

Air Purifying Respiratory Protection during Overhaul: Evaluation of CBRN Canisters and Cartridges

University of Arizona Research
Pathway: Bench-to-Practice

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Legacy of Overhaul Respiratory Protection Research

- pre-2000 to 2013 (ongoing)
- Interdisciplinary Collaboration
 - Over time, the team has included over 17 faculty, students, and industry/public service partners
- Laboratory Infrastructure
 - Smoke chamber, Environmental Chamber, Exposure Manifold
- Controlled Burn, Live Fire Access through partnerships

2000 – Characterization of Firefighter Exposures during Fire Overhaul

Bolstad-Johnson, DM, JL Burgess, CD Crutchfield, S Storment, R Gerkin, and JR Wilson

*Am. Ind. Hyg. Assoc. J.*2000; 61:636-641

Results:

- Respiratory protection rarely used
- Exposures to contaminants particulates, vapors can exceed C and STEL

2001 – Adverse Respiratory Effects following Overhaul in Firefighters

– Burgess, JL, CJ Nanson, DM Bolstad-Johnson, R Gerkin, TA Hysong, RC Lantz, *et al.*

• *J Occup Env. Med.* 2001; 43(5): 467-473

- 25 firefighters - no APR/ 26 with APR (multipurpose cartridges)
- baseline and 1-hr post.
- Concentrations of analytes were generally below levels of prior overhaul study

2001 – Adverse Respiratory Effects following Overhaul in Firefighters

RESULTS

- Forced Vital Capacity (FVC) =
 - Forced Expiratory Volume, 1 sec. (FEV₁) =
- }  wearing APR
- Serum Clara cell protein (CC16) =  both groups
 - Serum Surfactant-Assoc Protein A (SP-A) =  wearing APR

2007 - Method Evaluation in Fire Overhaul Exposures

– Anthony, TR, Joggerst, P, James, L, Burgess, J, Leonard, SS, and Shogren, ES

• *Ann. Occ. Hyg.* 2007; 51(8):703-716

- Lab method development - multi-gas APR **cartridges** (2) and CBRN **canister** (1)
- Combustion of wood and foam
- Evaluated at “Smolder”
- Airflow rates simulated “heavy breathing”

2007 – Method evaluation of APR cartridges in Overhaul

- Concentrations @ field overhaul levels
- 91 analytes (particulates, aldehydes, PAHs, hydrocarbons, methyl isocyanate)



Results

- Cartridge penetration
- Aggregated irritant levels penetrating cartridge exceeded NIOSH REL = 0.1ppm

Results Continued

- Method worked!
- Several analytes **penetrated the cartridge**
 - Aldehydes
 - PAHs
- Cartridge breakthrough fractions for aldehydes:
 - Formaldehyde 3-14%
 - Acetaldehyde 13-57%
- Breakthrough for PAHs ranged up to 100% in preliminary analyses
- Analytes varied (combustion vs smolder)

2009 - The Evaluation of CBRN Canisters for Use by Firefighters during Overhaul

– Currie J, Caseman D, Anthony TR

- Ann Occup Hyg. 2009; 53(5): 523-538.

- Following established methodology
- Combustion of wood and foam
- CBRN **canisters** (4) for 30 min.
- Analytes: aldehydes, PAHs, cyanide, hydrogen chloride, naphthalene, carbon monoxide, nitrogen dioxide, sulfur dioxide

2009 - Evaluation of CBRN Canisters

- Concentrations of contaminants near prior overhaul levels

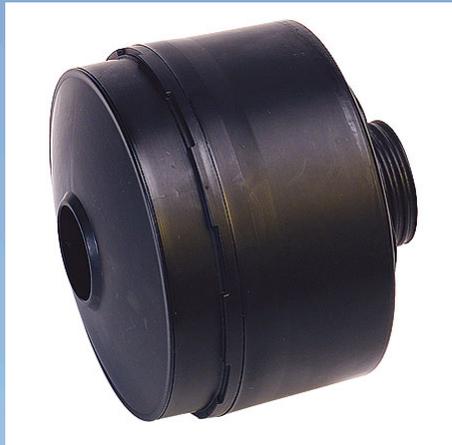
Results

- No chemical or particulates ($.1-10\mu\text{m}$) penetrated **canisters** – **except CO**
- Naphthalene and cyanide were not produced at measurable quantities
- As expected - analytes varied (combustion vs smolder)



Summary - Preliminary indications

- In lab controlled overhaul studies, canisters indicate superior performance to cartridges



- Next step – live fire evaluation.

