COLLECTIVE PROTECTION (COL PRO) 2005 CONFERENCE

MONTEREY CALIFORNIA, 21-23 JUNE 2005

Air Purification Technology Overview

Presented by

Christopher J. Karwacki

Co-Authors: Michael Parham, Greg Peterson,
Alex Balboa, Cheri Borruso, John Mahle

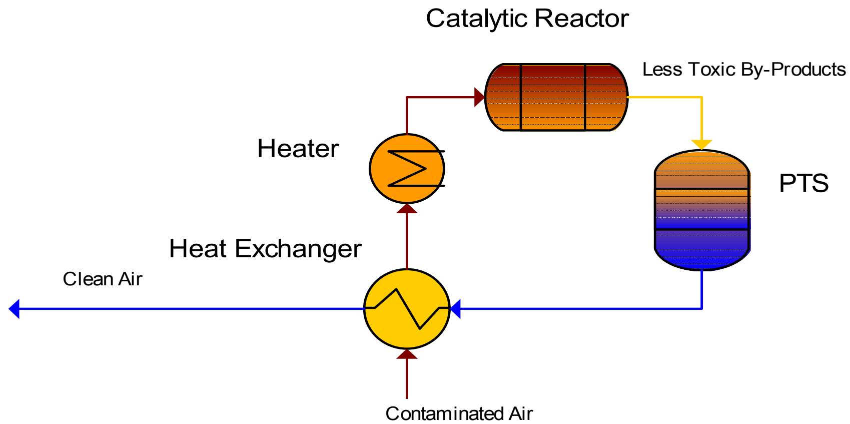
Chemical Biological Radiological Filtration Team
Research & Technology Directorate
Edgewood Chemical Biological Center

AP TECHNOLOGIES

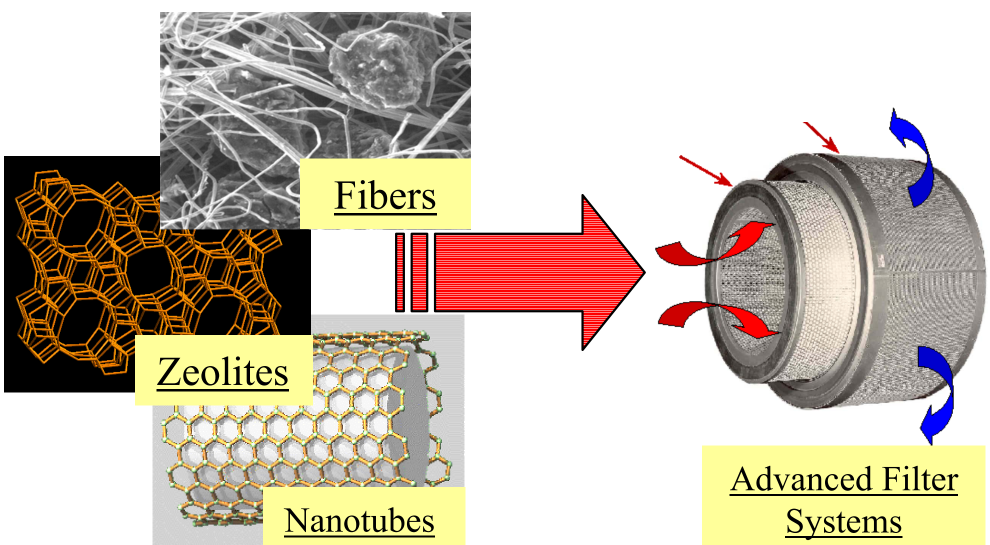
ECBC Mission

- Develop a Center of Excellence in respiratory protection through technology development, design, test, and evaluation of advanced air purification technologies
- Develop test standards for technology selection, integration and certification
- Support the Warfighter/DHS in development programs incorporating air purification technologies

