Radial HEPA Filter Testing at Mississippi State University Institute for Clean Energy Technology

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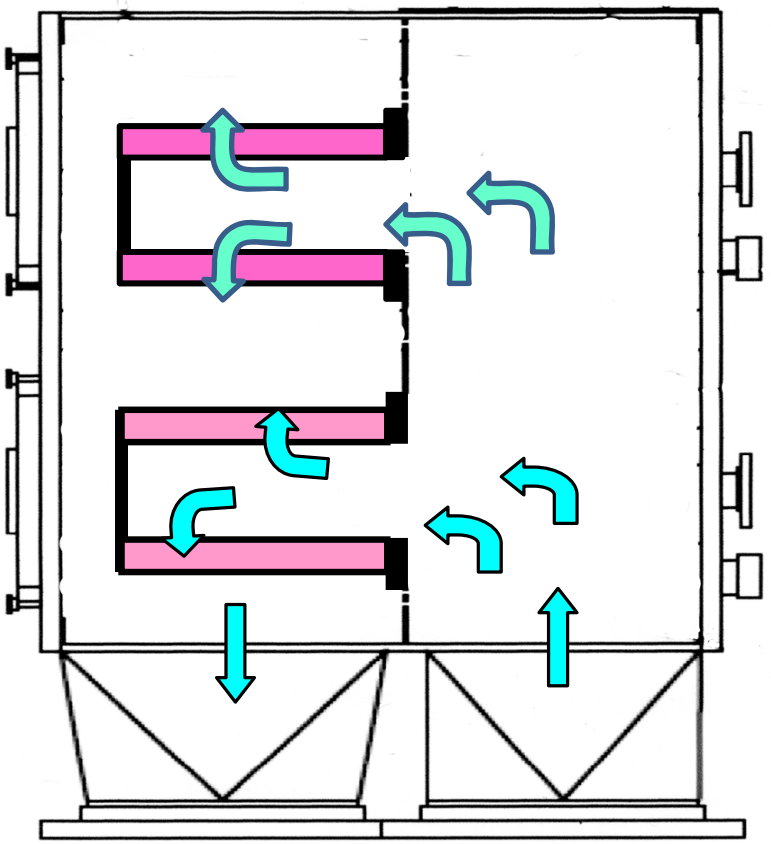
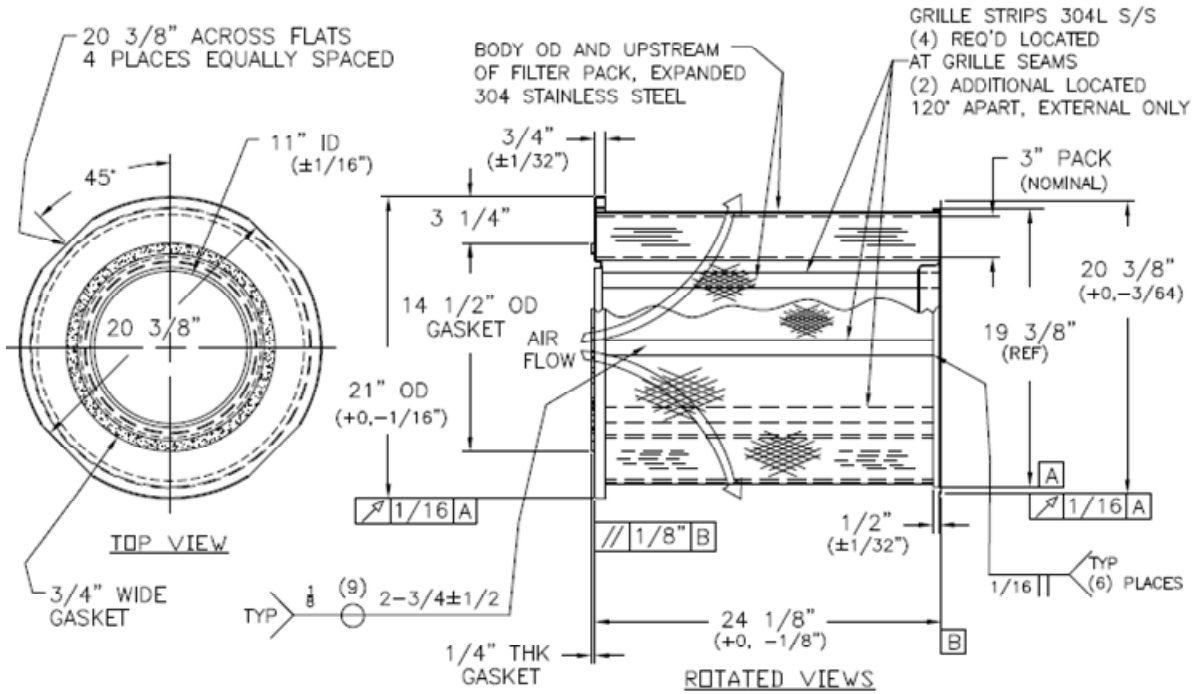
Michael Parsons

Description of WTP HEPA Filter Design:

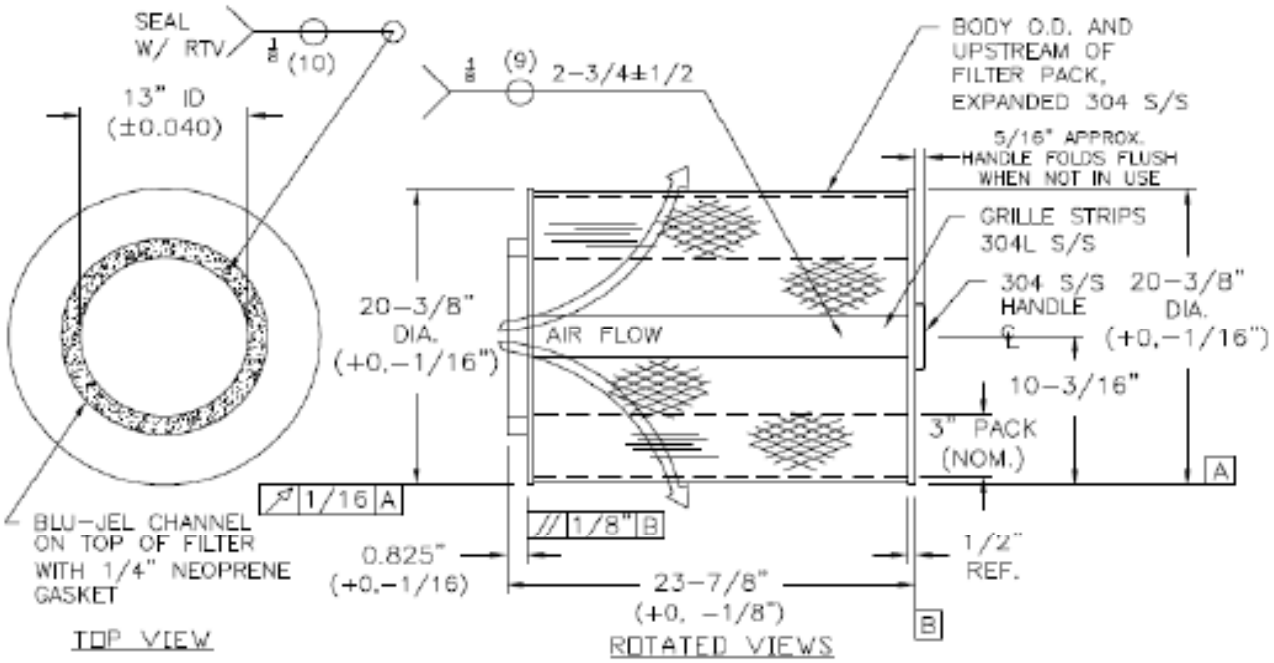
- Radial flow, frequently used in Europe
- Section FK of ASME AG-1 (added in 2008)
- Loading capacity is credited in WTP accident scenarios
- Loading capacity is an unverified assumption in a WTP calculation



