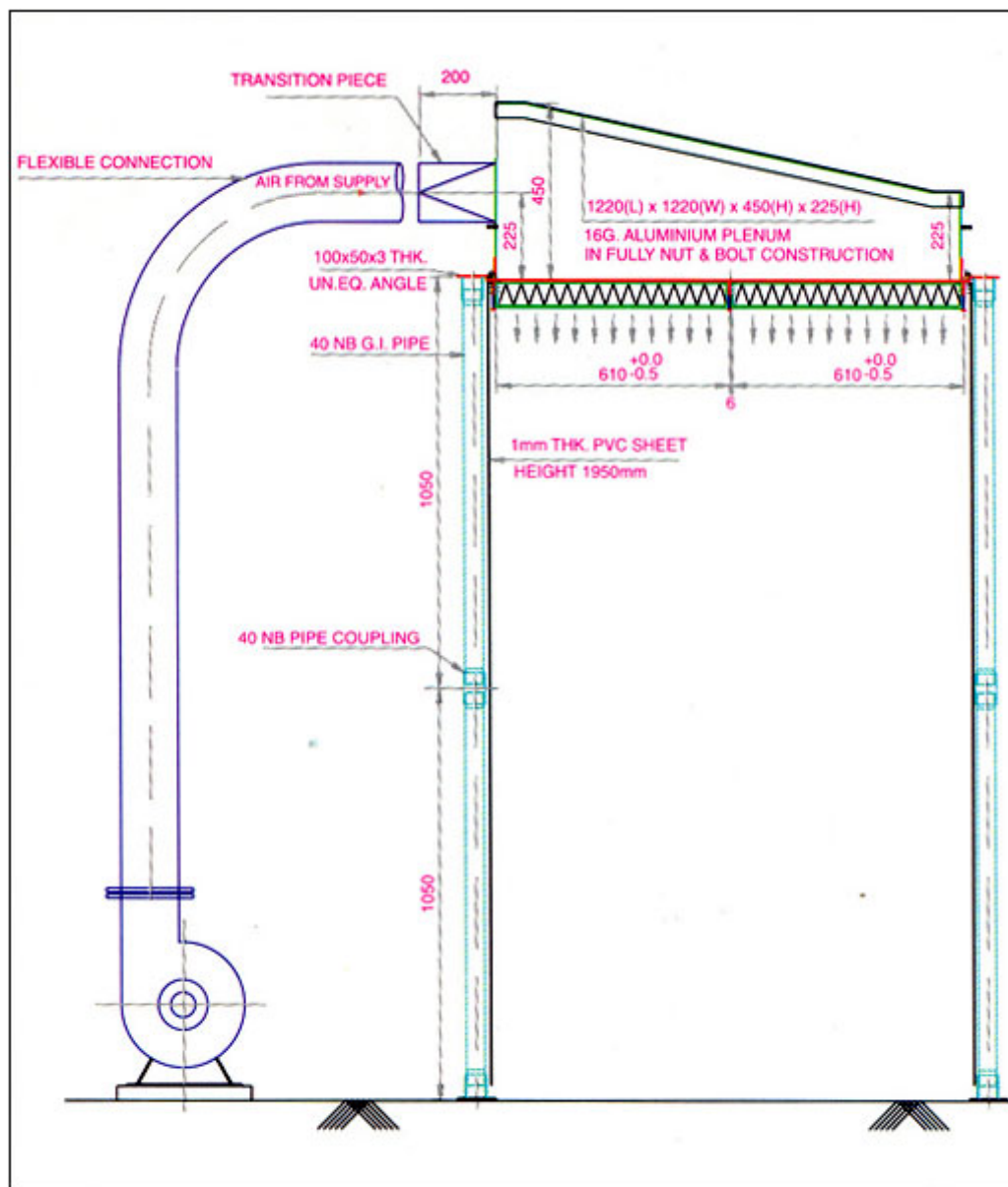


Figure 6 : Class 100 Clean Air Tent

## Conclusion

A HEPA filter frame with very low attic was designed and fabricated by Bhabha Atomic Research Centre. This frame was tested for the cleanliness level at the workshop "Clean Room India 2001". The results are very encouraging and as intended. The readings were taken for a once-through system and there should be an improvement in particle counts for a recirculatory system. This frame should meet the requirement of class 100 and better cleanliness level. We are confident that this can be a substitute for installations where imported frames are required. This will encourage our local vendors to develop other components also which are required for class 100 and better applications.

## Acknowledgements

The authors would like to thank the officers and staff of Central Workshop, BARC who took a lot of pain in order to fabricate the frame in a very short span of time. We would also like to thank Filter Manufacturing Industries, Calcutta for providing mini-pleat HEPA filter for the clean air tent and Associated Engineers, Mumbai for providing a filter plenum for the set-up.



Photo of Clean Air Tent shown in drawing below

Thanks are also due to the organisers of "Clean Room India 2001" for giving us a chance to exhibit the clean air tent during the workshop.