the standard in safety

Characterizing the Products Formed in Furniture Fires

Workshop on Fire Retardants and their Potential Impact on Fire Fighter Health
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Structure Fires

Products of Combustion

$CH_4 + O_2 \rightarrow CO_2 + H_2O + heat$ ⇐ only complete combustion

Smoke

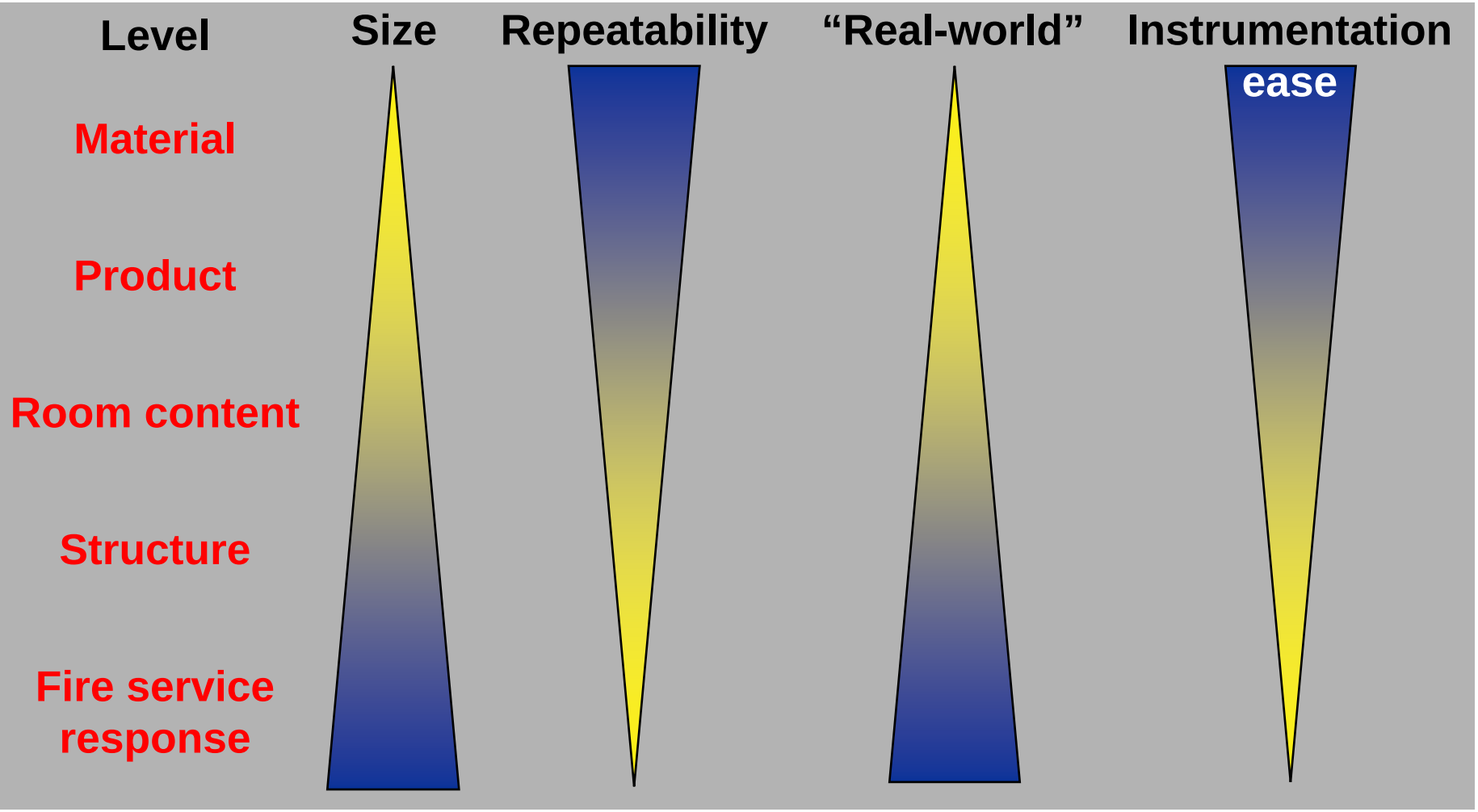
Heat

Vapor

Light

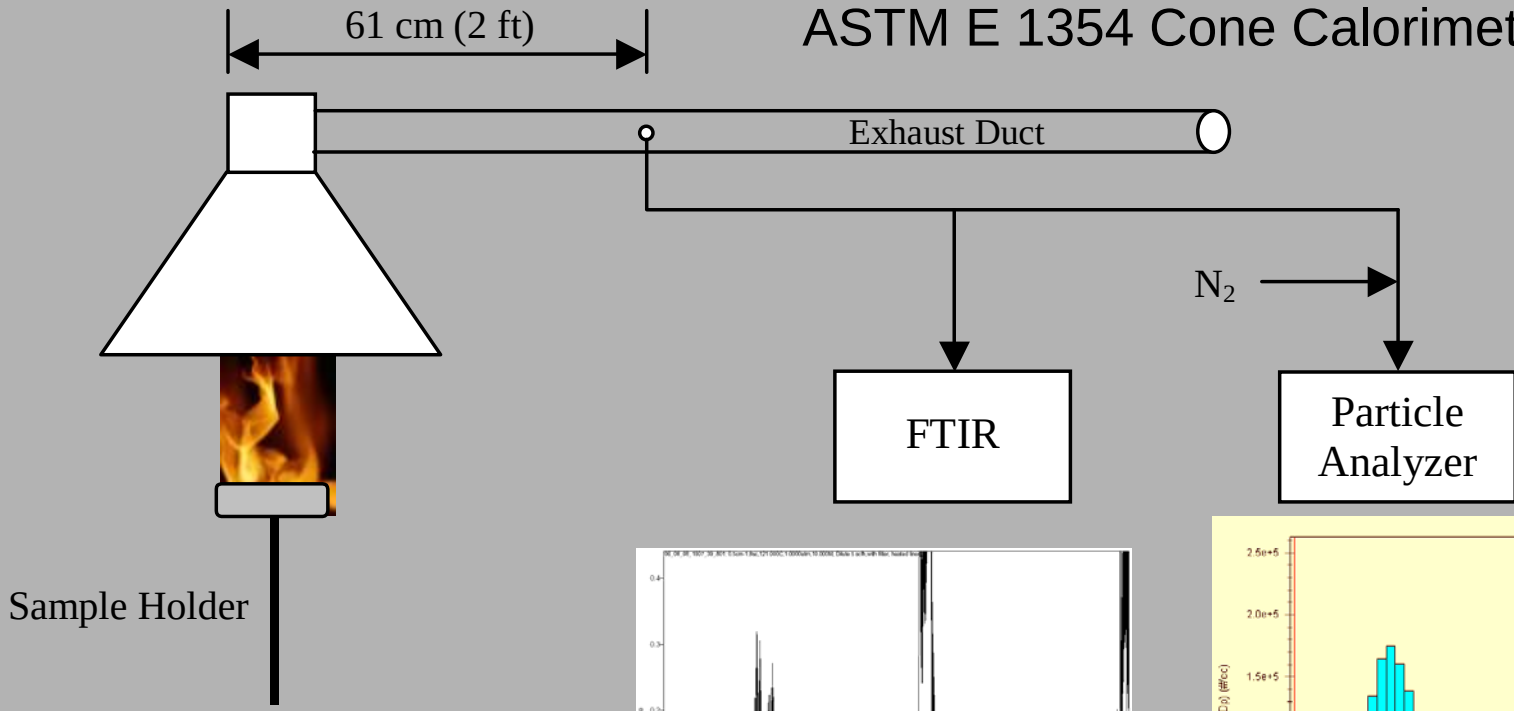
Gas

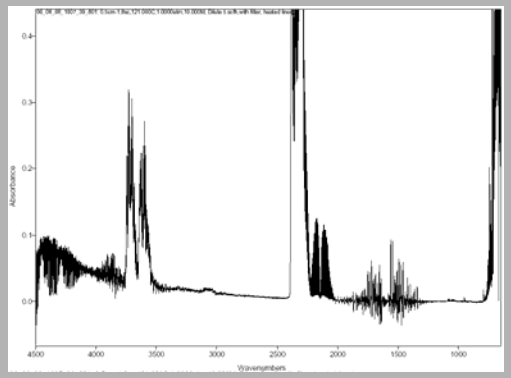
Levels of Combustion Product Investigation

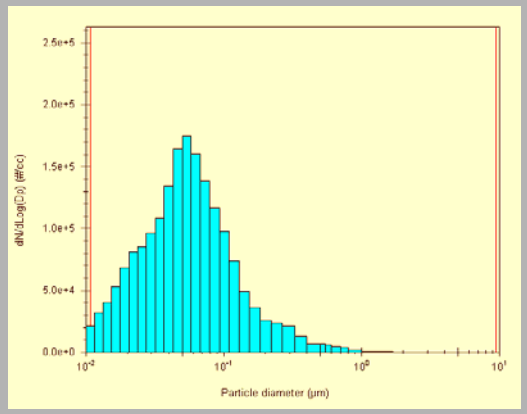


Material-Level Test