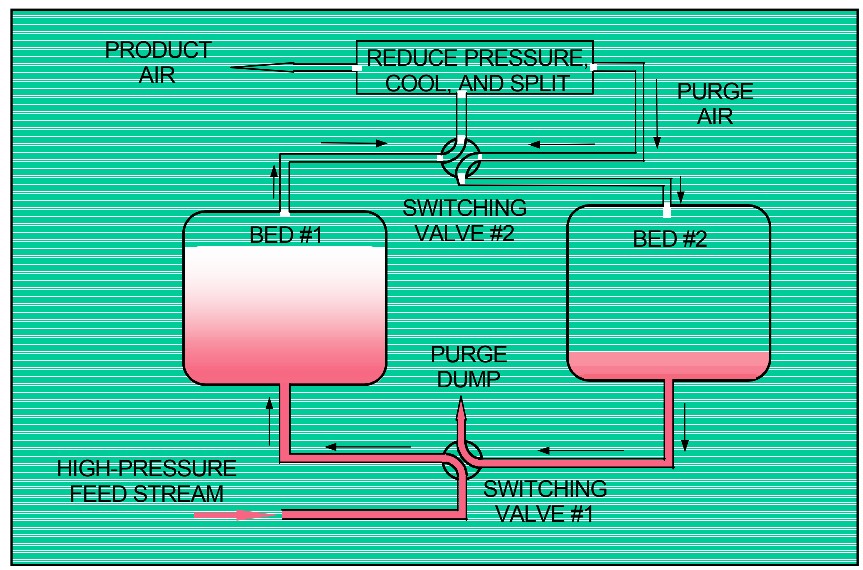
Catalytic Oxidation (CatOx)



Single Pass Filtration w/ Optimized Adsorbents



Regenerative Filtration (Regen)



ECBC PARTNERSHIPS & CUSTOMERS

ACE
DARPA
DHS
EPA
JECP
JPEO – CBD
JSTO – DTRA
OSHA/NIOSH
NSWC
NIST
PM-IP
PM-COLPRO
PM EFV
PM FCS
PM Guardian
TSWG

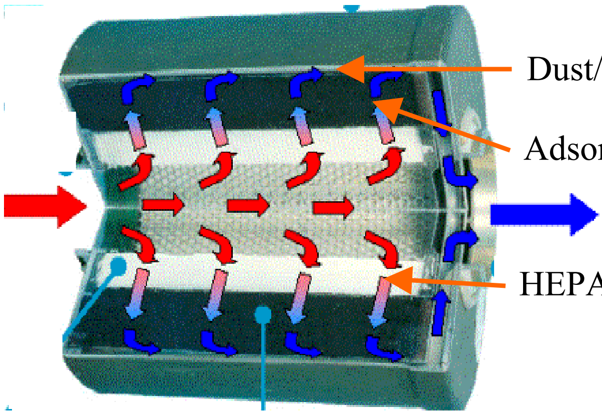
Air Purification Technology Development

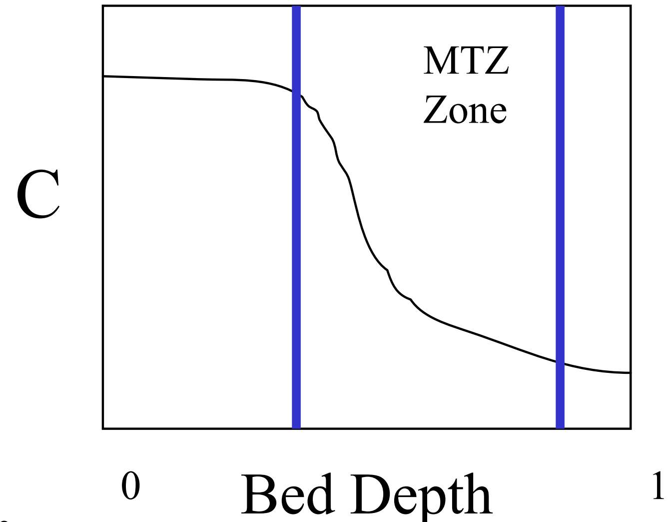
- Concept Exploration
- AP Technology Development
- Material/System Modeling
- Application Requirements
- AP Selection and Integration
- Standards for Qualification and Certification

Reaching Out to The Community

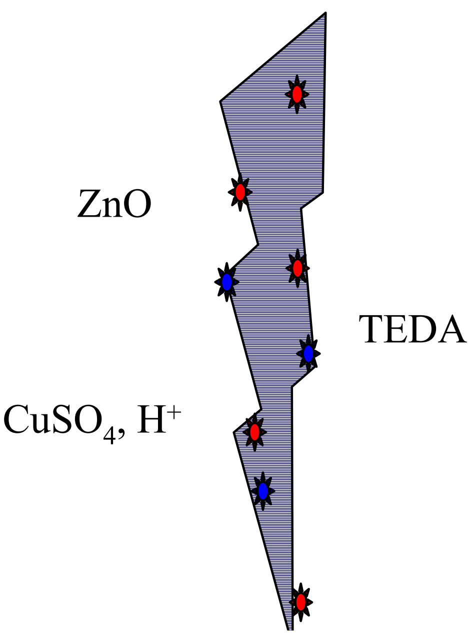
- CRADAs
- MOU
- Proposals
- Publications
- Conference Presentations
- Patents