Remote Change WTP HEPA Filter Design:



Safe Change WTP HEPA Filter Design:



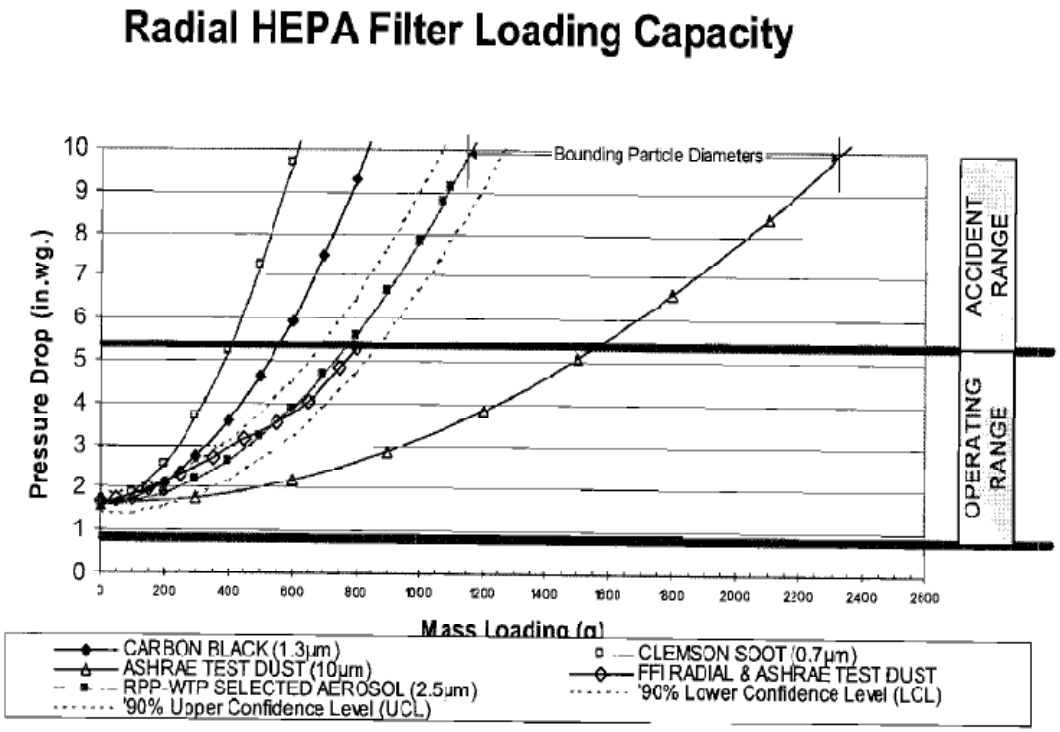
Housing Style:

Remote Change

Safe Change

Test objectives:

- Establish loading performance at three different challenge particulate sizes
- Establish maximum differential pressure (dP) at failure



Data currently used by BNI, based upon testing in UK in late 1980's

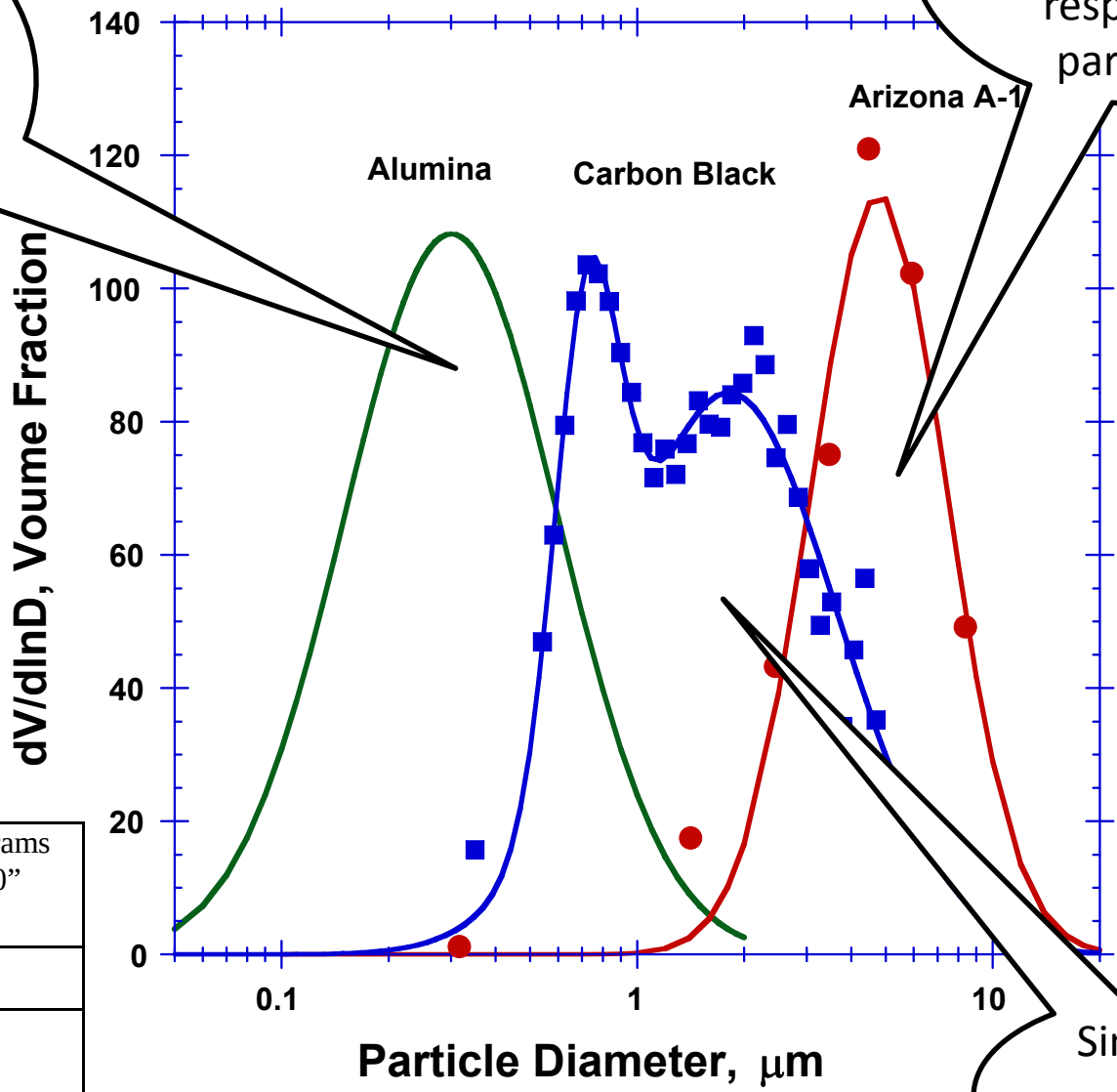
Test scope:

- Funded by DOE-Environmental Management (EM)
- Technical and QA oversight by Waste Treatment Plant Engineering division (W.E.D)
- Technical support by W.E.D Contractor and W.E.D peer reviewers
- Conducted by Mississippi State University (MSU)-Institute for Clean Energy Technologies (ICET)

Test aerosols

Simulates typical loading…small particles that penetrate inbleed filters

Simulates WTP accidents & large respirable particles

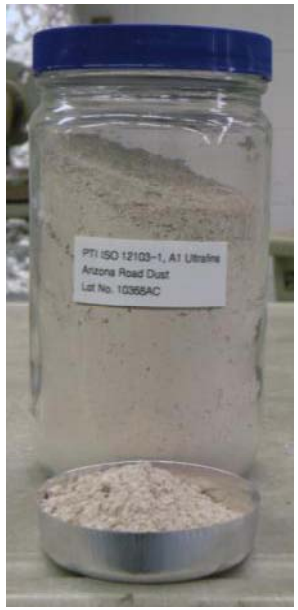


Simulates Fire Scenarios

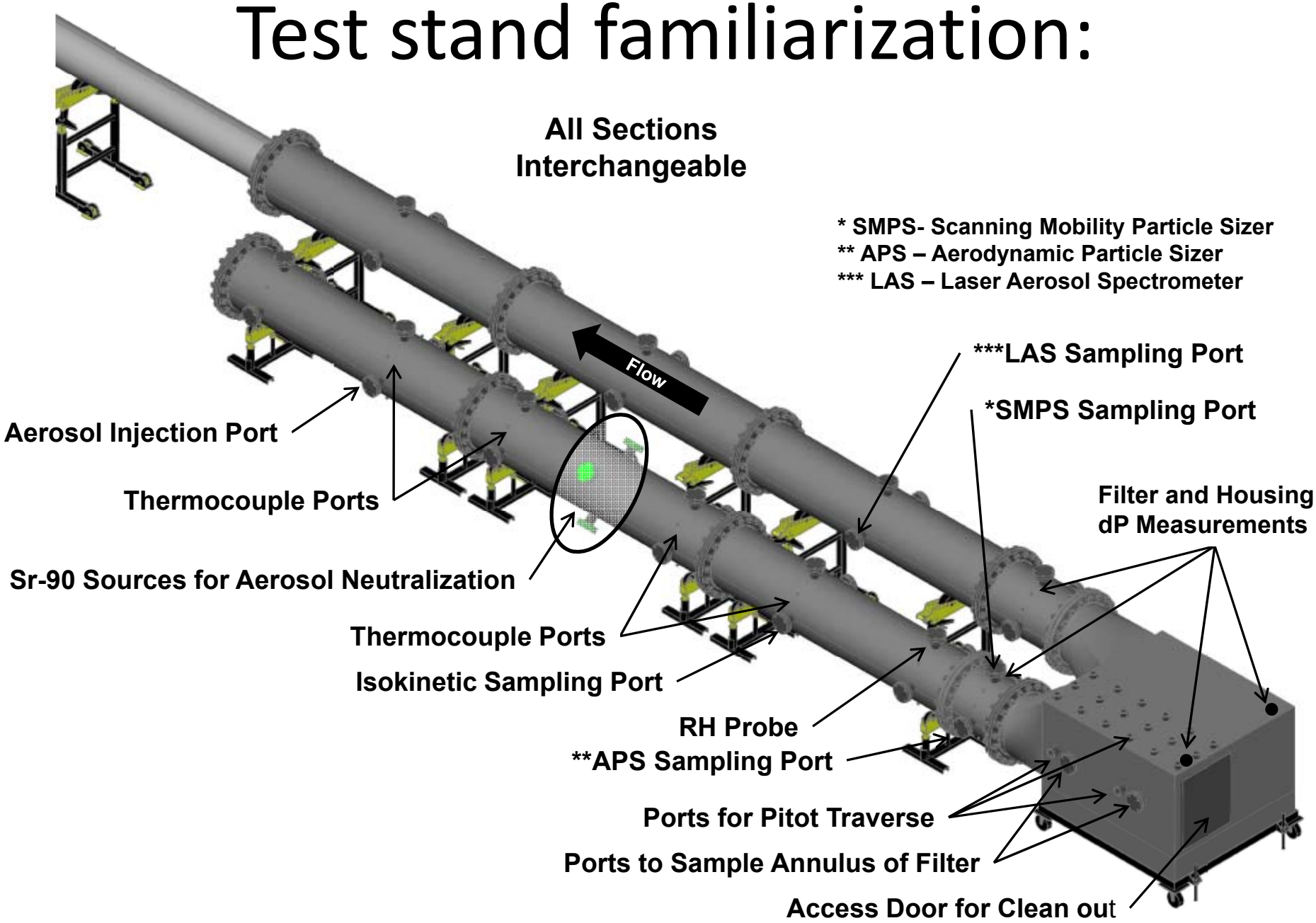
Loading media	Expected grams to load to 10”
Alumina, Al(OH)3	400
Carbon black powder	800
Arizona Road Dust, Ultra-fine	1600

Test Parameters

2000 cfm (56.63 m^3/min) **70 - 75 ^{0}F (21.1 - 23.9 ^{0}C)** **40 - 60% RH** **Max dP and/or Failure**	**Aerosol #1** **0.25 µm** **Alumina**	**Aerosol #2** **2.0 µm** **Carbon Black**	**Aerosol #3** **5 µm** **AZ Road Dust**



Test stand familiarization:

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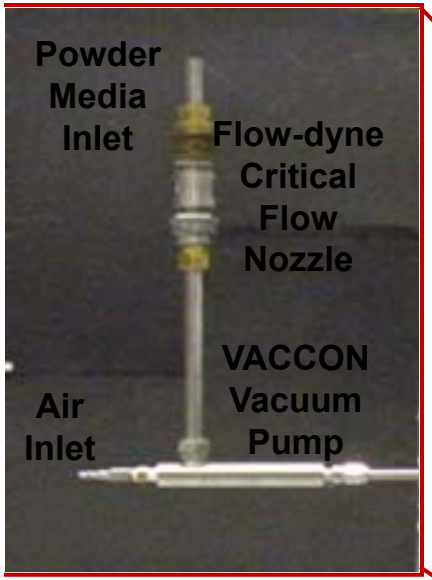
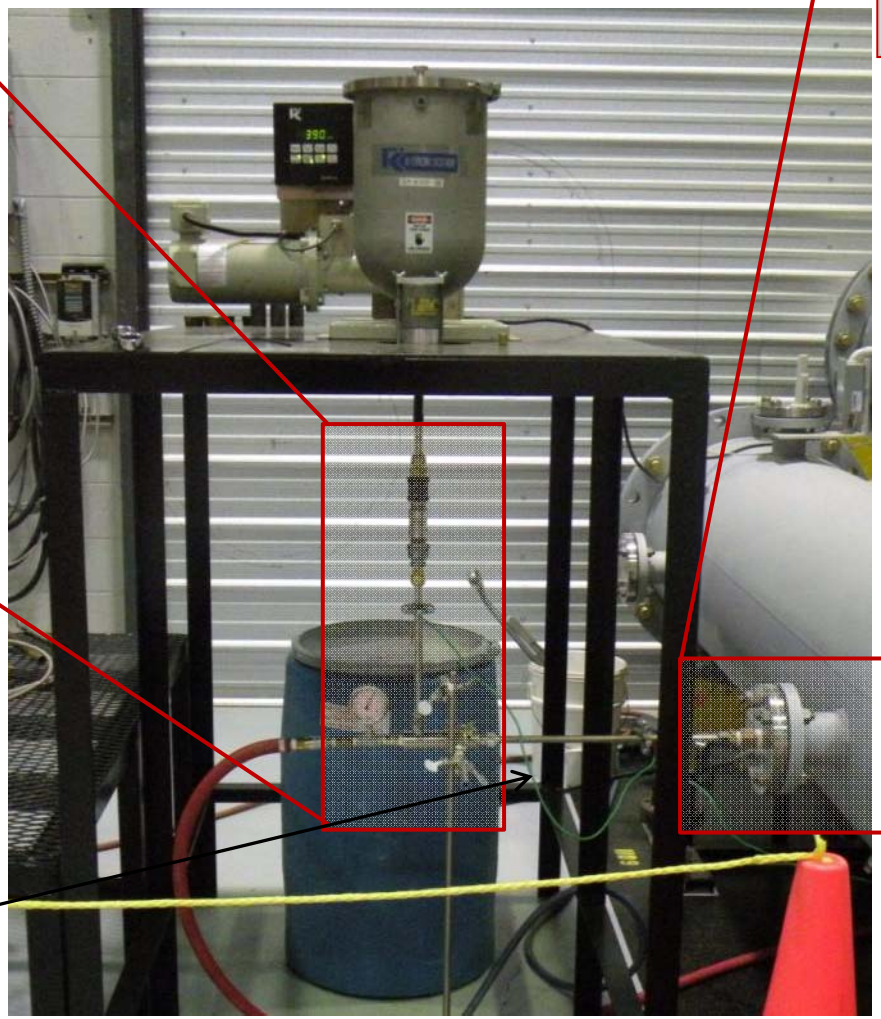
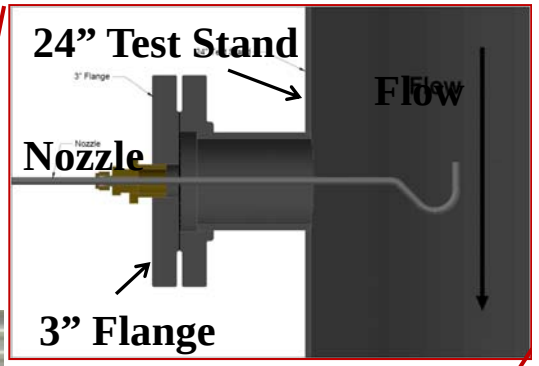
Fan and Venturi

Fan Capacity: 4000 cfm @ 50 in/W.G.

