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Filtration Technology

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Past-Present-Future

1940s	1950-60	1980	2000-10
M11 Filter	**M13 Filter**	**C2 Filter**	**JSGPM Filter**
H-Capacity	Sorbent/HEPA	M-Capacity	Primary CWA
H-dP	L-M Capacity	M dP	Secondary TIC
H Weight	M dP	M Weight	Packed Bed
H Profile	L weight	M Profile	L-M Capacity
	L Profile		L-M dP
			L-M Profile

2010	2020 +
NGGPM Filter	**NGGPM Filter**
Composite Beds	**Non Sorbent**
Interchangeable Media	**SCBA**
Broad Spectrum Prot	
L-Capacity	
L Profile	
Larger Area	

Direction and Challenges

- Rapid Advancement In Sorbent Technology
- New Requirements
  - Increasing Number And Classes Of Chemicals
- Technical Challenges
  - Broad Spectrum Protection
  - Small Integrated Envelope
  - Lightweight And Acceptable Pressure Drop

Direction and Challenges

- Current Filters Continue To Be Oriented To Granular Packed Bed.
- Community Moving Towards Broader Spectrum Protection With Lower Capacity Requirements.
- There Are Improved Filter Technology Solutions In The Form Of **Supported Sorbent Structures** And Particulate Media That Will Offer Lower Profile Filters With Broad Spectrum Protection Capabilities.

Filtration Principles

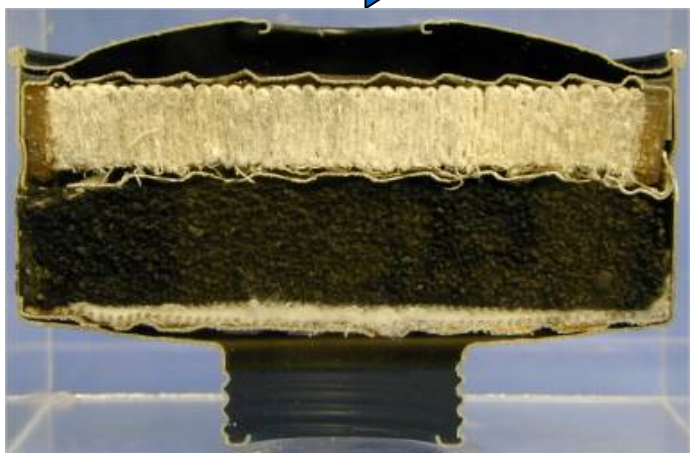
HEPA

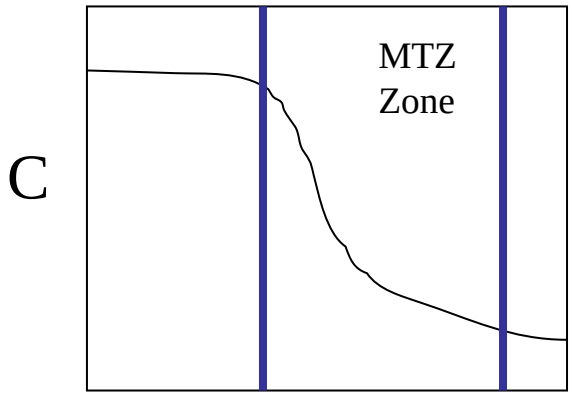
(Particulate)

ADSORBER

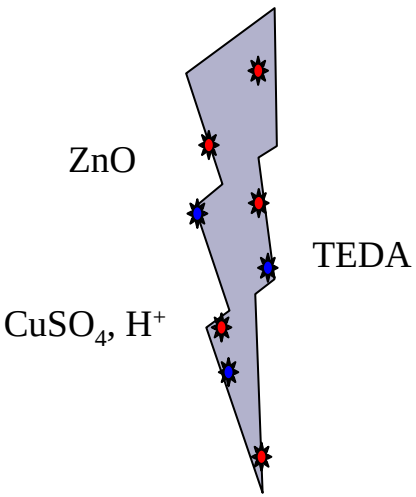
(Vapor)

C2 CANISTER



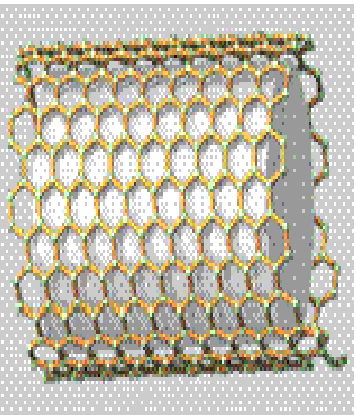


Adsorbent Requirements



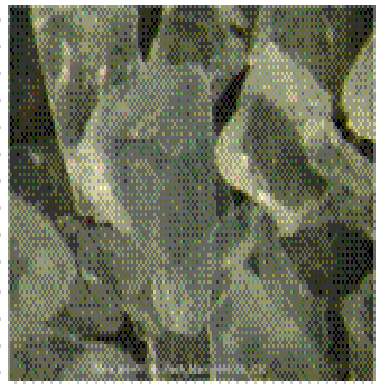
- ✓**Microporosity for physical adsorption**
- ✓**Pore distribution that can support reactants**
- ✓**Basic sites for removal of acid gases**
- ✓**Acid sites for removal of base-forming and basic gases**
- ✓**Access to reactive sites when adsorbed water is present**