ASTM E 1354 Cone Calorimeter based







Gases Beyond H_2O, CO_2, CO

Deck chair pad: Acetic acid, HCN, C_2H_4, CH_4, C_2H_2, HCl

Cabinet: CH_3OH, Phenol, Formaldehyde, HCN, HCl, NH_3, C_2H_4, CH_4, Phenyl isocyanate

Dresser composite: CH_3OH, Phenol, Formaldehyde, HCN, Isocyanic acid

OSB: NH_3, C_2H_4, CH_4, CH_3OH, Phenol, Formaldehyde

Sofa microsuede: 2,4-toluene diisocyanate, CH_3OH, Phenol, HCN, C_2H_4, CH_4, C_2H_2

TV housing: Styrene, HCl, HBr, benzene, CH_4, C_2H_4, v, HCN

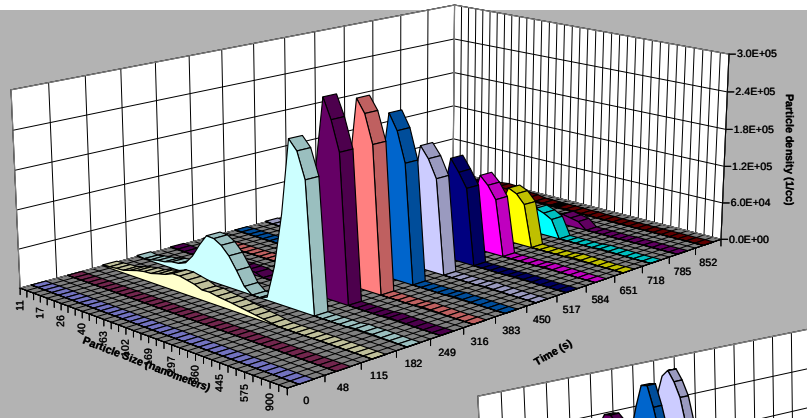
Cotton bed sheet: Formaldehyde, Phenylisocyanate, C_2H_4