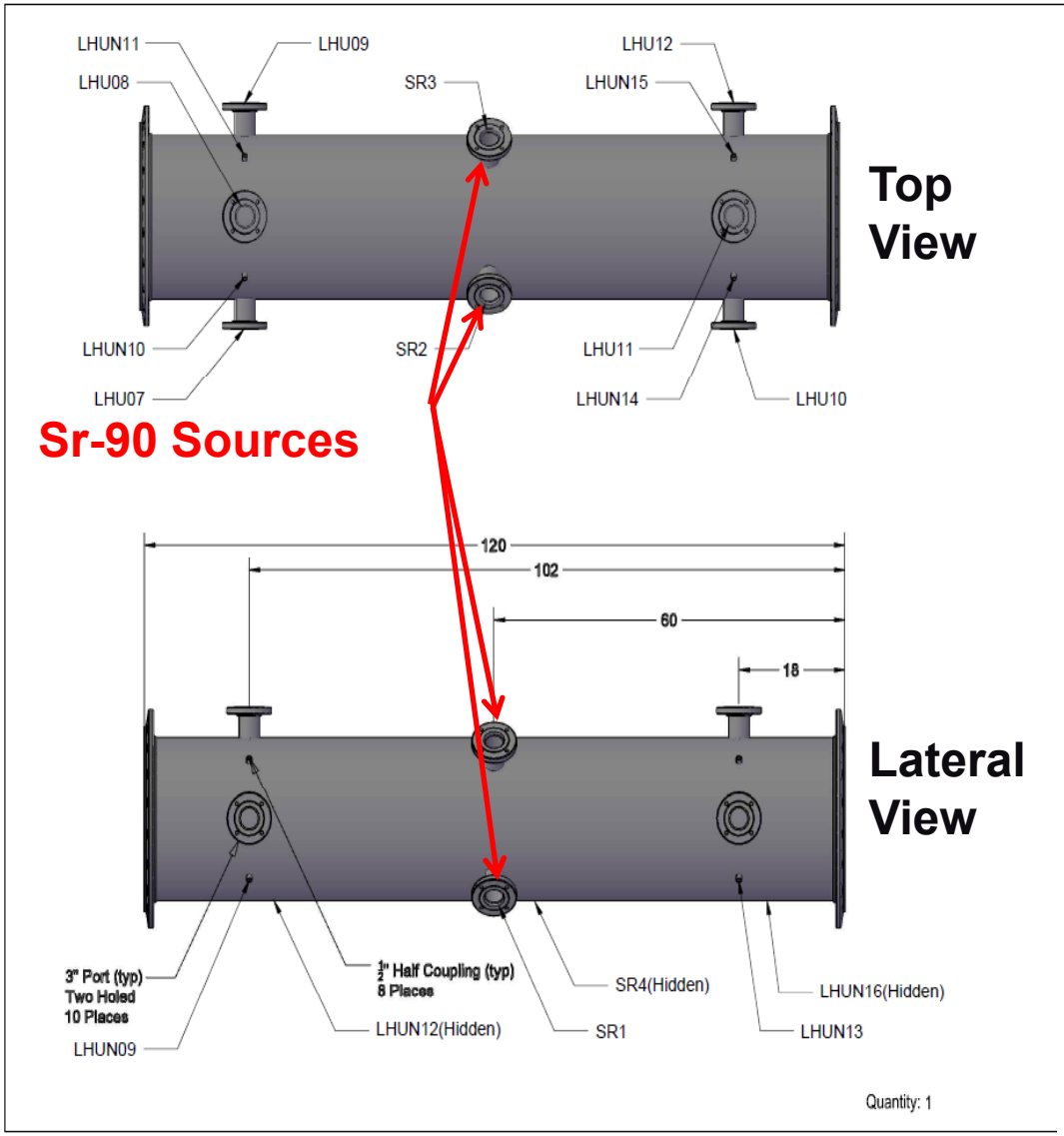
Aerosol Injection

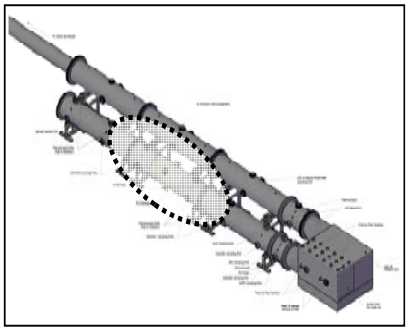






Aerosol Neutralization





- **Active Length 12' (3.7 m)**
- **Ion Pair Concentration $1x10^8$/cc**
- **Residence Time 1 sec**

- Strontium-90 (Sr-90)
  - Beta Decays
  - 1.48 x 10^9 Bq (40 mCi)
  - 546 keV Beta Particle
  - Forms Yttrium-90 (Y-90)
  - Half-Life: 29.1 years
- Yttrium-90 (Y-90)
  - Beta Decays
  - 2.26 MeV Beta Particle
  - Forms Zirconium-90
  - Half-life: 2.7 days

Aerosol Neutralization

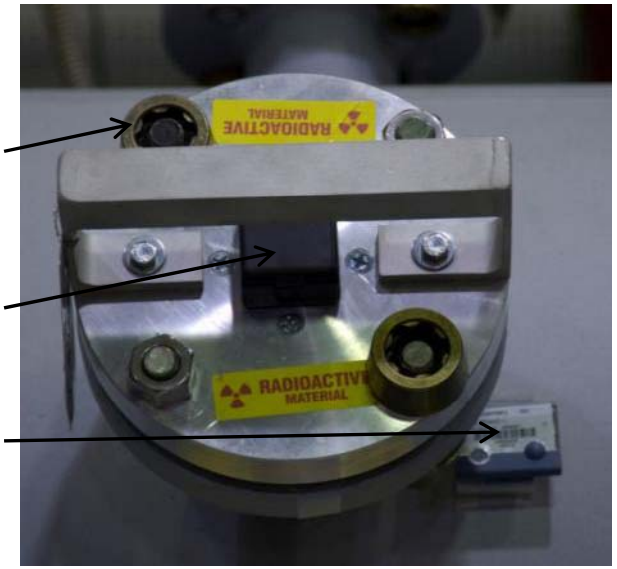
Lead Lined Storage Cask for Sr-90 Source

Sr-90 Source Holder

Hardened Steel Bolts with Security Nuts

Asset Sensor to Alarm System

Radiation Dosimeter

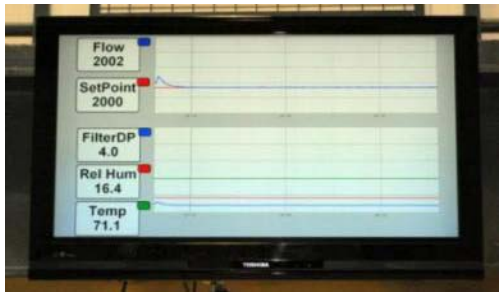


Sr-90 Sources Installed in Neutralization Section of MSU/ICET Large-scale HEPA Test Stand

Test Stand Instrumentation

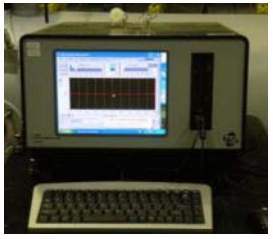
- Computerized Control and Data Logging
- Aerosol Measurement Instrumentation
  - Upstream Sampling
    - SMPS (Scanning Mobility Particle Sizer)
    - APS (Aerodynamic Particle Sizer)
  - Downstream Sampling
    - LAS (Laser Aerosol Spectrometer)

