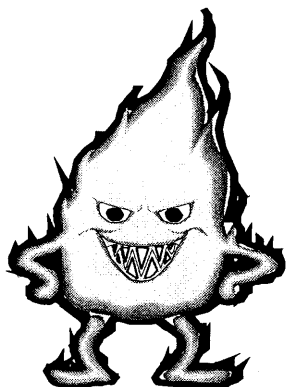


International Study of the Sublethal Effects of Fire Smoke on Survivability and Health (SEFS)



Richard G. Gann, Ph.D.

Senior Research Scientist
Fire Research Division
National Institute of Standards
and Technology (NIST)
rggann@nist.gov

FPRF Fire Risk and Hazard
Research Application Symposium
July 11, 2003

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Today's Outline

- Purpose of SEFS
- Accomplishments under Phases I & IIa
- The Future: Phase IIb, Validation of Bench-scale Apparatus for Generating Toxic Potency Data

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



SEFS Goal

Provide public and commercial decision makers with the best possible guidance for quantifying the effects of smoke on people's survival in fires

- identify the fire scenarios in which the role is substantial
- compile the best toxicological data on heat and smoke, and their effects on escape and survival of people of differing age and physical condition
- develop a validated method to generate product smoke data for fire hazard and risk analysis
- develop guidance for policy makers for using these data correctly in fire safety decisions



National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Impetus

- Inaccurate/inconsistent representations in the marketplace
- Continued difficulty in addressing smoke toxicity in standards and codes
 - Tendency to ascribe toxicity to products, even though other factors in the fire affect toxic smoke yield and exposure more
 - Inadequate measurement methods for and data on the sublethal effects of smoke
 - Inconsistent interpretation of the existing data
 - Lack of consensus on a method for measuring smoke and smoke component yields
 - Unknown relationships between exposures and effects on escape and survival
- Underestimation → not providing intended degree of safety
- Conservative → bias markets, increase construction costs



National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Sublethal Effects

- *Incapacitation (inability to effect one's own escape)*
- Reduced egress speed or choice of a longer egress path due to, e.g.:
 - sensory (eye, lung) irritation
 - heat or radiation injury
 - reduced motor capability
 - visual obscuration
- Post-fire health problems

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Phase I Accomplishments

- Determined potential for generating significant sublethal impacts
- Identified limiting hazard for prime scenarios
- Estimated number of U.S. people receiving smoke exposures
- Estimated share of fatalities affected by sublethal exposures
- Compiled best information available on the lethal and incapacitating potency of smoke under various fire conditions
- Estimated toxic potency of smoke for people
- Compiled information on the generation and transport of smoke
- Reported in NIST Technical Report 1439 (2001)
- To be published in a special issue of *Fire Technology* (2003)

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Phase IIa Objective

- Develop basis for (in)validating bench-scale methods
 - Establish accurate room-scale measurement methodology for obtaining smoke (component) yield data for commercial products
 - Generate a set of reference data
- Co-sponsors: Alliance for the Polyurethane Industry, American Plastics Council, Lamson & Sessions (Carlton), Underwriters Laboratories, Vinyl Institute
- Help from: PolyOne, BASF, Southwire, Schwartzkopf Laboratories

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



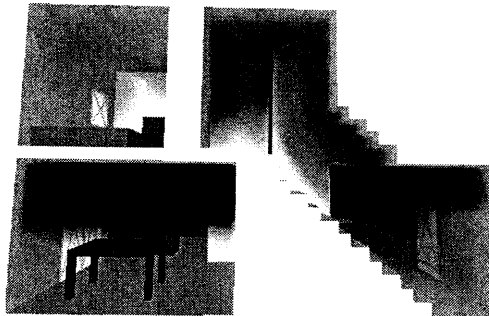
Estimating Life Safety in Fires

- Do **not** use a bench-scale pass/fail test
- Estimate the time people will need to escape or find refuge (= required safe egress time, RSET)
- Estimate the time before people are overcome by heat and/or toxic gases (= time available for escape, ASET)
- If $ASET > RSET$, the building is "safe"
- If $ASET < RSET$, re-design and recalculate