Adsorbents

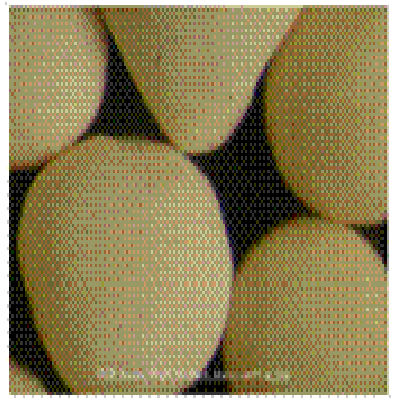


Carbon Nanotubes

Activated Carbon



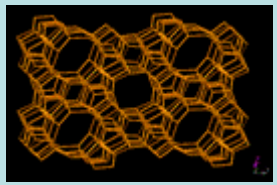
Silica



Zeolites

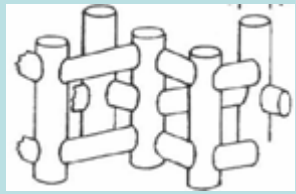
Sorbent Development

BF-38



- **ZSM-5**
  - MFI-type zeolite
  - Acidified
- **Removes basic/base-forming TICs**
  - Ammonia
  - Ethylene oxide

KRM-623

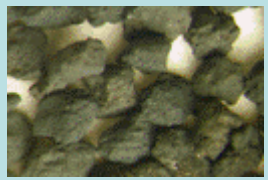


- **ZSM-5**
  - MFI-type zeolite
  - Alkaline
- **Removes fuming nitric acid, nitrogen dioxide**

ARC

- **Ammonia Removal Carbon**
- **Bituminous coal based activated carbon**
- **Impregnated w/ copper chloride**

90/10 Blend

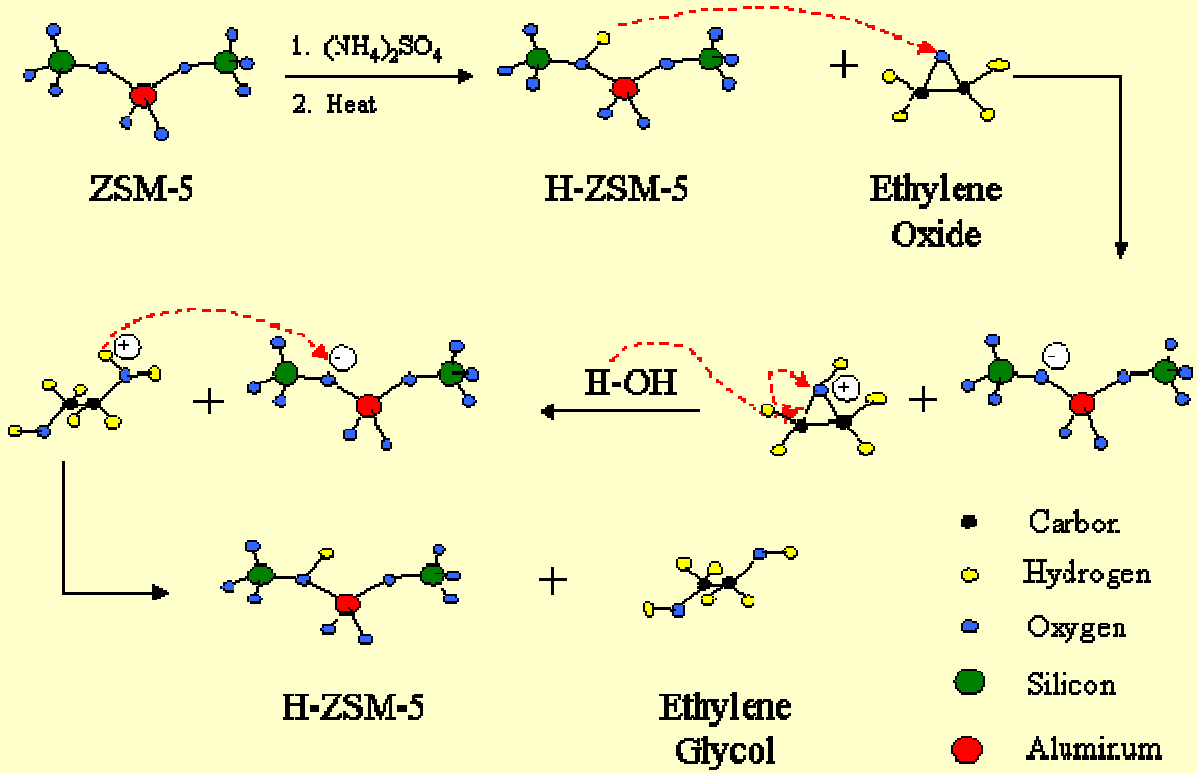


- **Blended activated carbon**
  - 90% ASZM-TEDA
  - 10% acid chloride impregnated carbon
- **Removes traditional CWAs + ammonia**