Crib mattress: C_2H_4, CH_4, C_2H_2, HCl, HCN

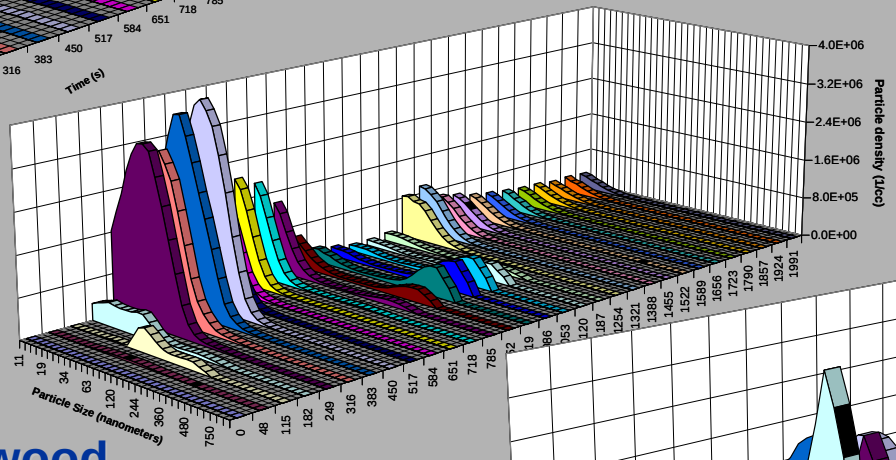
Mattress: C_2H_2, C_2H_4, HCN, Formaldehyde

Material Chemistry Influence on Smoke Particle Size and Count

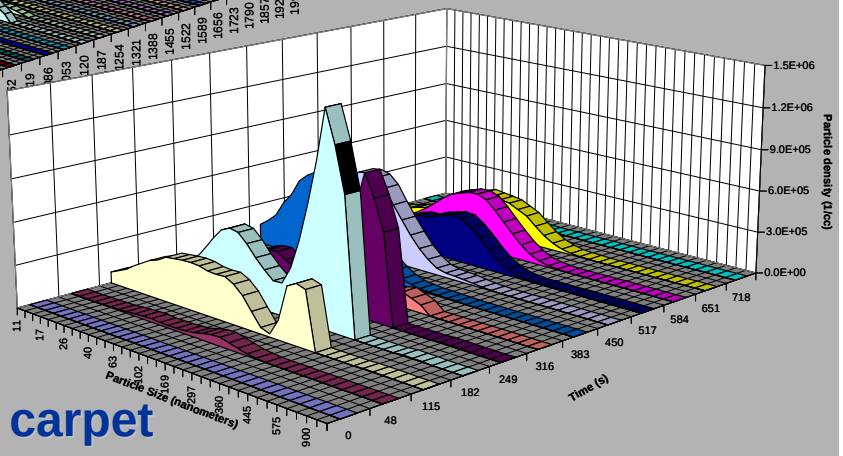
- From UL-FPRF Smoke Characterization Project (2007)