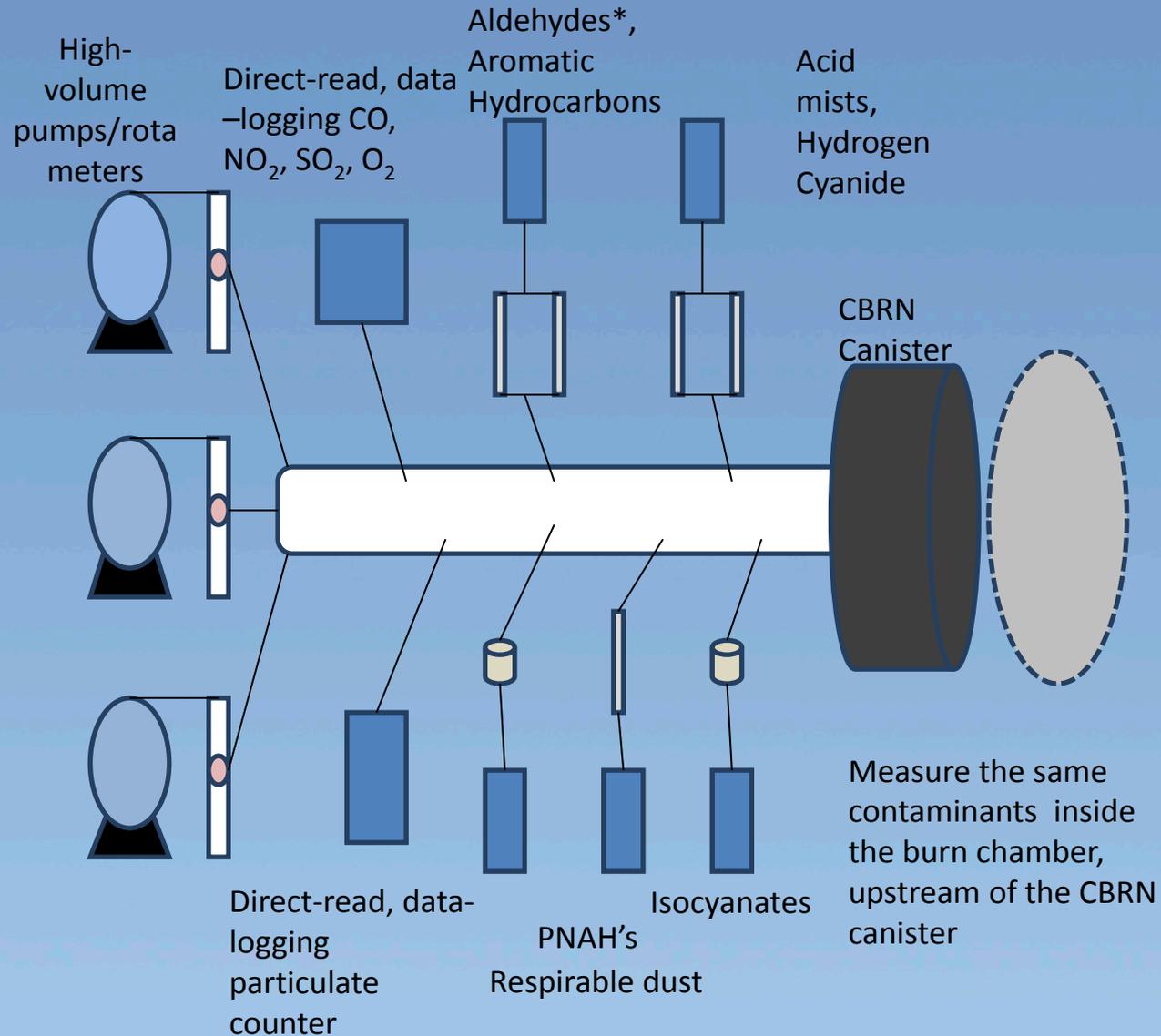
Expanding on Prior Work...

2012/2013 - Assessment of CBRN Canisters during Firefighter Overhaul

- Collaboration with NPPTL – Jay Snyder
- Controlled Live Fire (Northwest Fire, Tucson)
- Combustion of complex mixture of residential materials (mattress, foam cushions, wood, plastics/laminates, textiles)
- CBRN **canisters** (2) and **cartridge** (1) performance and time-to-break through



- Extinguish to smolder and delay until visible smoke is gone
- Challenge Time
 - 0-15,
 - 0-30, &
 - 0-60 min.
- 3 Reps each



* Aldehydes include acetaldehyde, butyraldehyde, formaldehyde, glutaraldehyde, acrolein and isovaleraldehyde



Analytes

- Particle size distribution (5nm-20 μ m)
- Respirable dust
- Isocyanate profile (6)
- PAHs (18)
- Aromatic hydrocarbon profile (10)
- Aldehydes (6)
- Acid mist (6)
- Hydrogen cyanide (integrated sampling)
- Direct read: CO, O₂, SO₂, NO₂

Outcomes

- measured contaminant generation
- temporal contaminant breakthrough
- performance of canisters and cartridge

Deliverables

1. Evaluation of direct-read instrument for predicting breakthrough
2. Recommendations - CBRN canister or cartridge
3. Preliminary estimation of exposure risk while wearing CBRN canisters or cartridges during overhaul

Questions

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