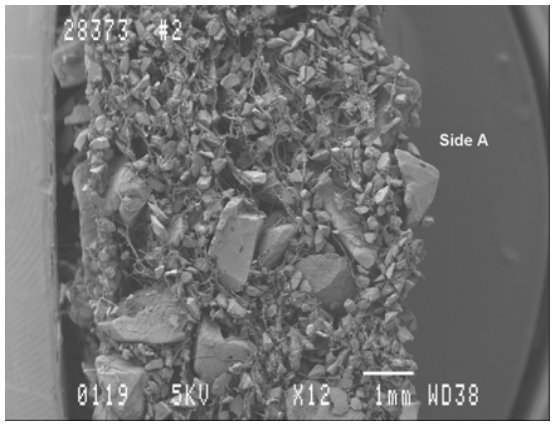
Sorbent Development

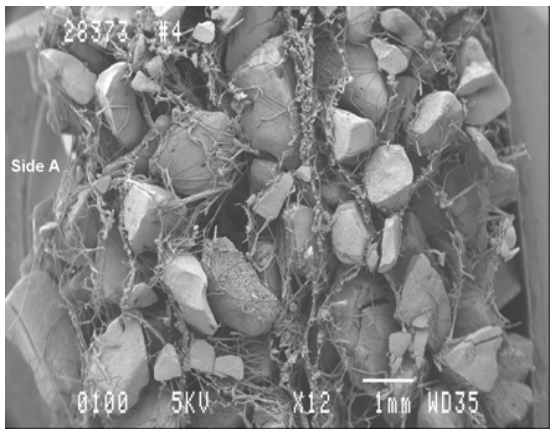
SORBENT DEVELOPMENT

EO Removal Mechanism by BF-38



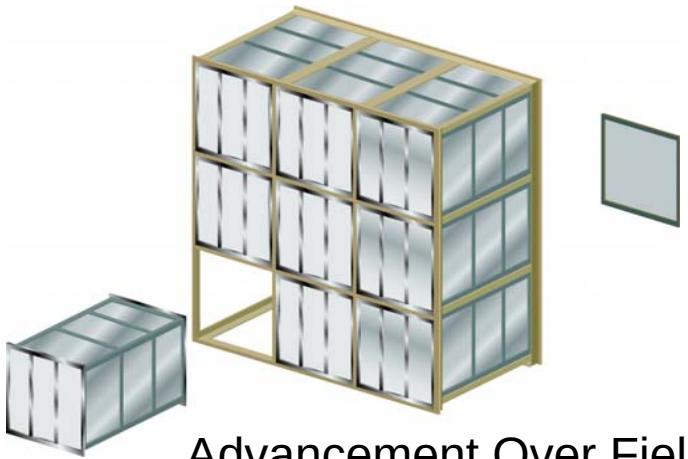
Advanced Adsorbent Supports





Description:

Flexible extruded web of elastomeric fibers loaded above traditional levels with broad range of treated carbon particles and with wide latitude in basis weight capability



Advancement Over Fielded Systems:

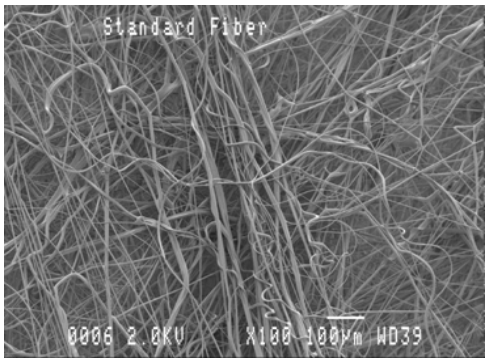
- Lower pressure drop, power
- Lighter weight, less maintenance
- Broader spectrum of protection CWAs + TIC/TIMs

Source: 3M

Advanced Particulate Filtration

Electret Filter Media

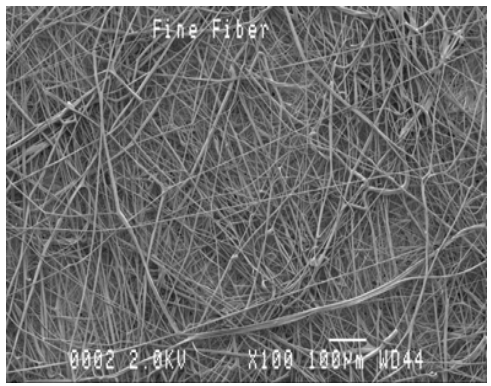
Description:
Multiple pleated layers of fiberglass, membranes, or electret webs combine to provide thermally stable non-clogging filters that are resistant to: wetting, oily mist, and Chem/Bio agents.