SINGLE PASS FILTRATION
PRINCIPLES





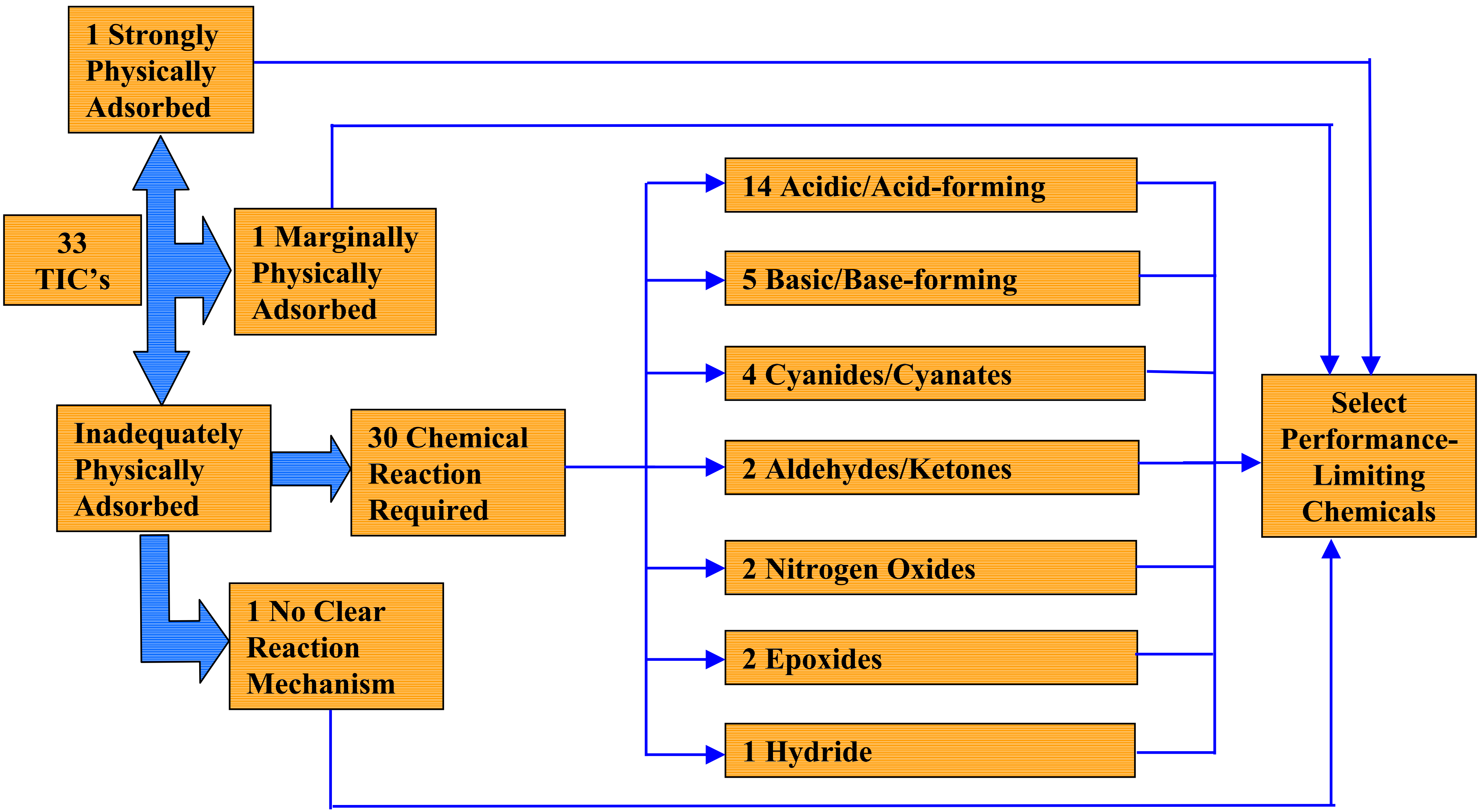
Adsorbent Requirements



- ✓**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**

SINGLE PASS FILTRATION

DESIGN-LIMITING CHEMICALS



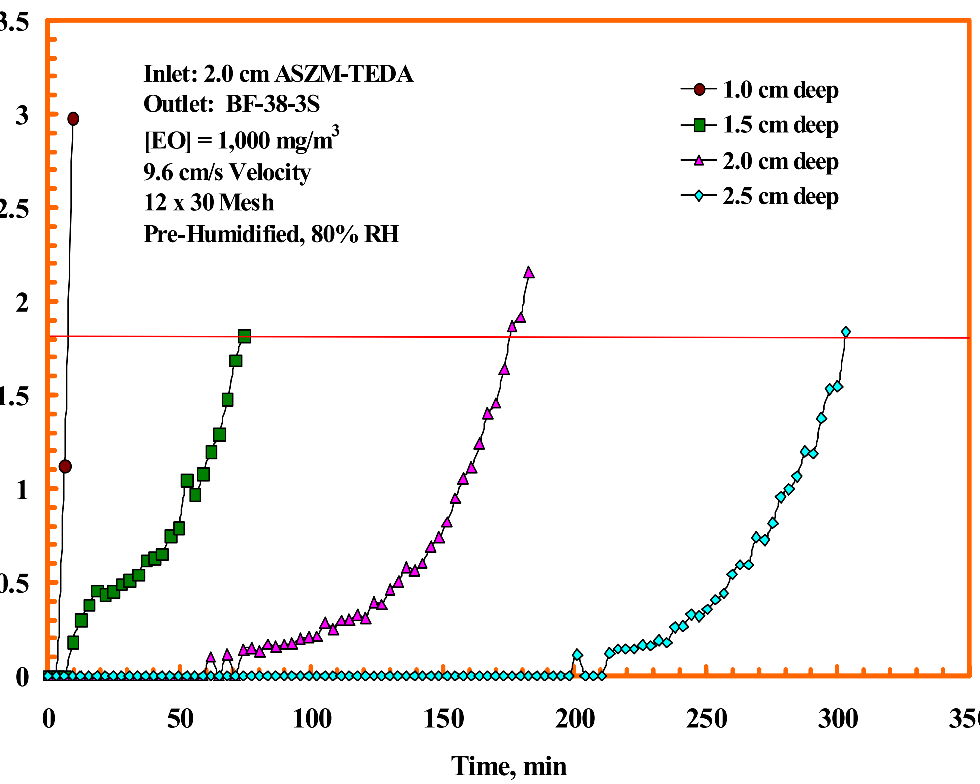
SINGLE PASS FILTRATION

