

Simulated Performance Qualification Testing of High-Strength HEPA Filters

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Background and Purpose

Simulated, high-strength qualification tests carried out on conventional FC filters, intended for baseline results, confirmed a relative lack of FC filter robustness.

-As expected, results of Level I filter performance were found to lie significantly above those of FC type filters.

-Standardized performance requirements needed to differentiate between, and set performance benchmarks for Level I and Level II type filters.

Table I: (Current) Select FC Filter Requirements (as comparative baseline for h-s filters)

Conditioning: $t_{RH, wet}$	Pressure Impulse Δp_{max}	Max. Final Particle Penetration
0 min	0.36 psid	0.03 %

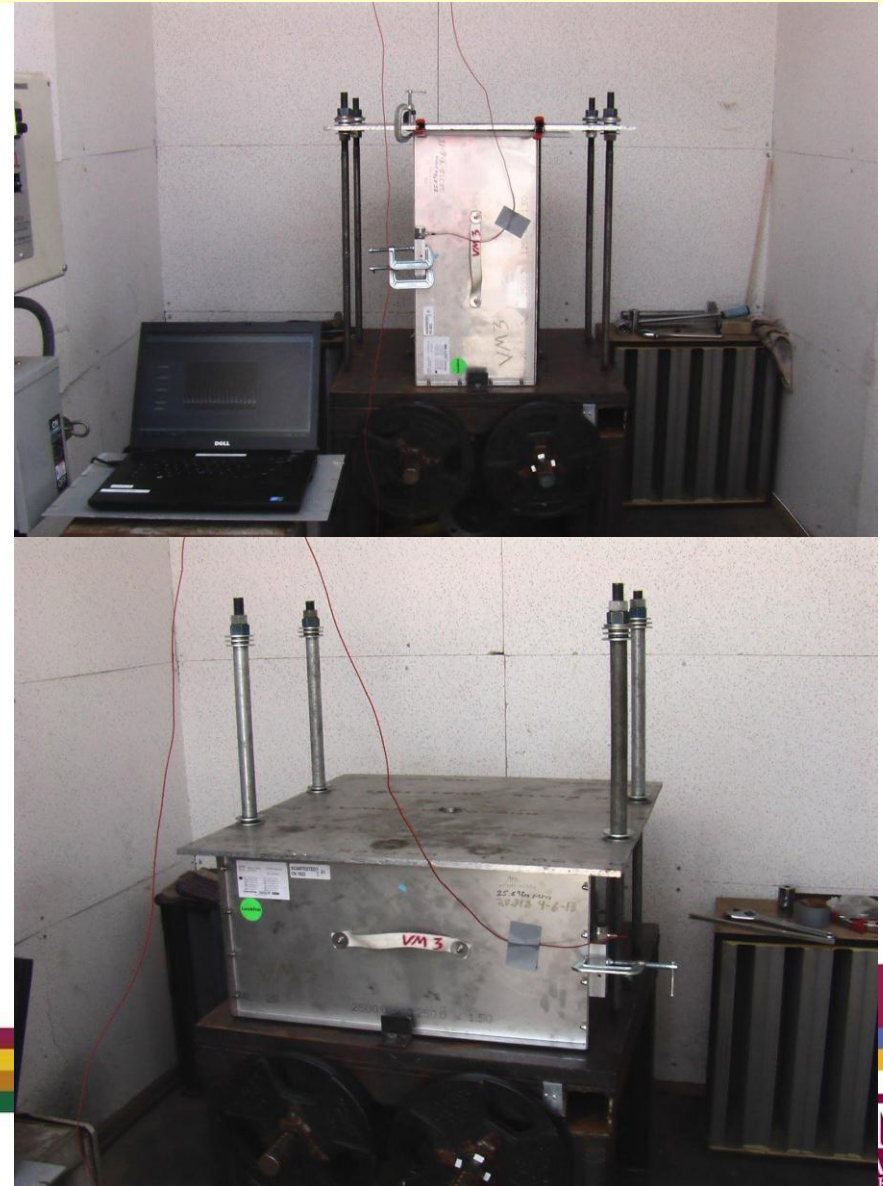
Objective

Provide a quantitative set of specifications for Level I and Level II performance during filter qualification for a high-strength designation.