Large Fiber

(20+ micron)

Standard fiber (7-10 micron)

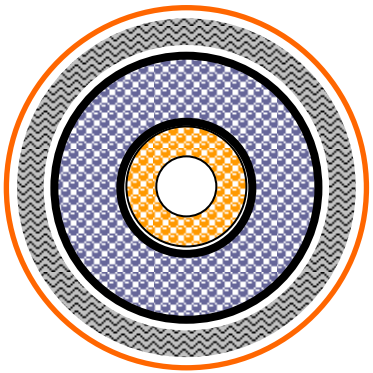


Fine Fiber (3-5 micron)

Source:3M

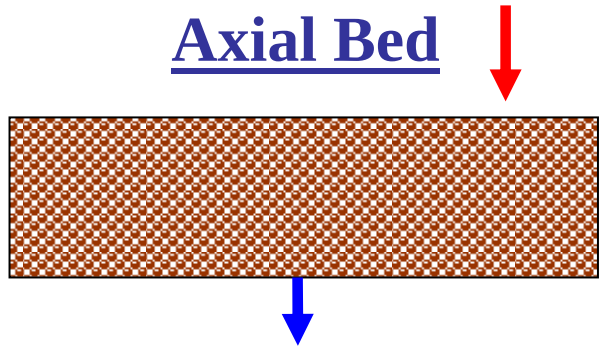
Filter Bed Design

Radial Bed

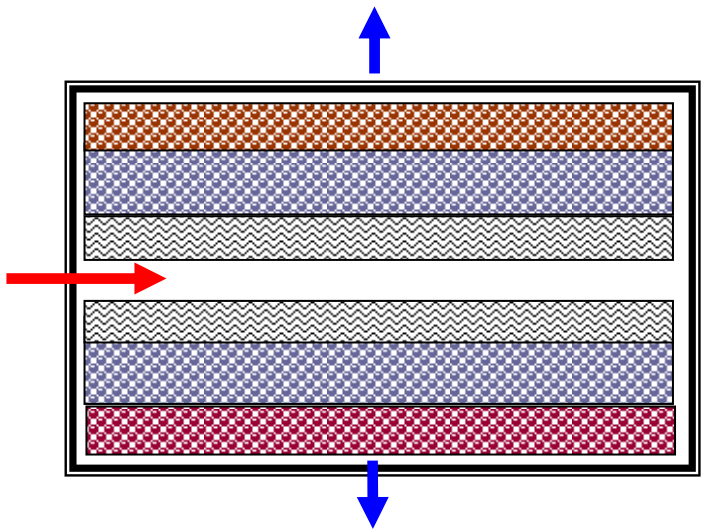


Radial Flow Filter - Inlet flow is directed to outer radial layer first and exits inner core, thus providing significant increase in chemical performance and reduction in airflow resistance

Axial Bed



Split Axial Bed



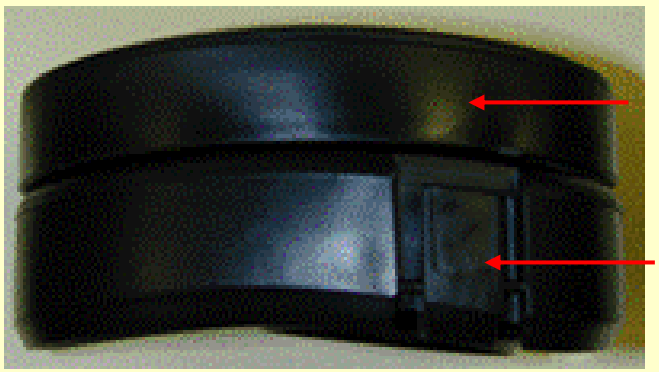
Split Flow Adsorber – Inlet flow is directed to center of two bifurcated cells, each containing particulate, CWA and TIC media

JSGPM

Joint Service General Purpose Mask (JSGPM)

Primary + Secondary Filter

Filter Configuration



Secondary - TIC

Primary -CWA

Objective

- Provide protection against field concentrations of all military agents
- Provide protection against Toxic Industrial Chemicals identified in ITF-25
  - Threshold = Group 1 chemicals
  - Objective = Group 1 + Group 2 chemicals

Target TIC's

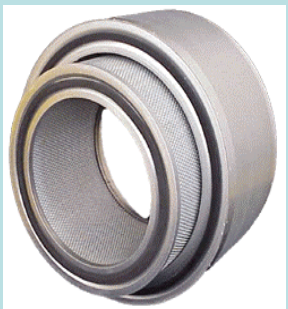
- Ammonia
- Ethylene Oxide
- Nitrogen Dioxide
- Carbon Disulfide
- Formaldehyde