NOVEL TIC FILTRATION MEDIA

OBJECTIVE: Develop adsorbents to improve filtration of representative TICs

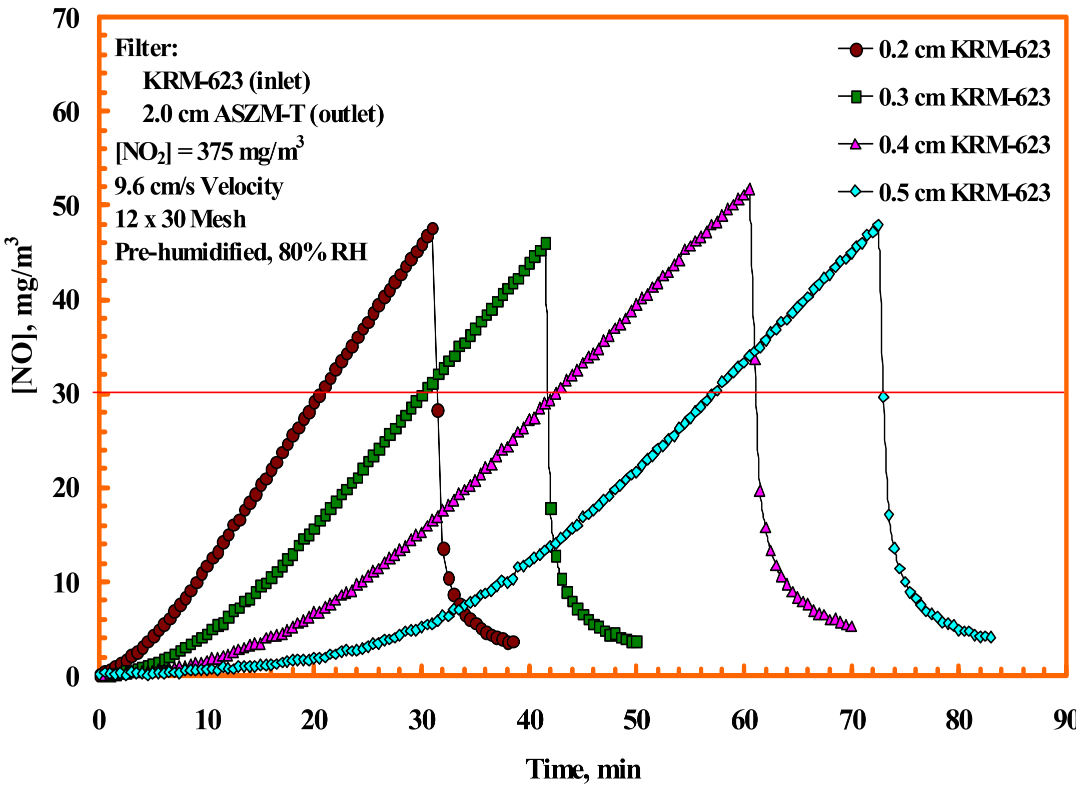
BF-38 Impregnated Zeolite

Target Chemicals: Ammonia
Ethylene Oxide



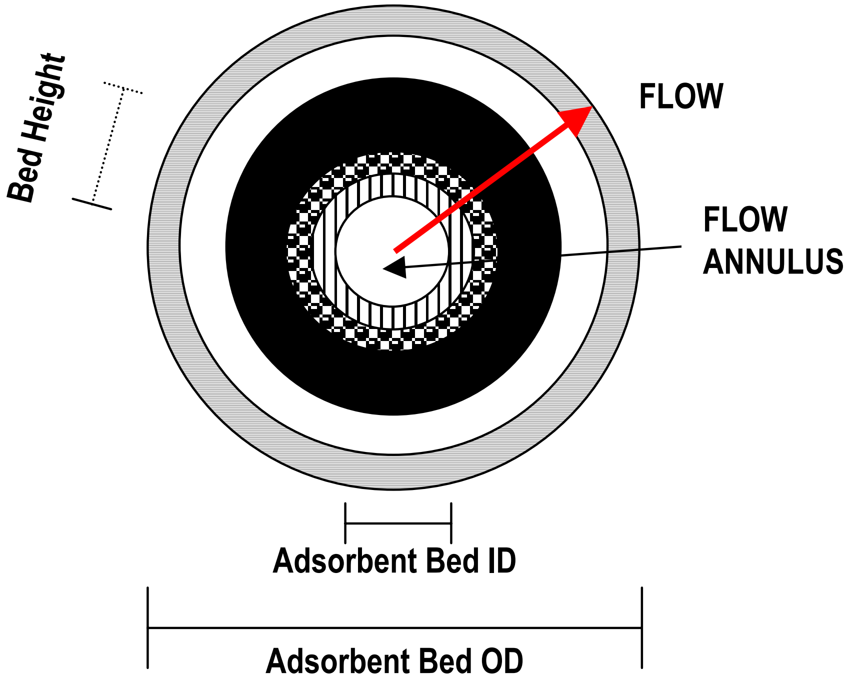
KRM Zeolite