- Design and develop test hardware and procedures**
- Gather and analyze quantitative and qualitative test data**

Hardware - Rough Handling Machine

- Verify initial filter robustness (dry) for Level I and Level II filters
- Verify filter-medium resistance to accelerated effects of fatigue (wet) and further simulate material aging effects
- Further condition filters for the pressure-impulse test



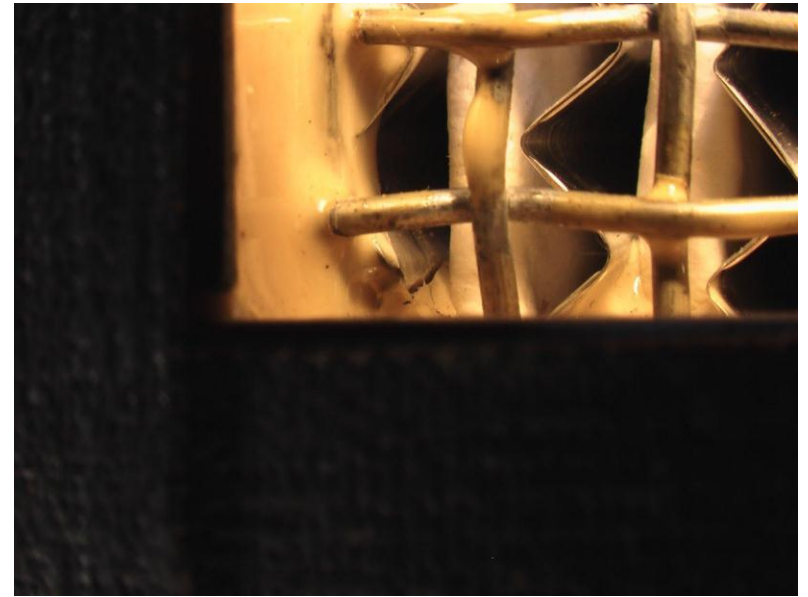
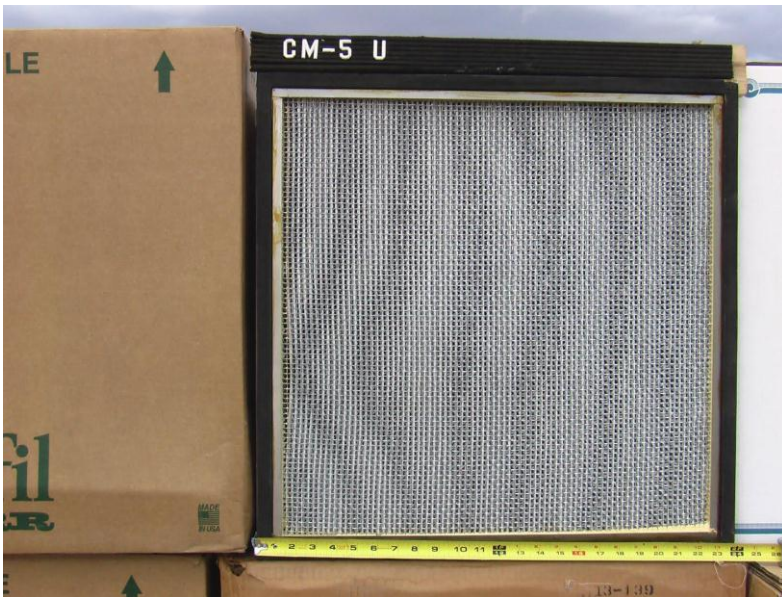
Hardware - Oven

Sized for three Cat. 5 filters to carry out static tests at elevated temperature

- **verify the suitability of filter constituent materials and their functional compatibility with each other**
- **further simulate material aging effects**
- **further condition filters for the pressure-impulse test**

Level I Filters

Characteristics (by intent and design): tighter, much more durably robust pack with much higher burst pressure and reliability than FC designs.



Level I - Conditioning and Qualification Testing

1. Initial visual inspection	Fx-5100
2. Resistance to rated airflow	Fx-5210
3. Test aerosol particle penetration at rated airflow and at 20% of rated airflow	Fx-5220
4. Resistance to rough handling, pristine dry	Fx-5230
5. Visual inspection for residual physical integrity	Fx-5280

1. Found loose filter packs, warped and loose face guards, gasket on incorrect side of filter.

4 & 5. Even dry, some Level I filters were noticeably damaged as determined by visual inspection. Filters would typically exhibit tears near edge of pack/frame adhesive bond.