Cooking oil

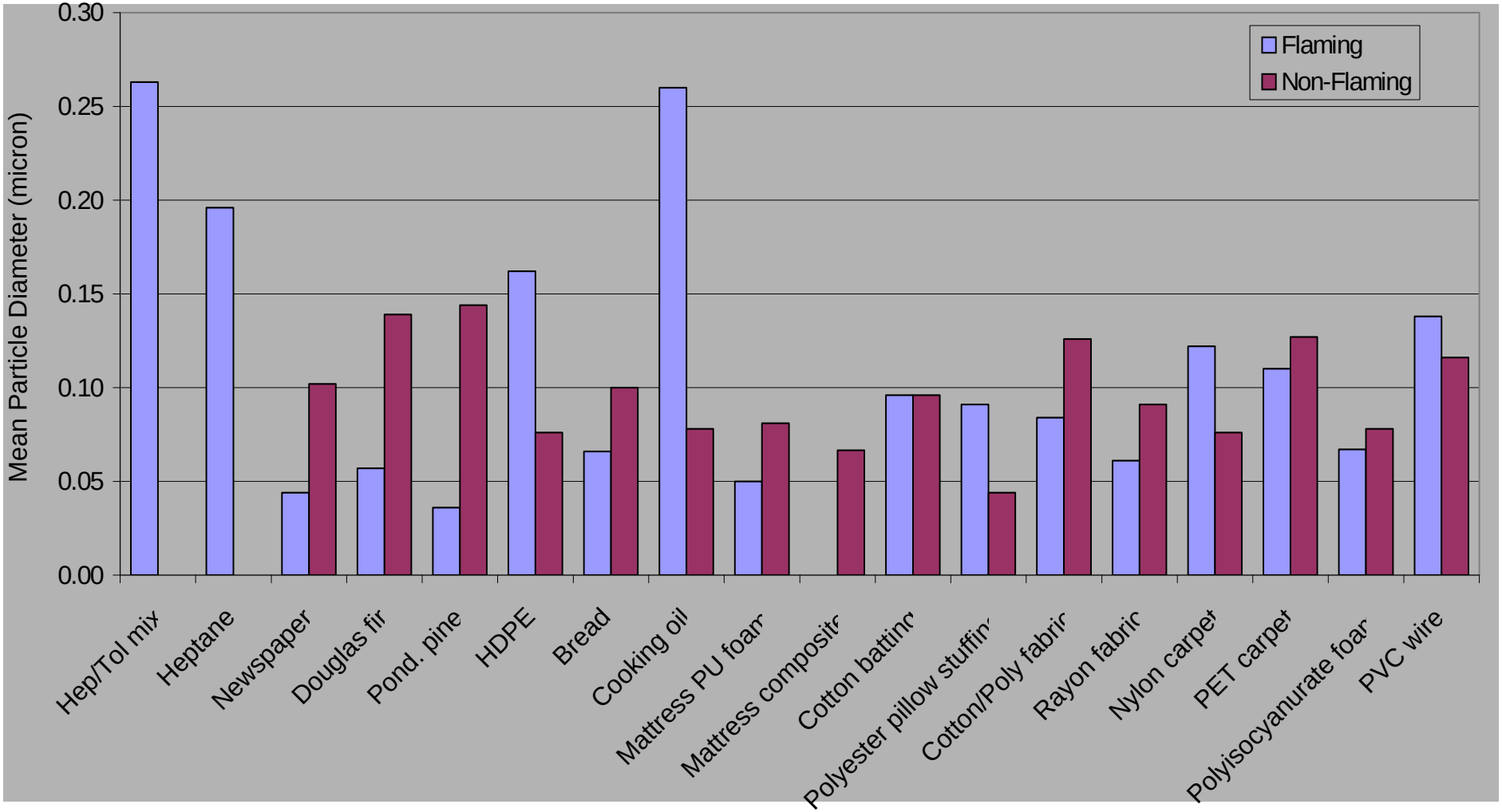


Douglas fir wood



Polyester carpet

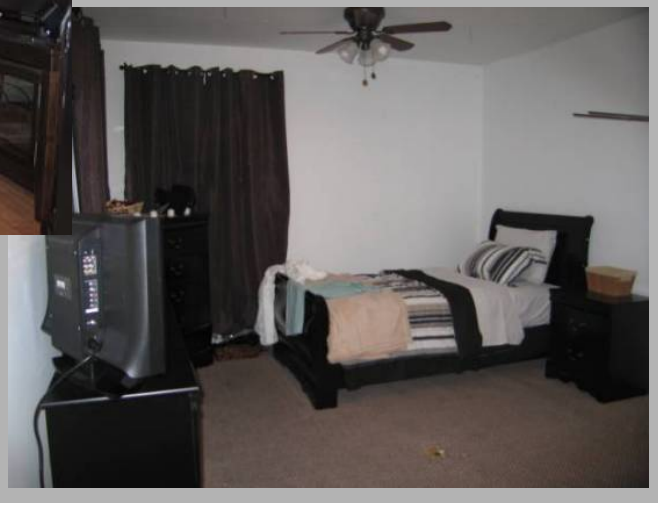
Influence of Combustion Mode: Smoke Particle Size



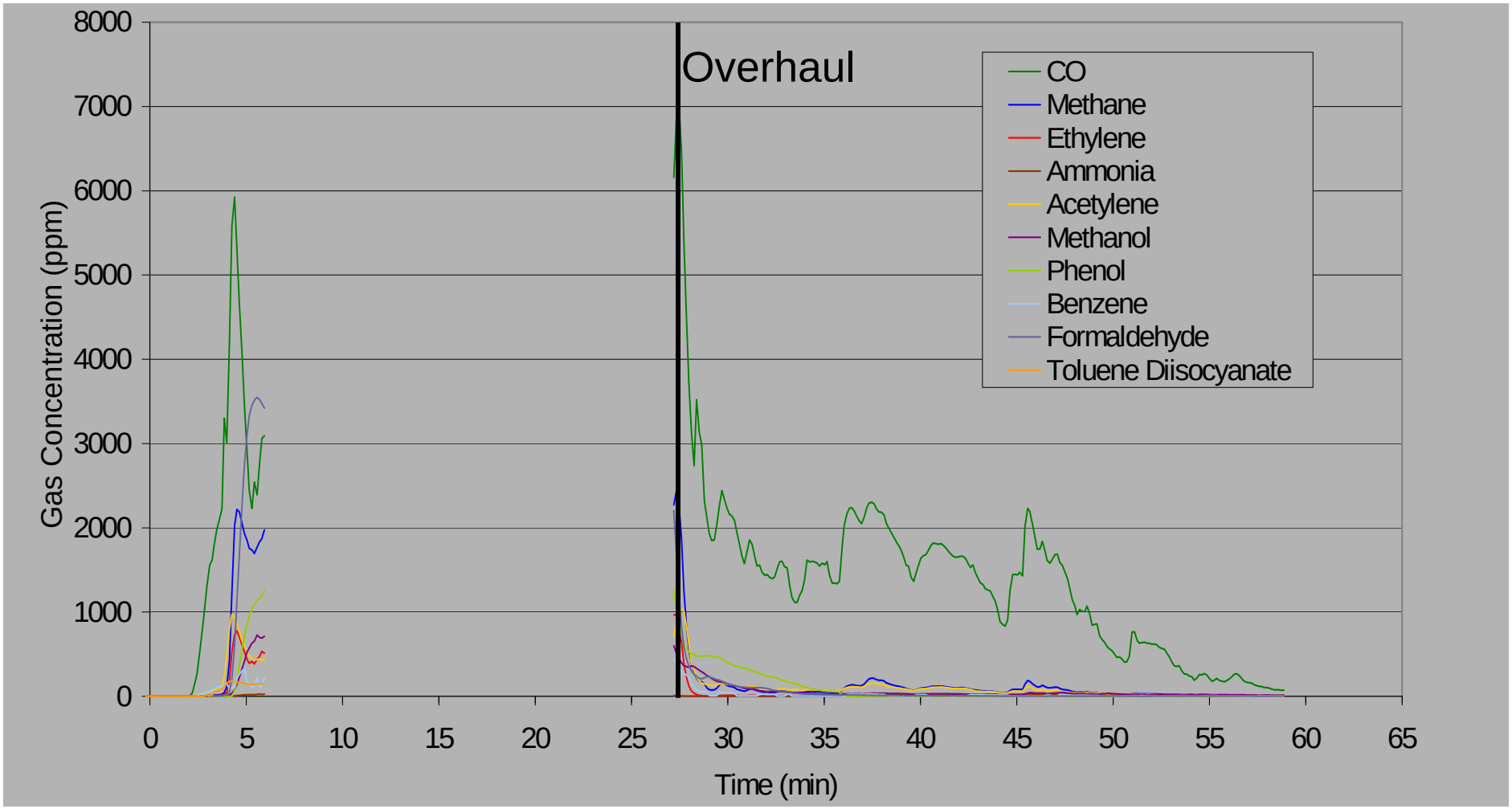
Room Content Test Level

Residential room content fire tests

- 12 ×14 × 8 ft. rooms with a doorway (32”) and a double hung window
- Rooms are furnished with typical residential furnishings and contents