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Modeling the Spread of Fire Effluent



Frame: 210
Time: 42.0 Frame rate: 3.4

- Pick a zone model (e.g., CFAST) or a CFD model (e.g., FDS)
- Insert data for burning of the combustible(s)
- Calculate the spread of heat and smoke

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Estimate ASET

- Pick an egress “path” and walking speed
- Use the smoke movement model results to determine the environment the occupant passes through
- Use the equations in ISO/TS 13571 “Life Threat from Fires: Guidance on the Estimation of Time Available for Escape Using Fire Data” to estimate the time at which the occupant has become incapacitated from:
 - Asphyxiant gases
 - Irritant gases
 - Heat
 - Visual obscuration

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Input Measurements

- The proper measurement is the yield of the combustion product = the mass of the gas generated per mass of the combustible that has burned
- Measure gases in a real- or bench-scale fire test
 - Pre- and post-flashover
 - Many products, few room-scale test facilities
 - Bench-scale device is faster, cheaper
- Let the smoke transport model determine the resulting concentration profile

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Bench-Scale Apparatus Accuracy

- How does one know whether a device produces *accurate* yields of toxic gases?
- Specific combustion conditions, specimen preparation, etc. can affect yields of combustion products
- This is especially true for pyrolysis vapors and partially-oxidized gases
- Only NFPA 269 validated (post-flashover fires)

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Phase IIa Approach

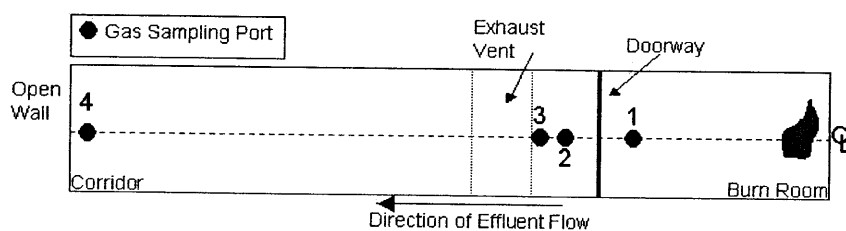
- Conduct a series of room-scale tests of different combustibles
- Measure the yields (per mass of fuel consumed) of the key combustion products contributing to lethal and sublethal effects
 - well ventilated fires
 - ventilation-limited fires
- Indicate the degree of loss of those species away from the fire

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Test Facility



Burn room: 2.44 m x 2.44 m x 3.66 m

Corridor: 2.44 m x 2.44 m x 9.75 m

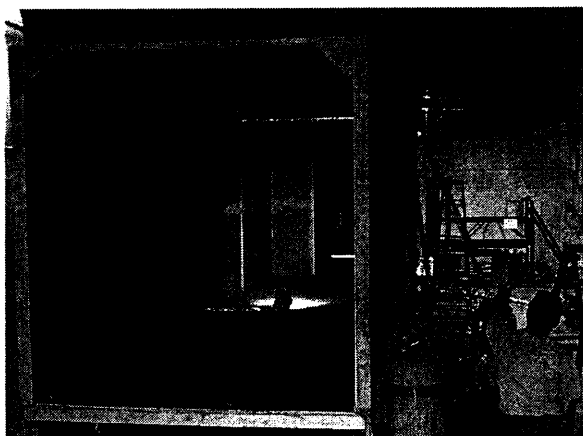
Doorway: 0.76 m x 2.0 m

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Test Facility



NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Fuels

- “Sofas” made of upholstered cushions on a steel frame
 - FPU padding, polyester/cotton fabric
- Bookcases
 - particle board with vinyl laminate finish
- PVC window frame material
 - unplasticized PVC
- NM-B (non-metallic sheath) electric power cable
 - PVC/nylon/paper