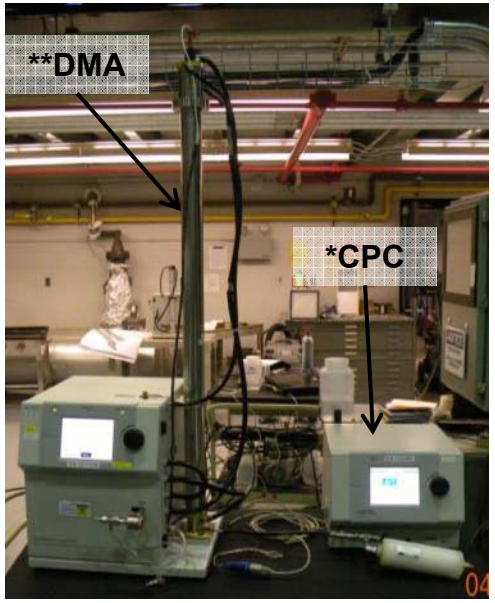
Control System



Test Stand Monitor


APS


LAS

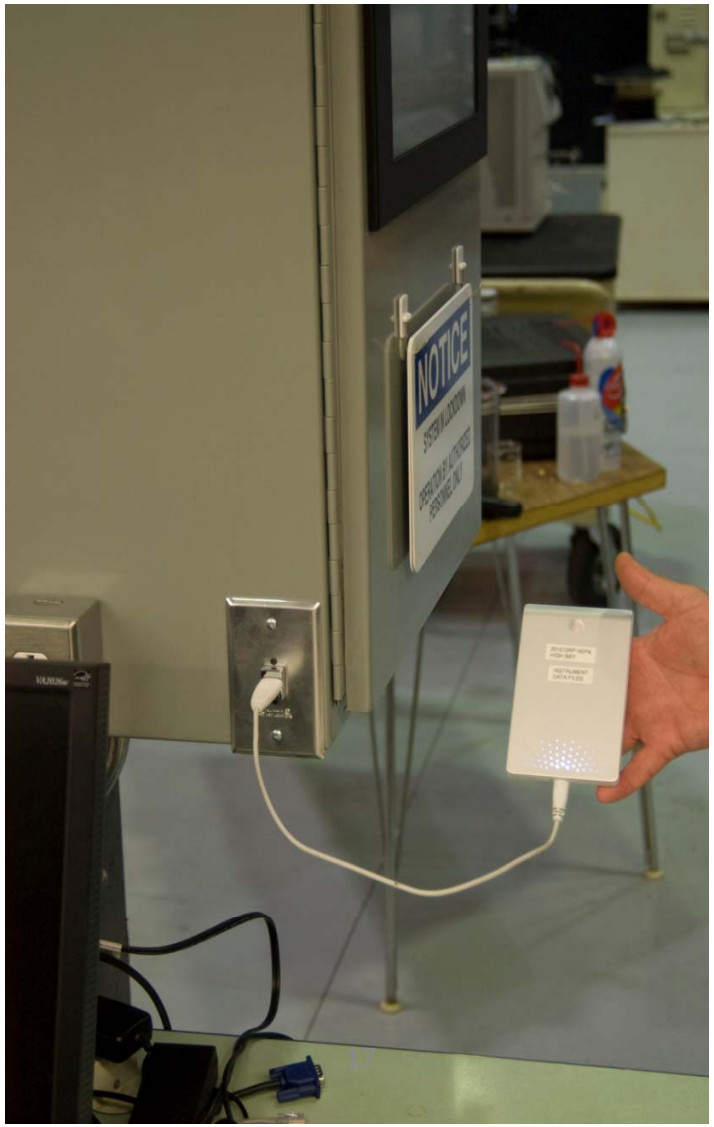


SMPS with Long DMA

* CPC – Condensation Particle Counter

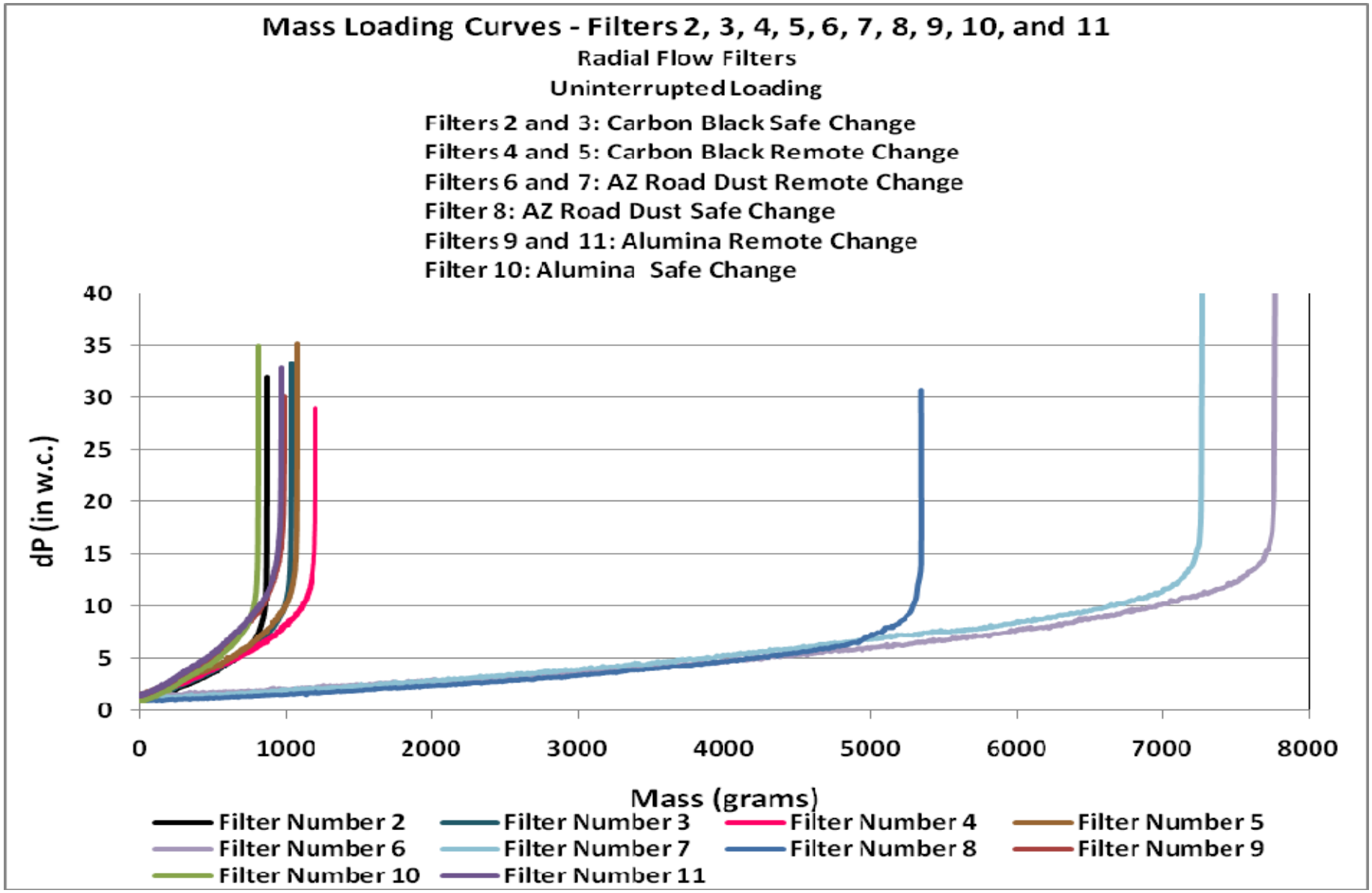
** DMA – Differential Mobility Analyzer

Test Stand Data USB Access Port

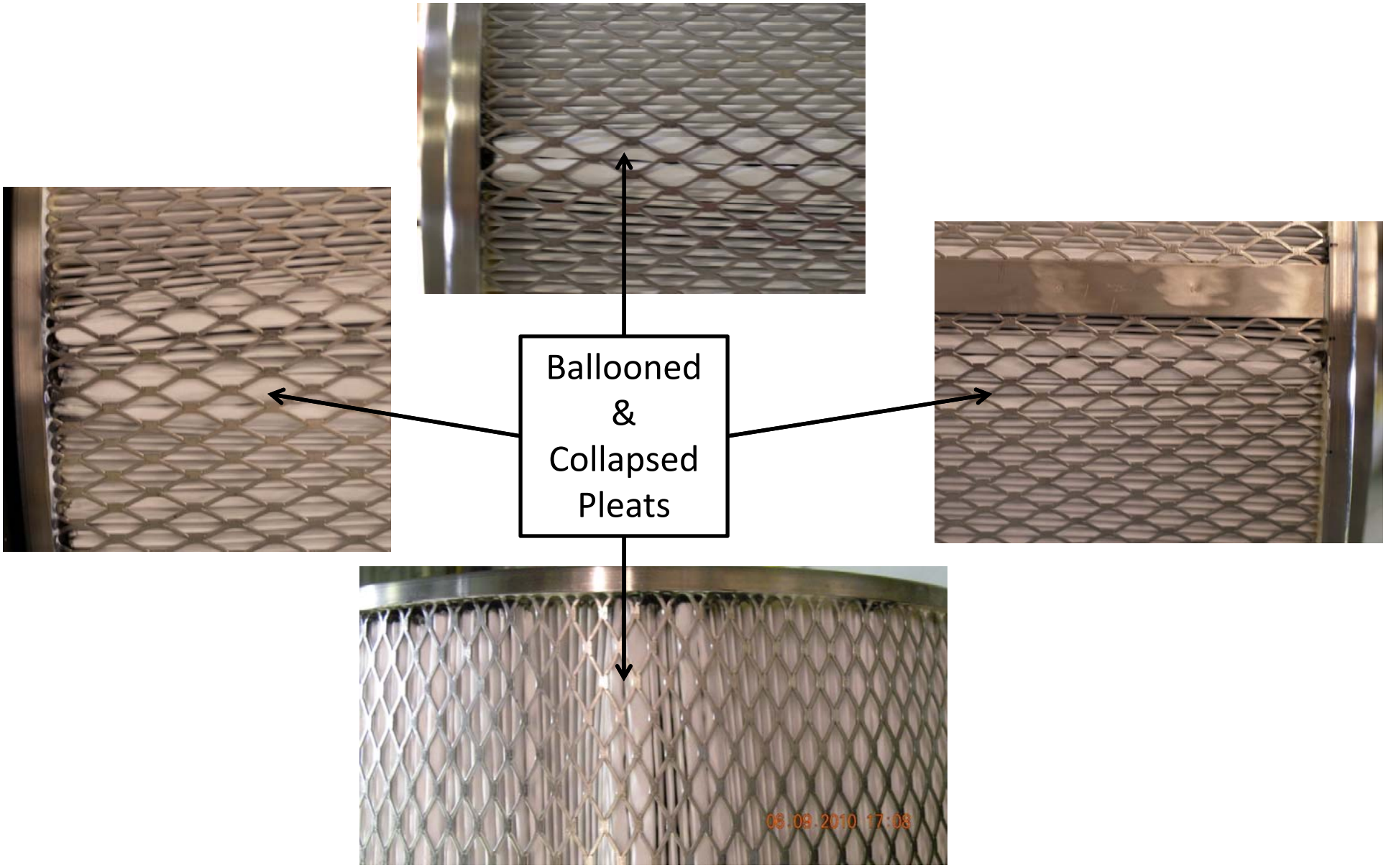


- PLC acts as central system controller and data collection center.
- Large 50” LCD Test stand monitor is visible throughout the test area to allow constant test monitoring vigilance
- Data collection through USB port to portable HD avoids conflicts or concerns with potential data corruption.
- Reduces sensitivity to NQA-1 software QA requirements by minimizing the required software.

Test Results to date:



Test Results to Date



Time to Rupture

							Time					
							minutes					hours
Filter No.	Type	Aerosol	Run ID No.	Initial dP (in w.c.)	Final dP (in w.c.)	Aerosol Mass (g)	7 in w.c. to Final dP	8 in w.c. to Final dP	9 in w.c. to Final dP	10 in w.c. to Final dP	10 in w.c. to 30 in w.c.	Initial dP to Final dP