Gas I (Living Room)

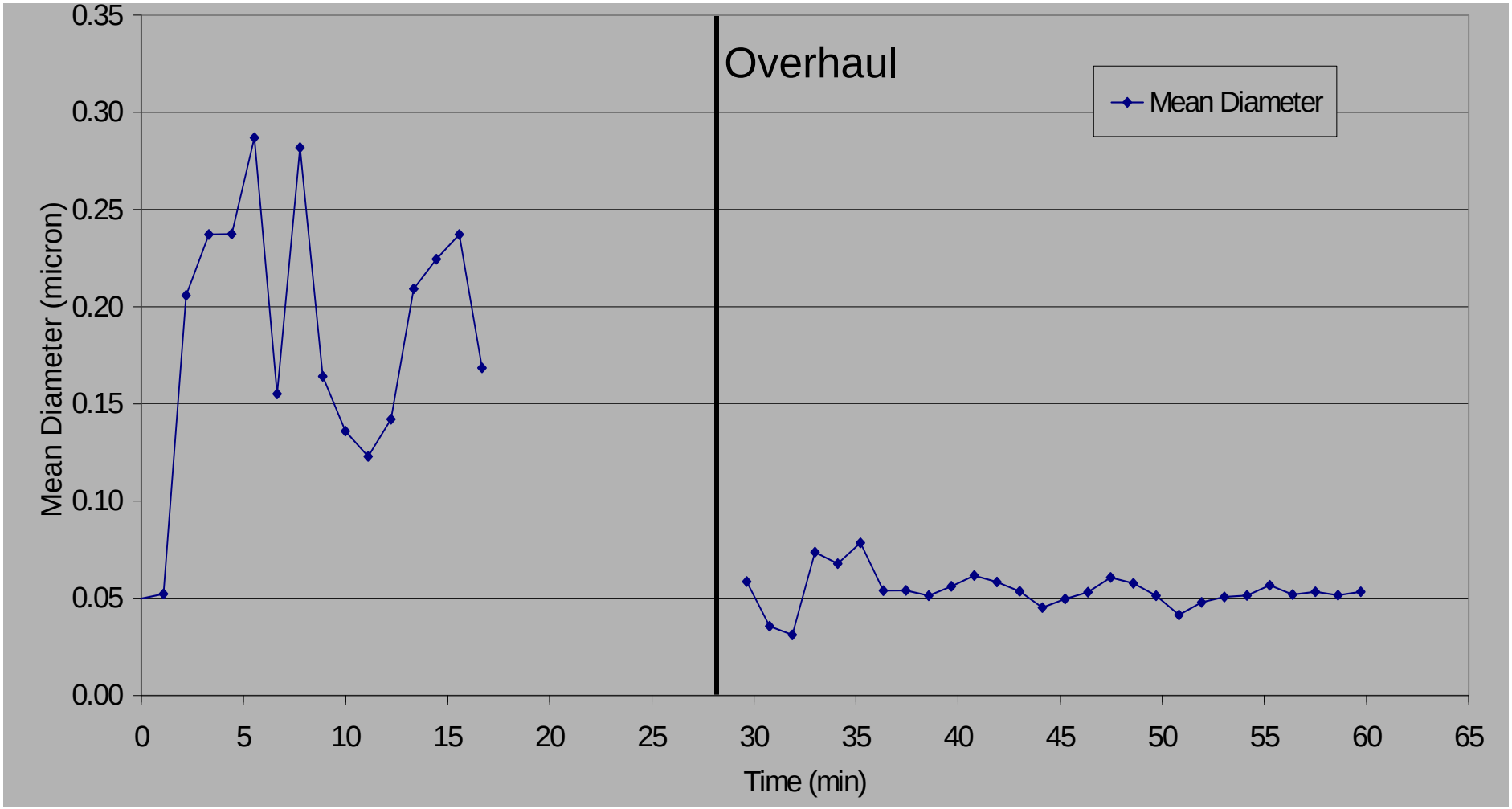


Gas II (Living Room)