Target Chemicals: Fuming Nitric Acid
Nitrogen Dioxide



SINGLE PASS FILTRATION
COLPRO APPLICATIONS

Novel COLPRO Filter Designs



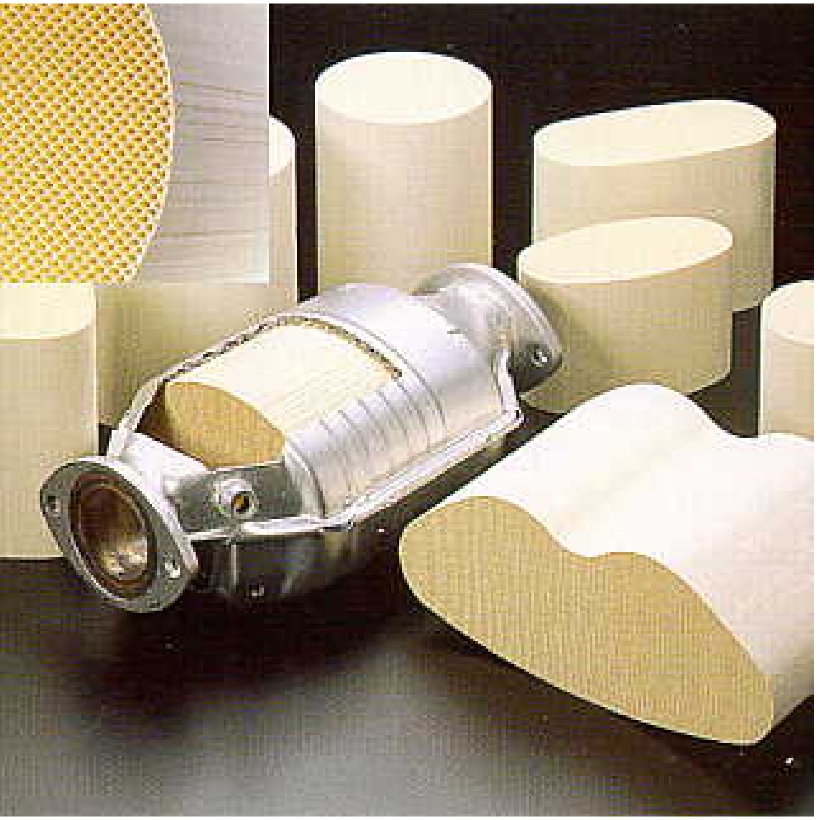
- HEPA FILTER
- BF-38 → Ammonia, Ethylene oxide
- ASZM-TEDA → CWA, Acidic/Acid-forming gases
- KRM → Nitrogen dioxide