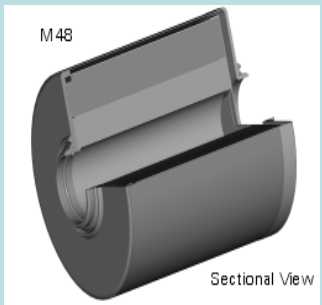
JCPE

Joint Collective Protection Equipment (JCPE)

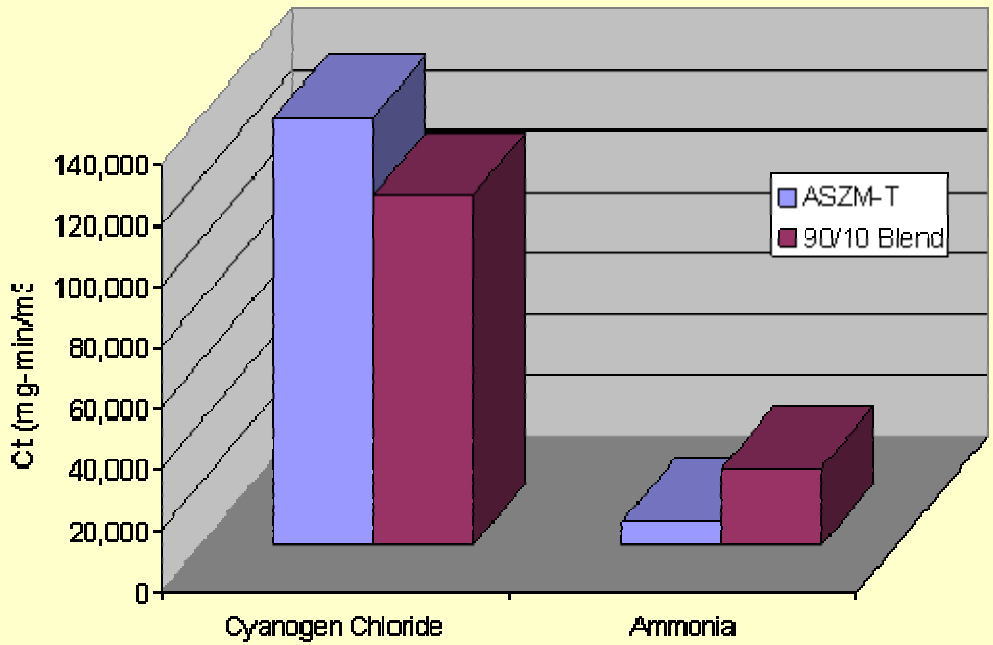
Objective

- Improve performance of current CP filters against target TICs with limited detriment to capacity for CWAs





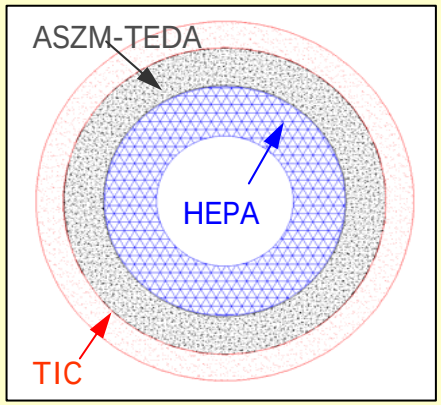
90/10 Blend vs. ASZM-TEDA
M98 Conditions