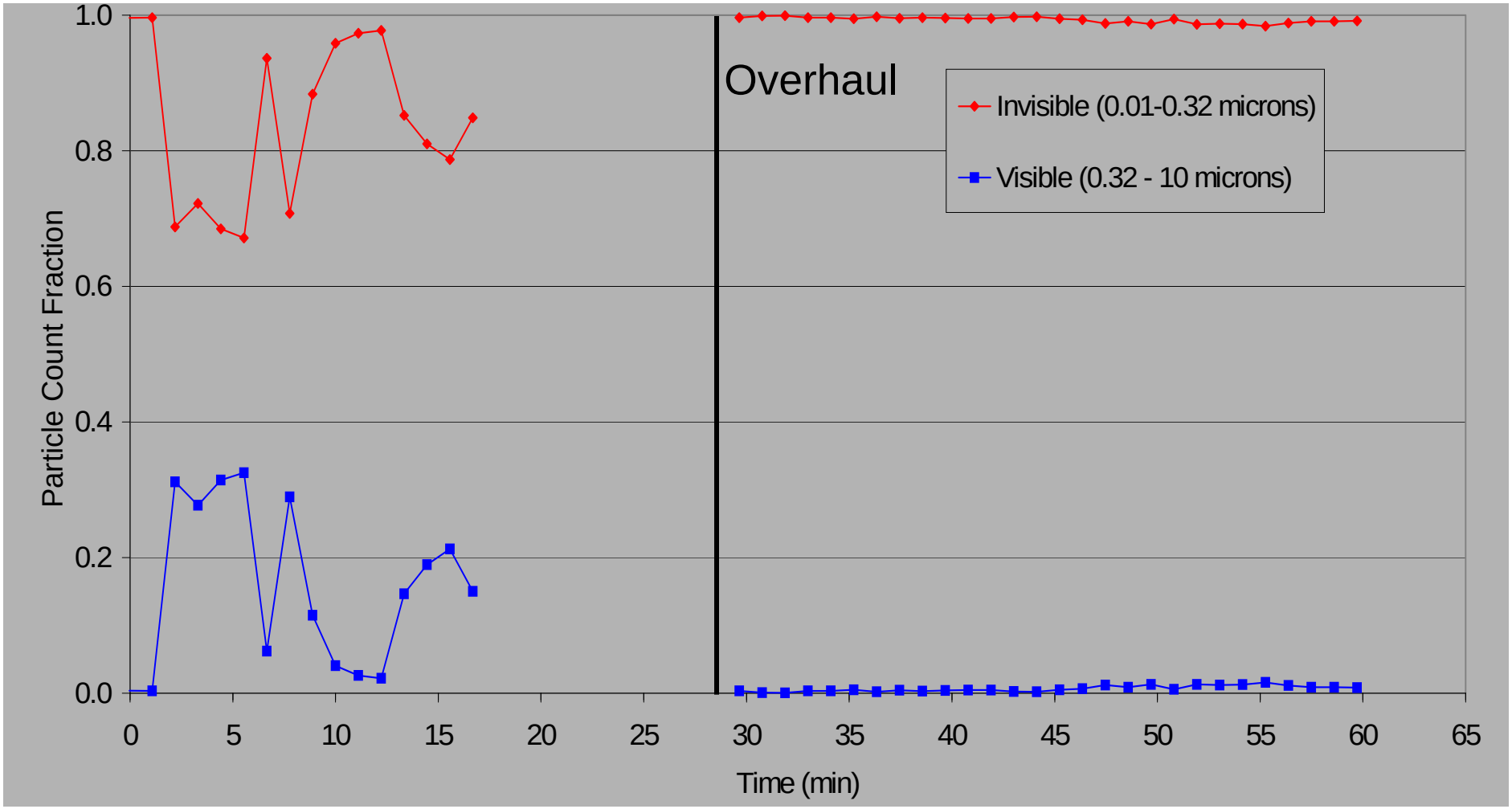
Species detected during overhaul –

- benzene, styrene, formaldehyde
- mercury
- PAHs: acenaphthylene, acenapthene, anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene

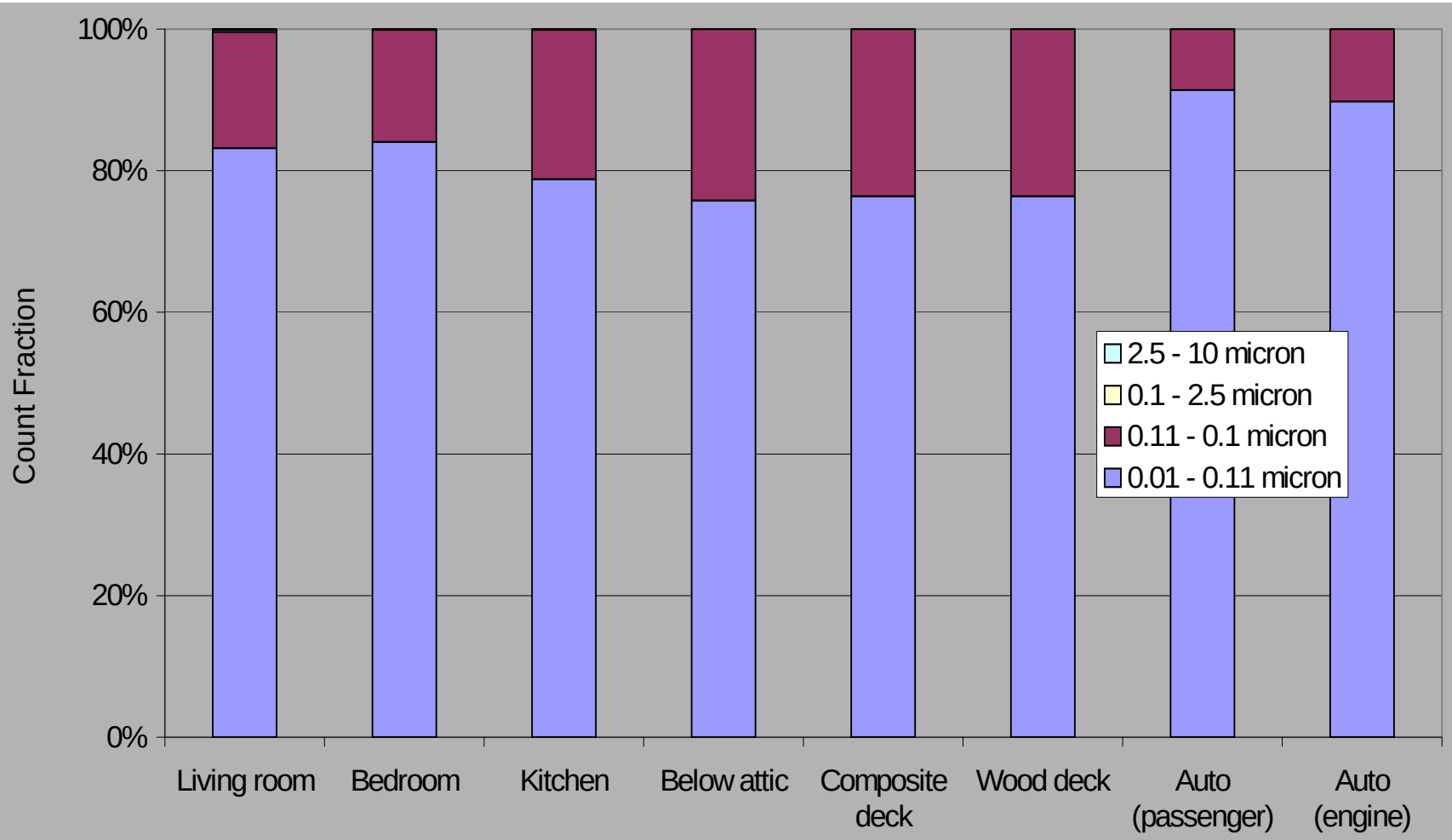
Mean Particle Size (Living Room)