Filter Composition

Material	Layer/Position	Bed Depth
KRM-623	Inlet	1.5 cm
ASZM-TEDA	Middle	5.2 cm
BF-38-3S	Exit	4.3 cm

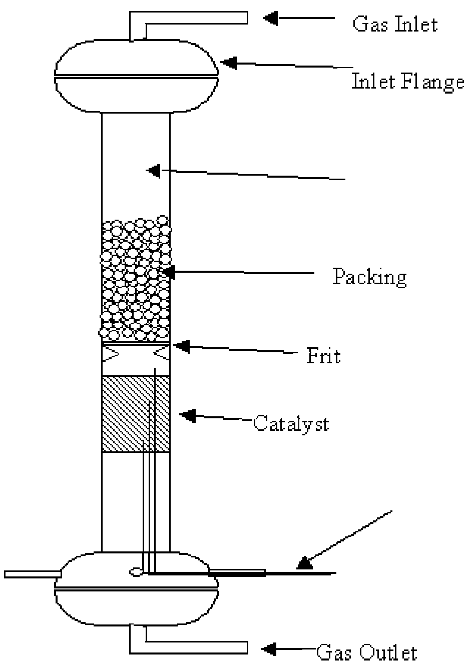
Chemical	Estimated Performance (mg-min/m^3)
DMMP	215,000
Hydrogen Cyanide (AC)	45,000
Cyanogen Chloride (CK)	62,000
Phosgene (CG)	226,000
Sulfur Dioxide	76,000
Ammonia	48,000
Ethylene Oxide	112,000
Nitrogen Dioxide	15,500

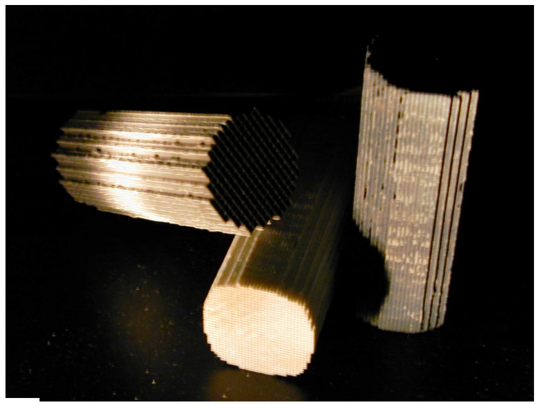
CATALYTIC OXIDATION
BROAD THREAT PROTECTION