10	Safe Change	Alumina	SC-DS1-001	0.96	36.7	808	101.92	63.50	42.25	28.25	27.67	10.2
2	Safe Change	Carbon Black	SC-DS1-002	0.97	33.2	874	70.33	37.25	21.25	11.75	11.42	11.1
3	Safe Change	Carbon Black	n/a*	1.04	36.7	1,036	142.75	95.17	62.75	37.08	36.42	12.4
8	Safe Change	AZ Road Dust	SC-DS1-003	0.95	35.5	5,361	66.58	35.08	14.17	7.42	7.25	12
9	Remote Change	Alumina	RC-DS1-001	1.41	32.6	981	351.17	245.92	177.75	123.33	122.92	17.5
11	Remote Change	Alumina	RC-DS2-007	1.52	34.0	974	280.08	222.92	177.00	130.33	129.92	13
4	Remote Change	Carbon Black	RC-DS1-002	1.36	29.3	1,196	230.25	166.50	106.00	66.17	66.17**	15.2
5	Remote Change	Carbon Black	RC-DS2-008	1.50	35.1	1,070	223.17	156.17	96.58	62.50	62.17	13.7
6	Remote Change	AZ Road Dust	RC-DS1-003	1.63	41.0	7,760	312.58	232.58	165.17	110.25	110.00	20.5
7	Remote Change	AZ Road Dust	RC-DS2-009	1.37	41.8	7,268	379.17	214.58	147.25	100.67	100.25	19.8

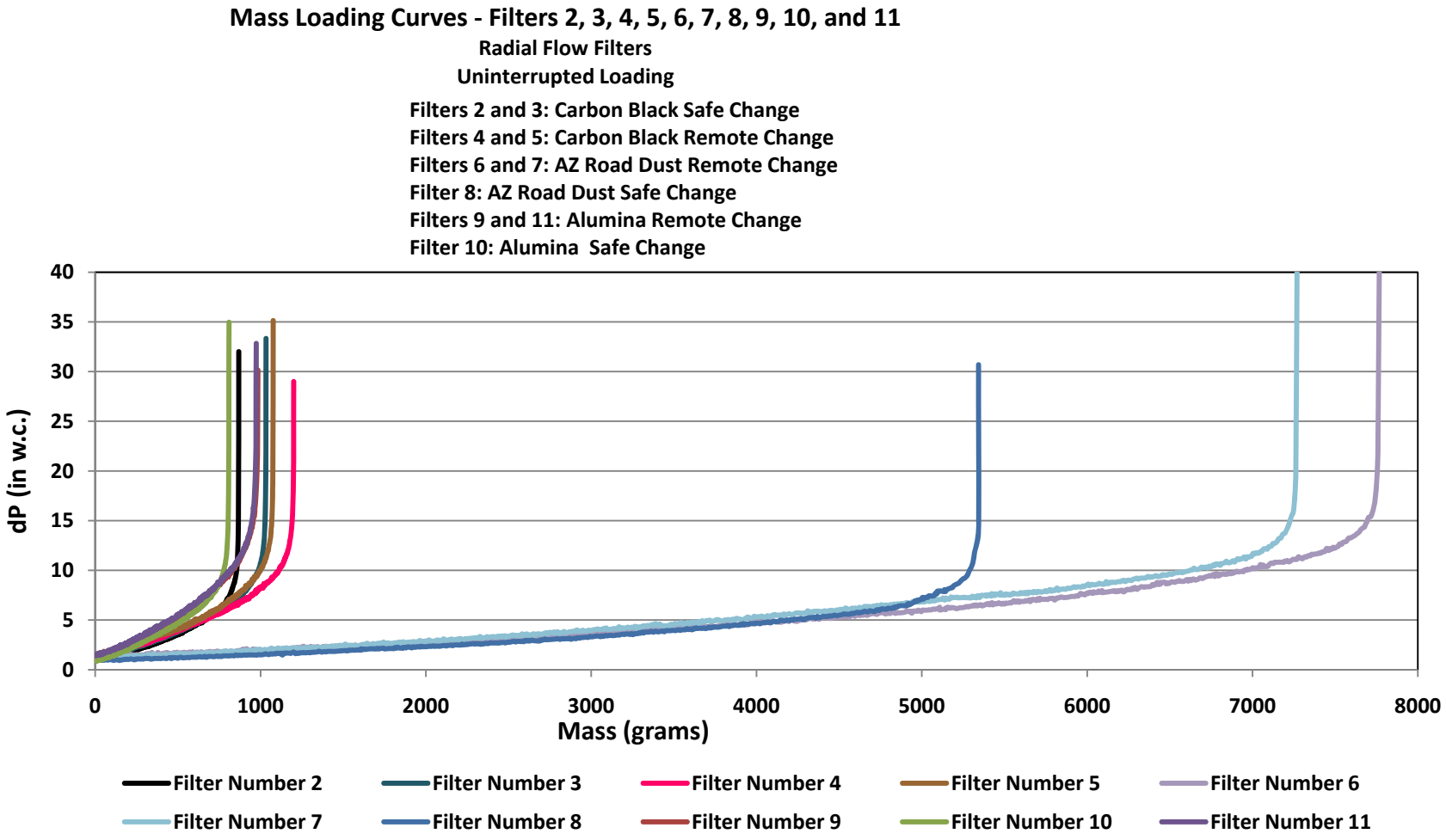
* Test filter not called for in test plan.