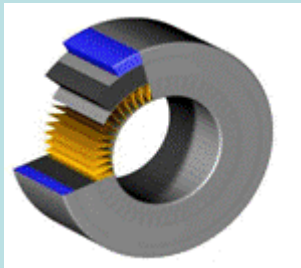
DARPA/NWA

DARPA/NWA CBR/TIC Filter

M98 Radial Flow CBR Filter



Radial Flow CBR/TIC Filter



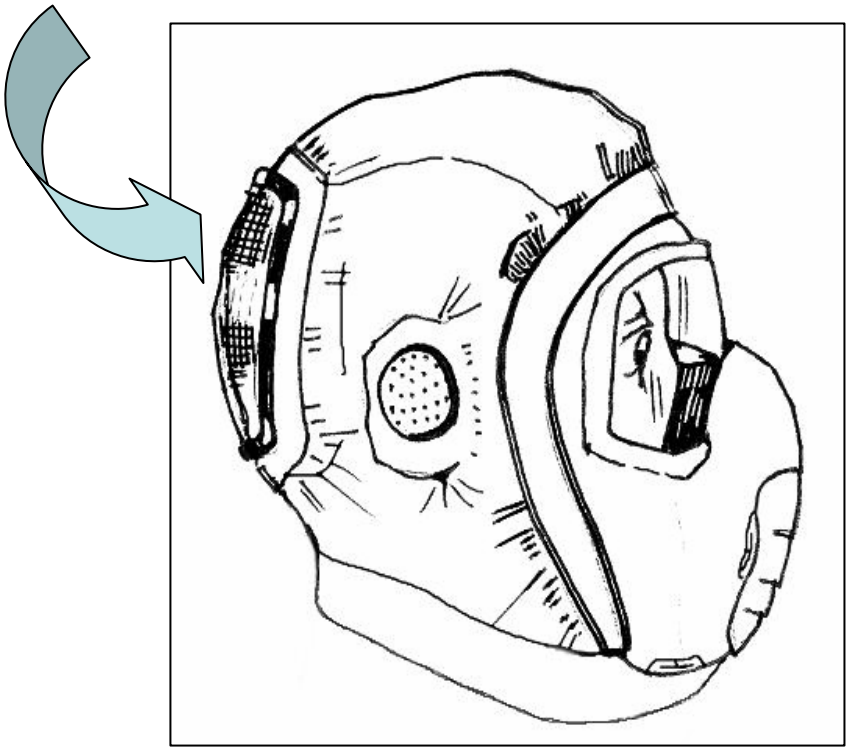
Objectives

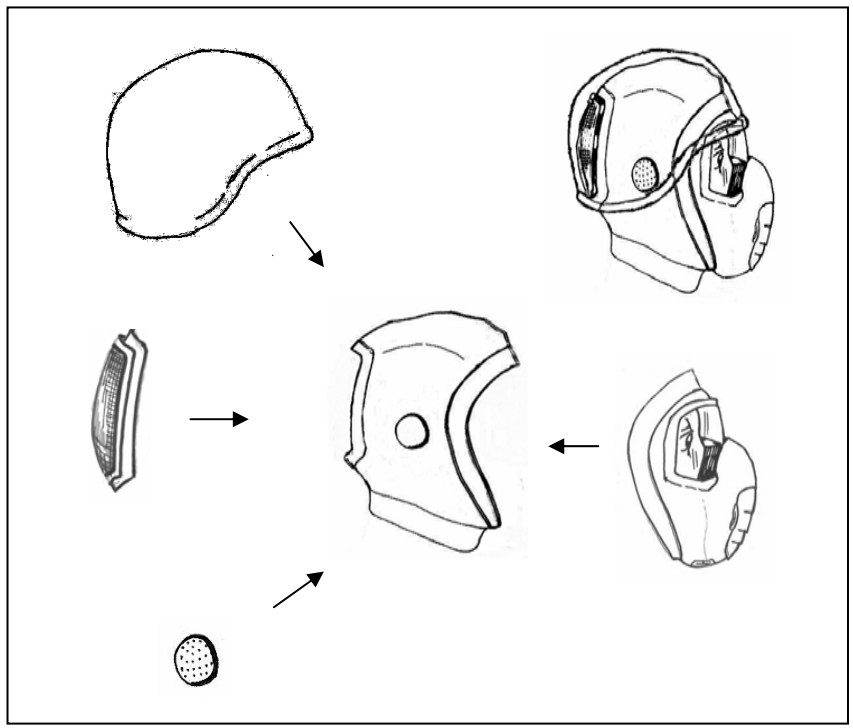
- **Provide ammonia, ethylene oxide and other TIC protection in addition to traditional CWA protection.**
- **Retrofit TIC protection into M98 filter housing.**

Source: NWA

Concepts for Next Generation General Purpose Mask

Filter





Sorbent Bed Type

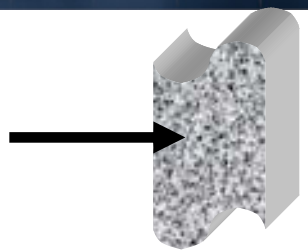
Packed Bed

- Maximum Sorption Activity per unit bulk volume
- Ideal for Higher Capacity Applications (>>50K CT)
- Constrained to Narrow Spectrum Chemical Protection
- Lower Unit Cost

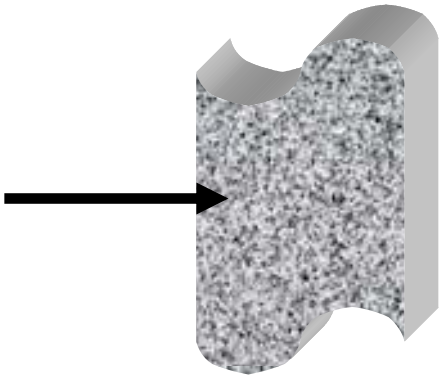
Supported Bed

- Sorbent on Fiber Composite
- Ideal for Lower Capacity Applications (<50K CT)
- Suitable for Broad Spectrum Chemical Protection
- Suitable for Large Bed Area and Shallow Bed Configurations
- Higher Unit Cost