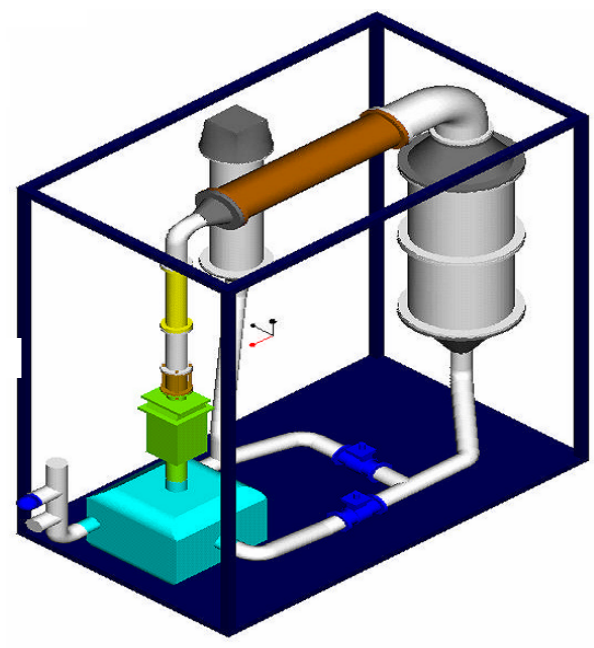


- **Catalytic Oxidation converts chemical vapor threats into carbon dioxide, water, and less toxic acid by-products.**
- **The catalyst monolith reactor is an established industrial technology.**
- **Combined with a post treatment system to remove acid gases, CatOx offers:**
  - Broad threat protection
  - Low maintenance
  - Destruction of chemical threats
- **Drawbacks of technology**
  - Catalyst operates at a high temperature (200-400°C)
  - Uses a recuperative heat exchanger which heats up incoming contaminated air with clean hot air.
- **Design Drivers**
  - Activity: What temperature is required for the desired level of chemical destruction?
  - Selectivity: What level of undesired by-products are generated at the operating temperature? What is the post treatment strategy?
  - Durability: How much loading of P, As, Se, B, Br can occur before activity decreases?

CATALYTIC OXIDATION
PROGRESS AT ECBC



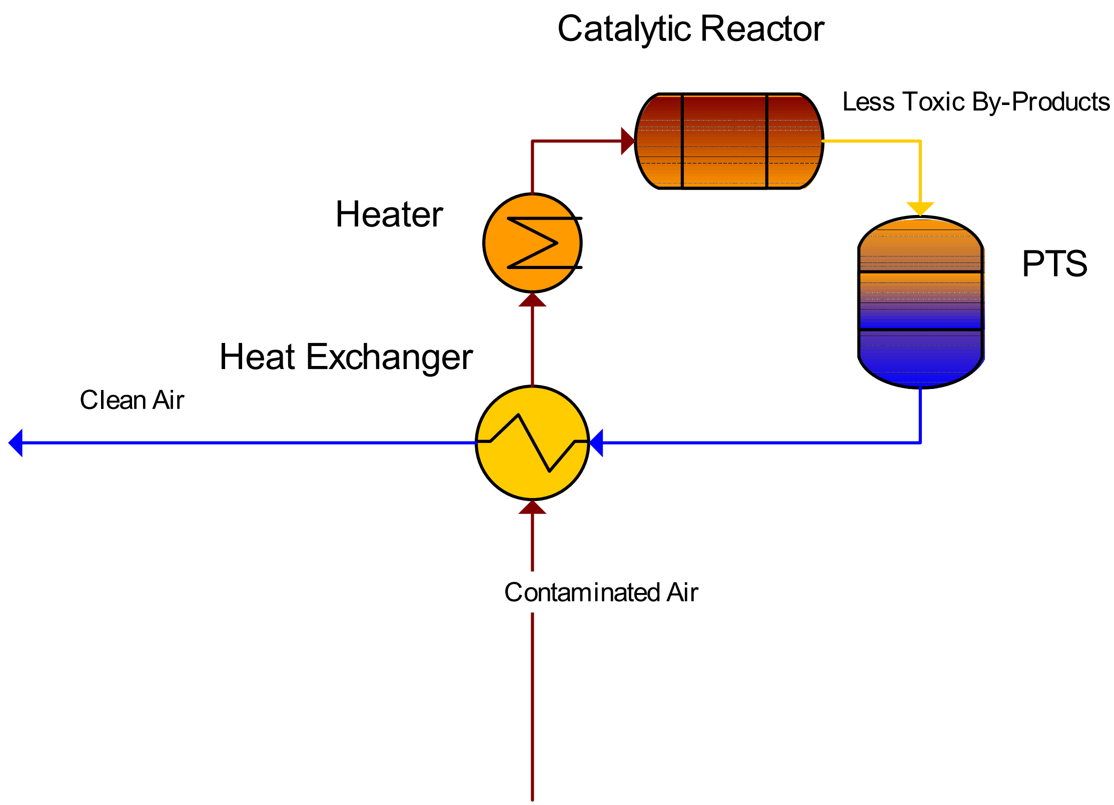




- **Partners**
  - Honeywell
  - Guild Associates
- **Commercial Catalyst Screening**
- **Lab scale catalyst reactor studies**
- **50 SCFM Demonstrator Test and Evaluation**
- **System Application Studies**