** Filter ruptured at 29.3" w.c.; i.e., did not reach 30" w.c.

Off-Normal DBE Significant

- < 30 min from DP of 9”W.G. to 10 “W.G. indicates plant operators will not have sufficient time from alarm to MAX qualified DP.
- Options:
  1. Assign lower alarm set point
  2. Modify System with addition equipment
  3. Modify Safe change HEPA filters similar to Remote change Filters

Apparent difference in filter load to failure DP
Remote vs Safe change



Unanticipated Result

Test reveals an area for improvement in design to Safe change HEPA filters!!

Remote change has a slightly higher pleat count which appears to improve durability.

Safe change filters modified with higher density pleats count similar to Remote change HEPA

Unanticipated Result #2

Test reveals another area for improvement in design to radial change HEPA filters!!

Loose “Filter Fuzz” material found in post test inspections. The cause was determined to be pleat flutter causing wear against the expanded metal filter shroud .

Radial change filters modified with sewn in reinforcing band to prevent potential wear hazard due to pleat flutter .

Remaining Testing

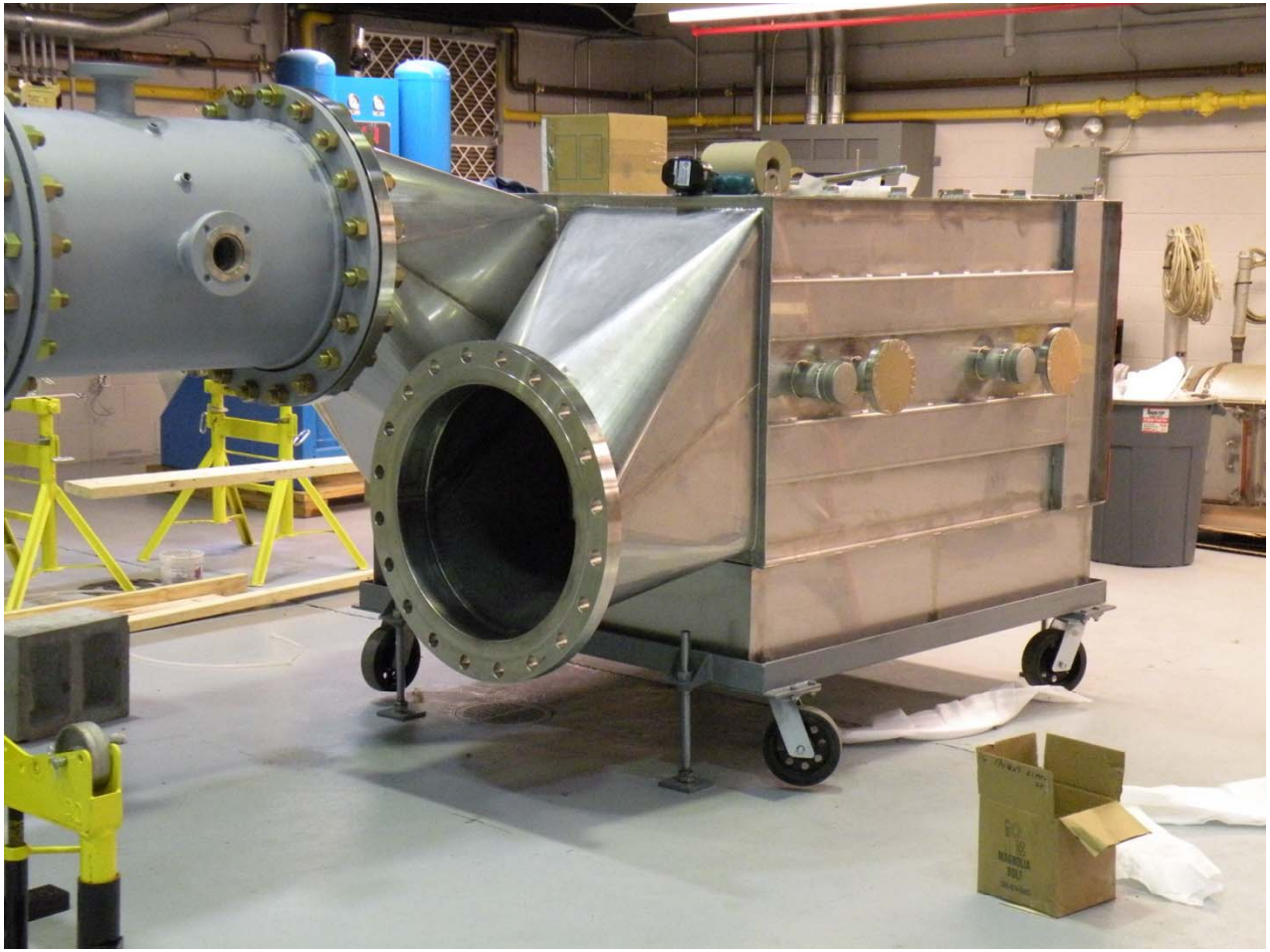
Complete Original Test Program:

- High humidity testing of loaded HEPA filters to determine RH operating band

New Test Items:

- Post pleat density upgrade Safe Change HEPA validation
- High Efficiency Moisture Eliminator (HEME) loading curve determination. May be required to credit HEME for Safety function in vessel off-gas systems.

Questions?



Acknowledgments

Thanks to :

- Mississippi State University Test Team
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  - Jaime Richert
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