Particle Distribution (Living Room)



Particle Size Distribution During Overhaul

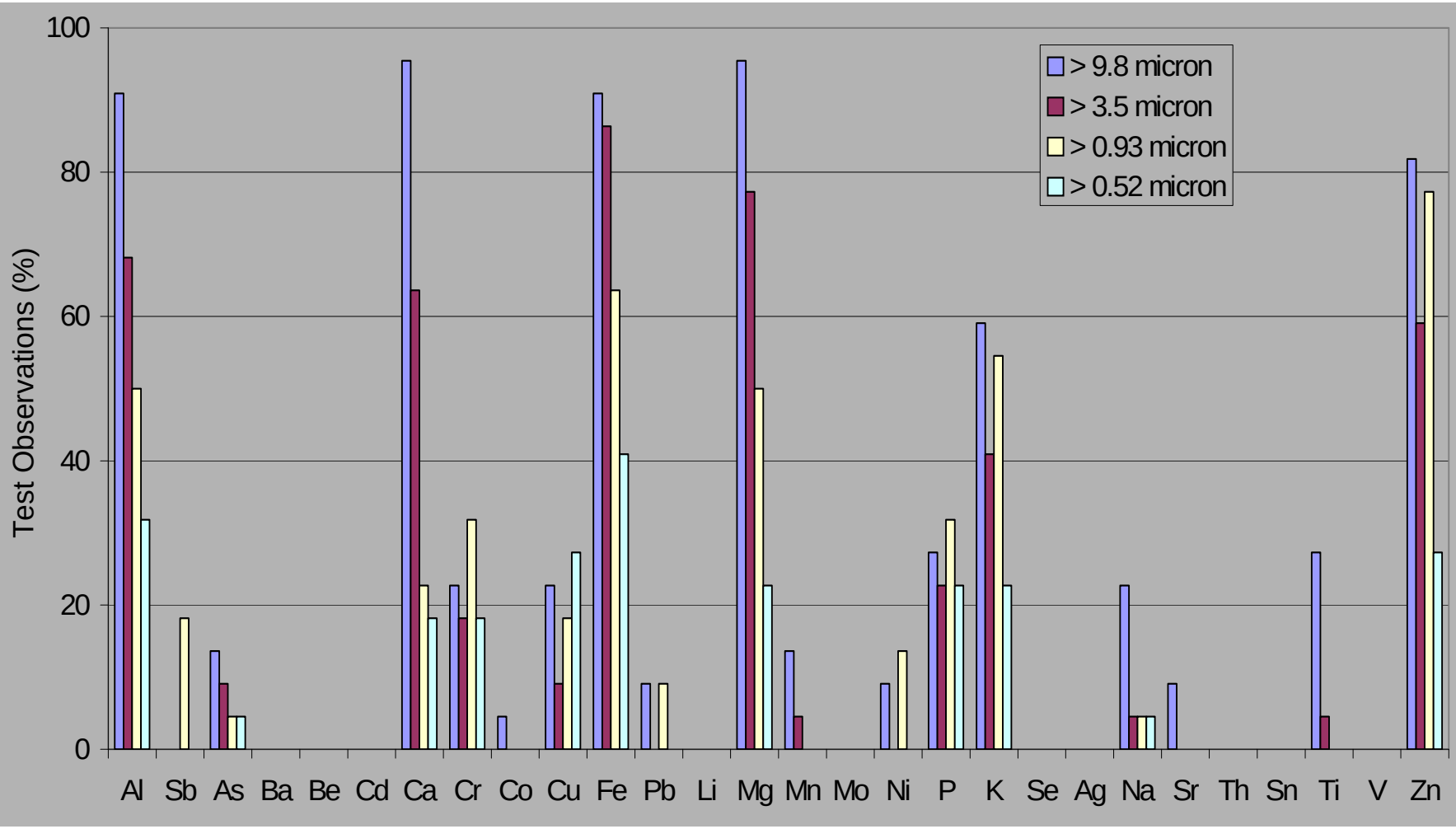


Fire Service Field Response

Personal particle impactor: smoke particle distribution

Gas monitor: CO, HCN, H_2S, NH_3, NO_2, SO_2

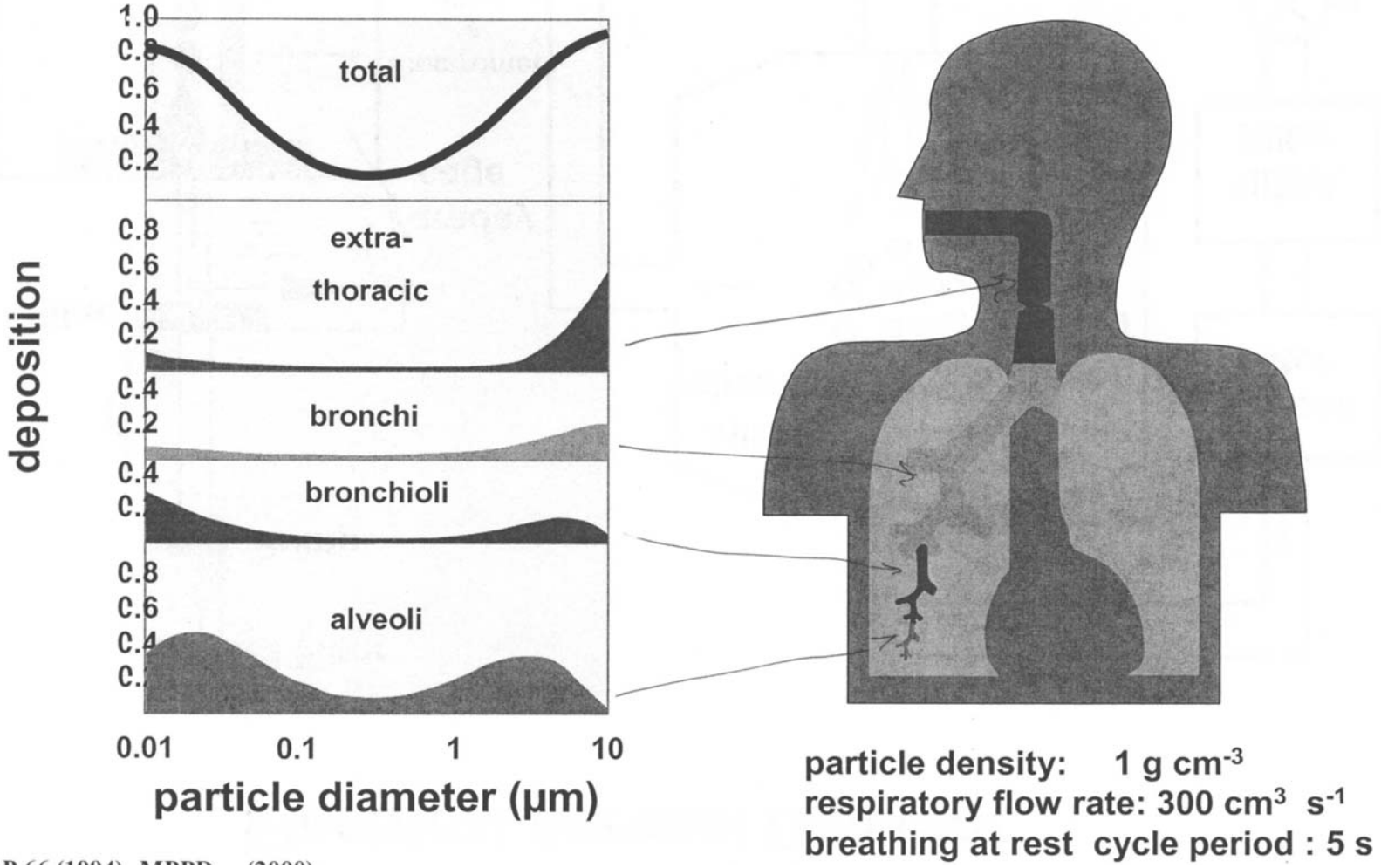
Fire Service Field Response
Inorganic Content of Smoke Aerosol Particles



Risk Factors for Firefighter CHD

- Personal factors
- Physical, heat and psychological stresses
- Extended work shifts
- Simple and chemical asphyxiants: CO_2, C0, HCN, H_2S
- Volatile agents: Benzene, Styrene, Formaldehyde

Particle Deposition



Ultrafine Particulates

Particle diameters less than 100 nanometers.

High potential for delivery of large amounts of reactive adsorbed agents to internal targets due to:

- High surface area to mass ratio.
- Penetration of deep airway compartments,
- Potential translocation from upper and lower airways to internal targets.

Ultrafine particulates in Cardiovascular Disease

UFP are a potential risk factor in cardiovascular morbidity and mortality based on studies on:

- Correlations established between particulate exposure and CHD in urban air.
- CHD impact of exposures in construction workers. *
- CV parameter changes in exposed healthy volunteers.**

* Torén K, Bergdahl IA, Nilsson T, Järvholm B. Occupational exposure to particulate air pollution and mortality due to ischaemic heart disease and cerebrovascular disease. Occup Environ Med. 2007;64:515-9.