CATALYTIC OXIDATION
SYSTEM OPTIMIZATION

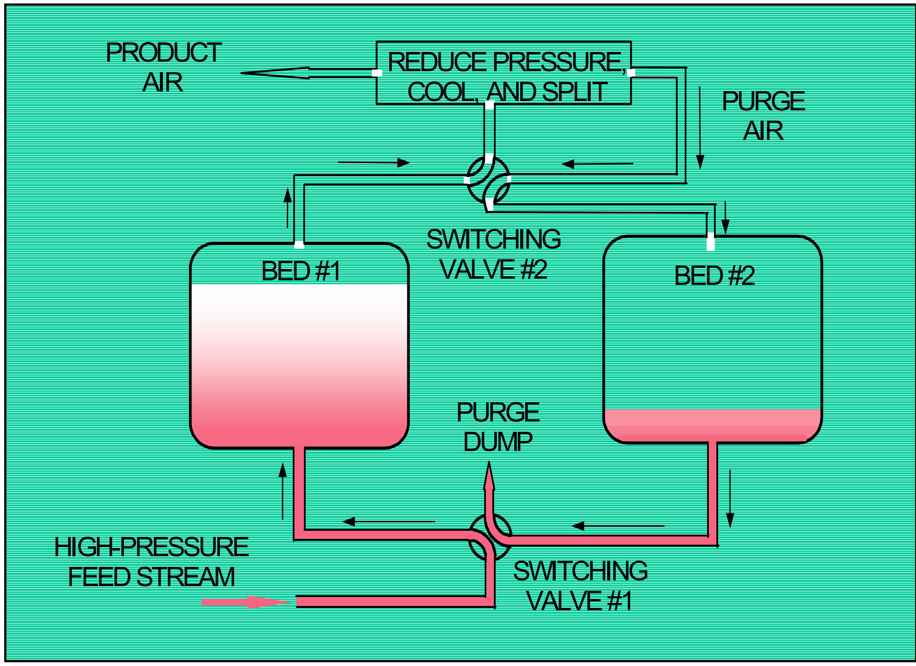
- **Catalyst**
  - Operating temperature drives energy utilization and determines burden on post treatment system.
- **Post Treatment System**
  - High temperature reactive adsorbent.
  - Ambient temperature water scrubbing.
  - In both cases NOx is design limiting.
  - All other compounds are more easily removed.
- **Heater or waste heat utilization**
  - Aggressive start up time requirements will drive up the peak power demand and lead to infeasible heater or waste heat exchanger designs.
  - Start up time requirements of 30 minutes are more reasonable.
- **Recuperative heat exchanger design**
  - Operating temperature of catalyst will drive material selection.
  - Utilization of waste engine heat or catalyst material improvements is a lower risk power reduction strategy.



REGENERATIVE FILTRATION

BROAD THREAT PROTECTION

- **Regenerative Filtration cleans air by adsorption**
  - Adsorbent beds are regenerated by counter-current by pressurized or thermal purge.
- **Regenerative Filtration is an established industrial technology**
- **Regenerative Filtration offers:**
  - Broad threat protection
  - Low maintenance
- **Drawbacks of technology**
  - Higher energy consumption may limit its use to suitable waste heat sources
  - Mitigation of contaminant purge
- **Design Drivers**
  - Chemical Requirement: What chemicals need to be removed and dosage
  - Bed Size/Cycling/Energy: Energy available for optimum pressurization



REGENERATIVE FILTRATION

Maturation

– **Adsorbents** – Adsorption Equilibria has been measured for a wide range of chemicals

– **Bed Design** – Sorbent type, layering, bed velocity

– **Process Optimization** – Cycling, temperature and purge characterized to minimize energy

– **Modeling** – Process models matured and validated to for a wide range of chemical requirements and operating conditions

REGENERATIVE FILTRATION

- **System Testing and Validation**
  - Industry test stands 50 – 200 CFM
- **Integration in Relevant Applications**
  - Abrams Tank, Shelter, EFV, FCS
- **Standard Test Method Development**
  - Technical Readiness Evaluation
  - JSTO Test & Evaluation

TRADE-OFF ANALYSIS

- **Single AP technology will likely not be suitable for all emerging requirements and applications**

- **Protection and application requirements must be assessed against the capabilities of a particular AP technology**

  – Energy per CFM
  – Size and Weight per CFM
  – Reduced Chemical threat
  – Critical Asset

CONCLUSIONS

- **Major advances in key AP technologies (single-pass filtration, regenerative filtration, catalytic oxidation) show promise in meeting current and emerging protection requirements**
  - **Technology must provide <u>BREATHABLE AIR</u>**
    - TIC, CWA, NTA
  - Technology must integrate effectively into application
    - Energy Requirements
    - Weight and Space Claim

Acknowledgements

- ECBC - Michael Parham, Greg Peterson, Alex Balboa, Cheri Borruso, John Mahle
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- New World Associates – Dr. Tom Van Doren