6. Resistance to pressure impulse conditioning to include: temp. resistance and thermal shock	Fx-5241
7. Visual inspection for residual physical integrity	Fx-5280
8. Resistance to pressure impulse	Fx-5242
9. Final visual inspection for residual physical integrity	Fx-5280
10. Test aerosol particle penetration at 20% of rated airflow, damp	Fx-5243

6 & 7. Even at rated max. continuous operating temperature, there were gasket and adhesive failures.

Level I - Testing Conclusions

After conducting simulated qualification tests on Level I filters, it was apparent that the rough handling machine condition was too stringent of a test for Level I filters in a wet state.

From Level I and FC filter testing, the effect of filter orientation on rough handling test results was determined. The vertical orientation was particularly detrimental to wet filter media. The horizontal orientation, however, provided time-effective exposure of the medium to fatigue effects without unduly quickly destroying it. This orientation (wet only) was therefore adopted for Level II filter conditioning.

Level I - Testing Conclusions (cont.)

Another deviation from FC Filter requirements is the max. allowable final particle penetration. The FC filter requirement of 0.03% was too stringent for Level I filters after the more challenging conditioning process and impulse pressure test.

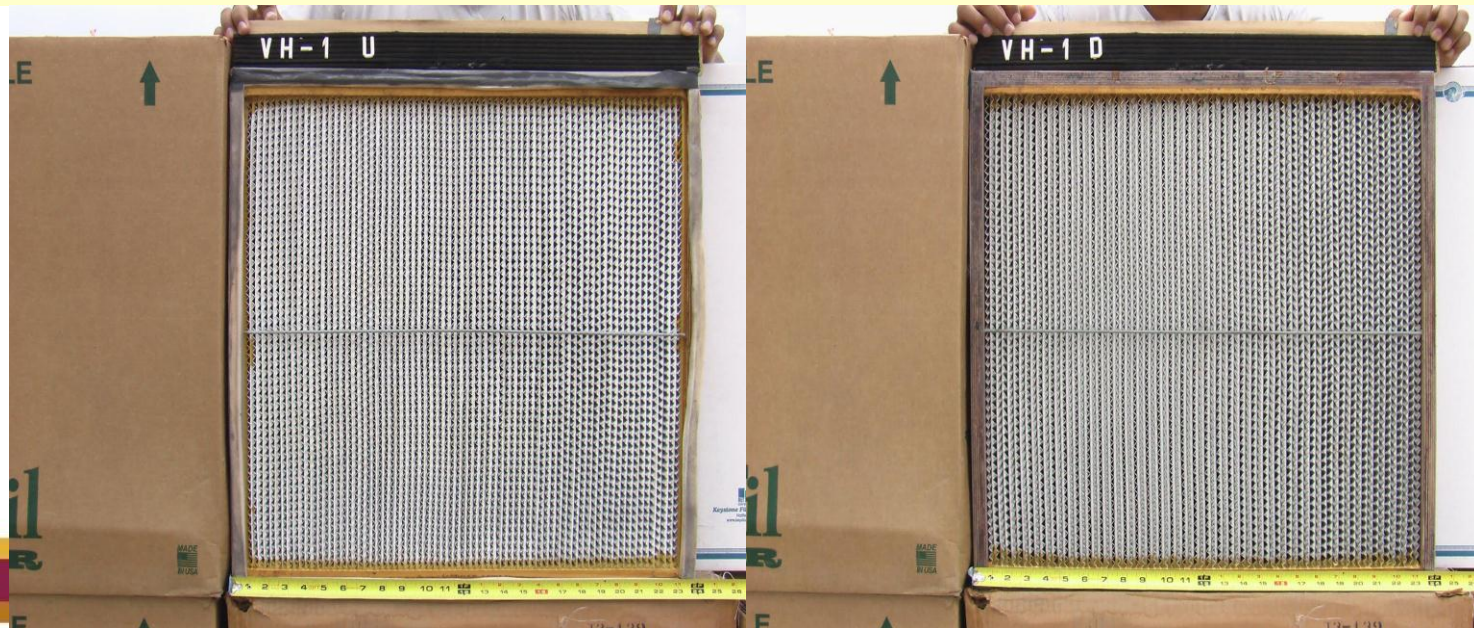
Table II: Select Level I Filter Requirements

Conditioning: $t_{RH, wet}$	Pressure Impulse Δp_{max}	Final max. Particle Penetration (0.3μm-dia.)
0 min	5 psid	0.10 %

Level II Filters

Level II Filter Characteristics (by intent and design): tighter, more durably robust pack with higher burst pressure and reliability than Level I.