** Samet JM, Rappold A, Graff D, Cascio WE, Berntsen JH, Huang YC, Herbst M, Bassett M, Montilla T, Hazucha MJ, Bromberg PA, Devlin RB. Concentrated ambient ultrafine particle exposure induces cardiac changes in young healthy volunteers. Am J Respir Crit Care Med. 2009; 179:1034-42.

** Gong H Jr, Linn WS, Clark KW, Anderson KR, Sioutas C, Alexis NE, Cascio WE, Devlin RB. Exposures of healthy and asthmatic volunteers to concentrated ambient ultrafine particles in Los Angeles. Inhal Toxicol. 2008;20:533-45.

** Zareba W, Couderc JP, Oberdörster G, Chalupa D, Cox C, Huang LS, Peters A, Utell MJ, Frampton MW. ECG parameters and exposure to carbon ultrafine particles in young healthy subjects. Inhal Toxicol. 2009;21:223-33.

Physiologic Responses to Ultrafines

- **Triggering of myocardial ischemia & infarctions.**
- **Endothelial dysfunction.**
- **Arrhythmias.**
- **Pro-coagulant/thrombotic actions.**
- **Chronic genesis of atherosclerosis.**

Preliminary Conclusions

- **Burning materials in model domestic structures result in:**
  - High concentrations of ultrafine particulates.
  - A predominance of ultrafines during overhaul when firefighters do not routinely use respiratory protection.

UFP exposure may therefore be a significant contributing factor for the increased risk of death from CHD in firefighters during fire suppression.

“Characterizing the Products Formed in Furniture Fires”

THANK YOU

UL-FPRF Smoke Characterization Report can be downloaded at –

http:\\www.nfpa.org

DHS Project Report “Firefighter Exposure to Smoke Particulates” will be available mid-December

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