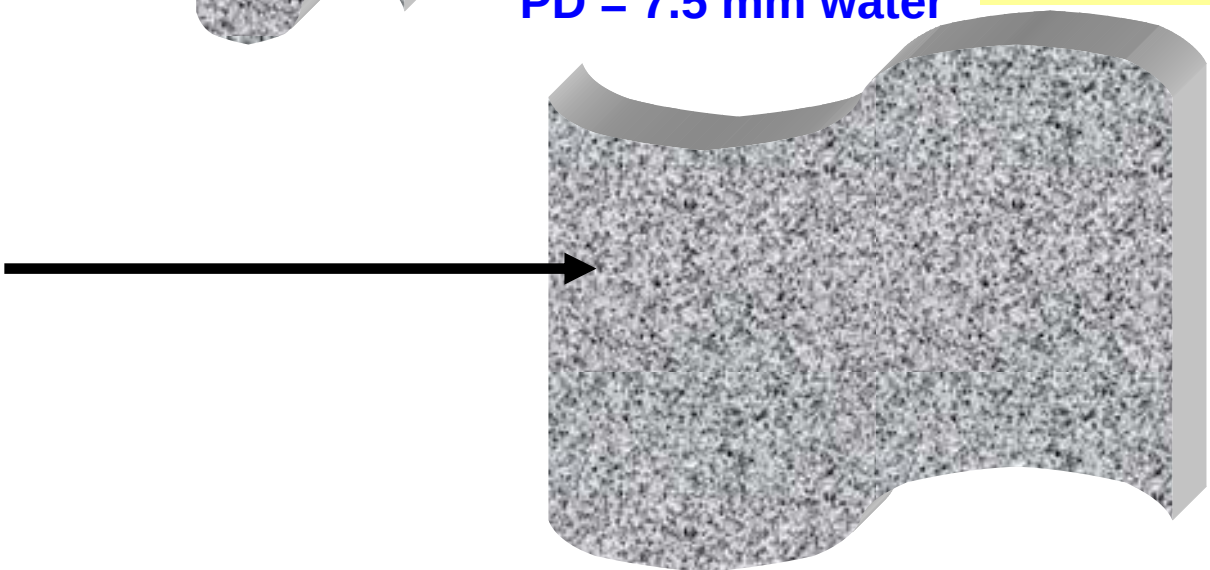
Effect of Filter Cross-Sectional Area on Performance



FR = 50 LPM
AFV = 9.6 cm/s
BA = 86 cm^2
PD = 15 mm water



FR = 50 LPM
AFV = 4.8 cm/s
BA = 172 cm^2
PD = 7.5 mm water



FR = 50 LPM
AFV = 2.4 cm/s
BA = 344 cm^2
PD = 3.8 mm water

Increasing Filter Area

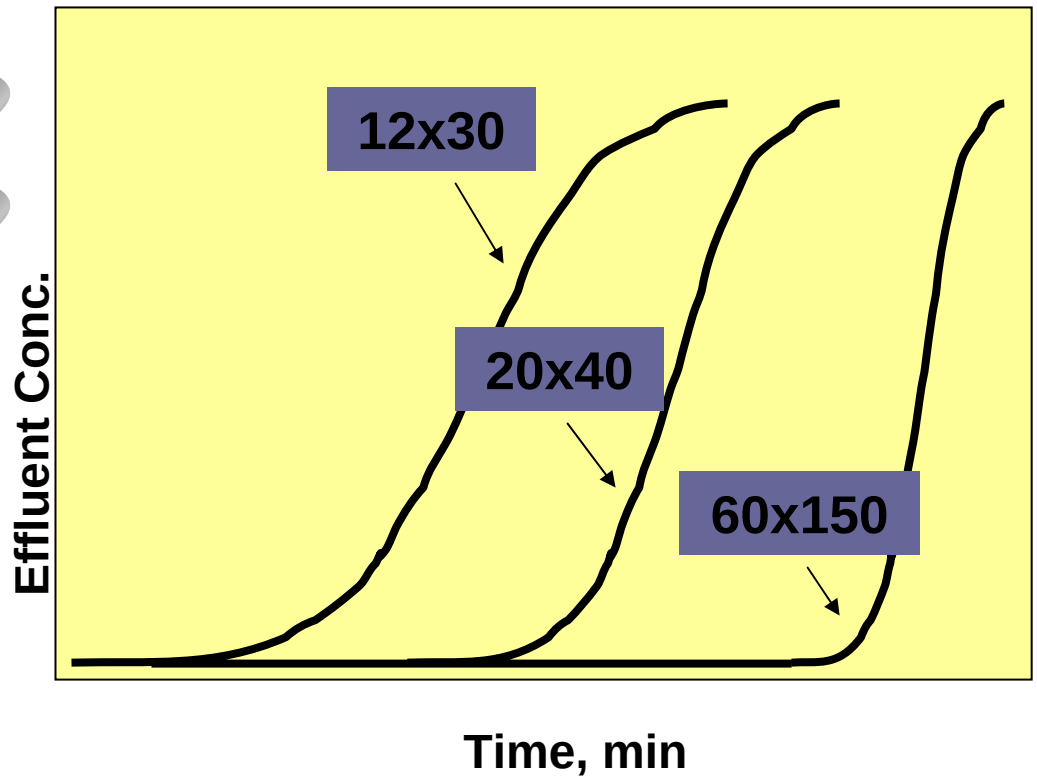
- Reduced AFV
- Reduced PD
- Reduced Particle Size
  - Thinner Beds
  - Increased Chemical Performance