For level II filters, wet rough handling conditioning was added.



Level II - Conditioning and Qualification

1-5. Same as Level I	Fx-5280
6. Resistance to pressure impulse ; with preconditioning to include: Temperature resistance, thermal shock, and wet rough handling (fatigue)	Fx-524100
7. Visual inspection for residual physical integrity	Fx-5280
8. Resistance to pressure impulse	Fx-5242
9. Final visual inspection for residual physical integrity	Fx-5280
10. Test aerosol particle penetration at 20% of rated airflow, damp	Fx-5243

6. Top plate addition - protected faces of filters from being damaged during testing from the lock bars

Locking Mechanism - used to keep filter in singular position during testing for providing accurate results from accelerometer

Accelerometer - provided the different accelerations the various massed fc, level I, and level II filters

Post to Rough Handling Machine - universally fitted to all filters to insure accurate acceleration readings of all test

Level II - Testing Conclusions

Level II qualification requirements contained were further separated from level I filters with the inclusion of wet rough handling conditioning.

Level II design enabled filters to keep tight packs with minimal tears/blistering in the medium throughout testing while also showing minimal overall damage compared to the Level I filters.

Table III: Select Level II Filter Requirements

min. Pressure Impulse Δp_{\max}	Conditioning: $t_{RH, \text{wet}}$	Max. Final Particle Penetration (0.3μm-dia.)
10 psid	10 min	0.10 %

Level II - Cracks in the Epoxy



Summary of Qualifications

Figure 1: Graph of Δp_{\max}

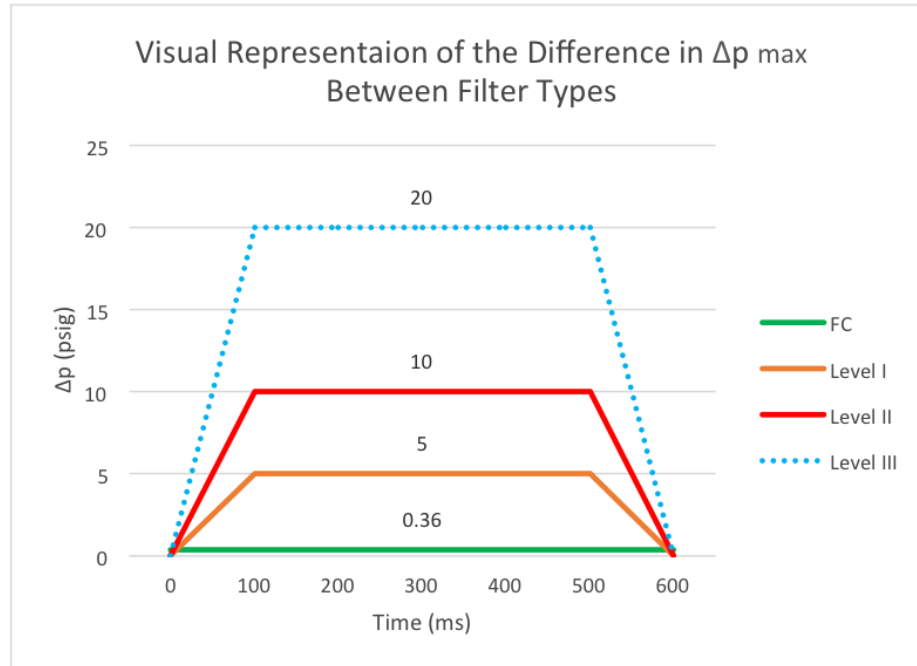


Table IV: Select FC, Level I, and Level II Filter Requirements

Filter Type	Conditioning: $t_{RH, wet}$	min. Pressure Impulse Δp_{\max}	Max. Final Particle Penetration (0.3 μ m-dia.)
FC	0 min	(0.36 psid)*	0.03 %
Level I	0 min	5 psid	0.10 %
Level II	10 min	10 psid	0.10 %

Conclusions

- Through a combination of systematic and trial-and-error processes, practical sets of test sequences were created to qualify h-s filters to two levels of performance. This represented achievement of the project objectives within the constraints of the modest resources available.
- Able to determine the most detrimental mode of failure for filters, being wet conditioning on rough handling machine.
- Optimal filter orientation during rough handling was determined from simulation testing
- A qualification order was derived from test results
- Testing allowed for Level III qualification extrapolation

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Flanders Filters

QUESTIONS?