Effect of Particle Size on Mass Transfer Zone

Pleated Axial Flow Bed

100 LPM
External Area: 86 cm2
AFV: <3 cm/s
Pleat Area: 600-900 cm2

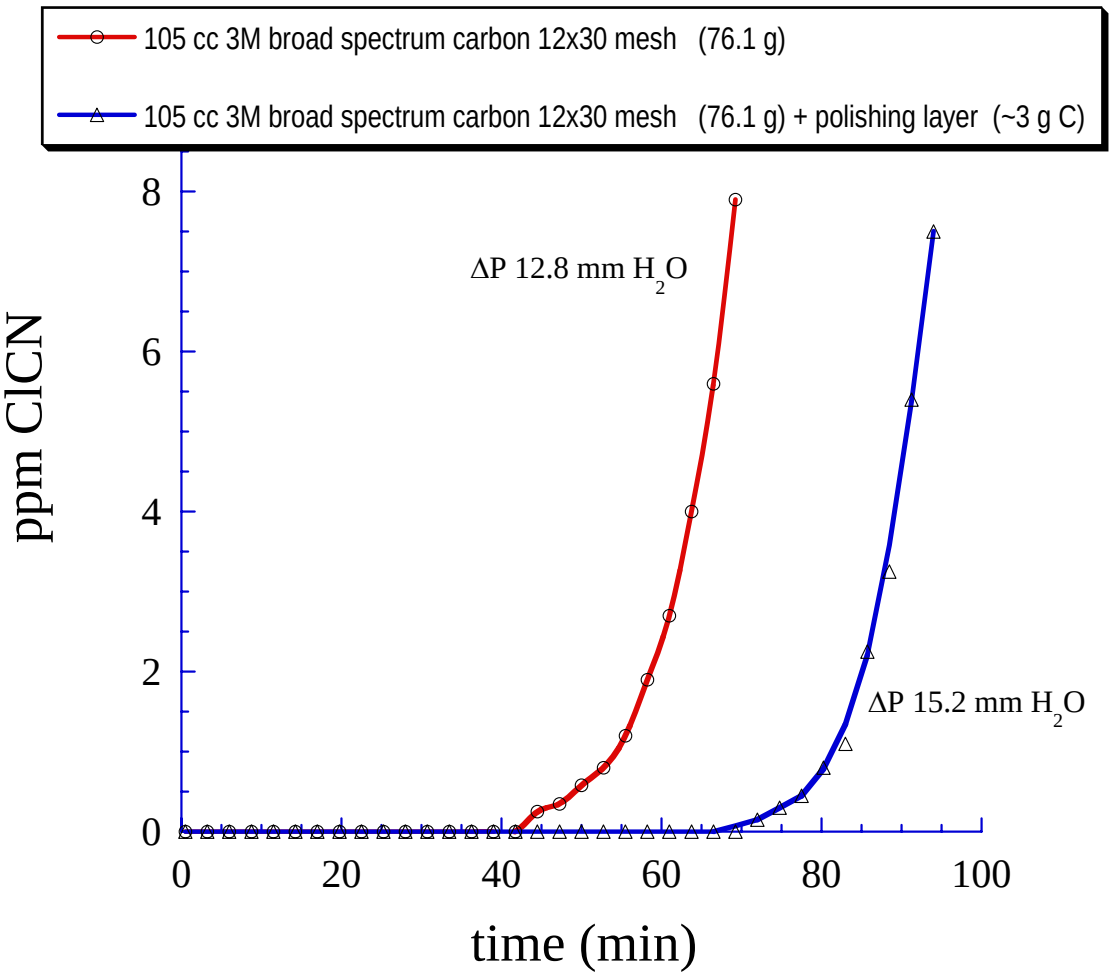
Effect of Particle Size on MTZ



Flex-c Web as CK Polishing Layer

550 ppm ClCN (1350 mg/m^3)
32 L/min; 93% RH

loaded into 3M 6000 series cartridges (~67 cm^2)



Source: 3M

Summary

- For low capacity, broad spectrum protection (TIC/TIMs + CWAs) filter bed designs other than traditional packed bed sorbents may be necessary and advantageous to meet near-term and future requirements.

- **Supported Sorbents** offer a wide range of capabilities:
  - Composite thin beds – with multiple sorbents
  - Suitable for non-conformal and pleated configurations
  - Smaller particle size sorbents
  - Lower airflow velocity and pressure drop
  - Flat sheet particulate media
  - Interchangeable beds and components

Summary

- Need for MATURING supported sorbent technologies
  - Supports
  - Gradual Increase in Sorbent Capability
  - Bed Design Concepts
  - Modeling
  - Compositions/Interchangeability
  - Manufacturability - QA/QC
- Need funding opportunities to MATURE technology in order to equip the Warfighter in the near-term

Acknowledgements

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