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Measurements

- Fuel mass
- Rate of heat release
- Species: CO₂, CO, O₂, HCl, HBr, HCN, HF, HBr, SO₂, acrolein, formaldehyde, nitrogen oxides, particulates
- Doorway flow (pressures, temperatures)
- Video

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Test Series

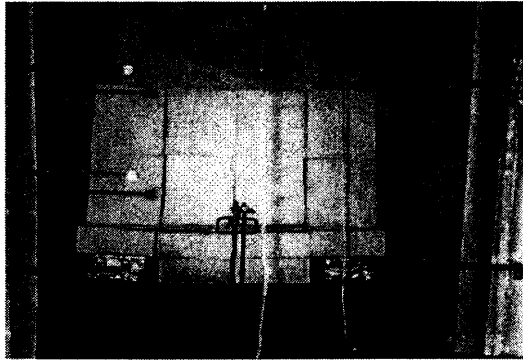
- Each test must have ≈ 2 min of burning before flashover and ≈ 2 min of burning after
 - 5 sofa tests – against back wall
 - 2 sofa tests – door closed
 - 7 bookcase tests – toward back wall
 - 3 bookcase plus PVC sheet tests
 - 4 cable tray tests – against back wall
- Incomplete data for some tests

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



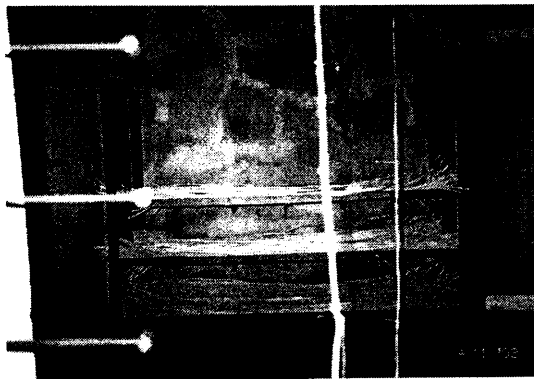
Sofa, Bookcases



NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Bookcase w/PVC Sheet, Cable



NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Nature of Results

- Post-flashover: logical gas yields, uncertainty $\approx \pm 25\%$ to 75%
- Pre-flashover noisier – sampling issues
- CO values low due to secondary burning
- Some irritants (NO_2 , acrolein, formaldehyde) not seen
 - At their detection limits in the sofa and cable tests, their contribution to potency would be small compared to HCl
 - Book case tests: They could matter, but high CO makes the irritant gases secondary in importance

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Phase IIb: Assessing the Accuracy of Bench-Scale Tests

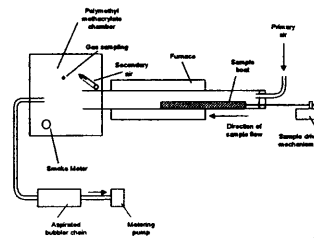
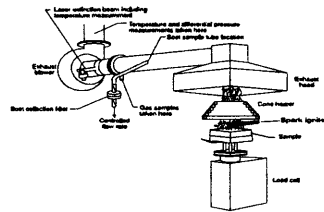
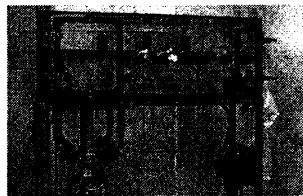
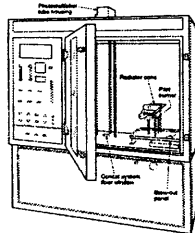
- Identify combustion conditions for that apparatus that replicate a fire stage
 - e.g., well ventilated flaming \rightarrow pre-flashover fire
- Use the same combustibles as in room tests
- Pick proper way to prepare test specimens
- Measure product yields
- Compare results with room test results

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Bench-scale Apparatus



NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Accessing Research Reports

- Go to www.bfrl.nist.gov
- Click on "Fire on the Web"
 - Click on "BFRL Publications Online" for downloads of ≥ 1993 BFRL work
 - Click on "FIREDOC" for a larger search
- Click on "FIREDOC Express" to register for fee-for-service copies from FIREDOC

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Accessing SEFS Ila Report

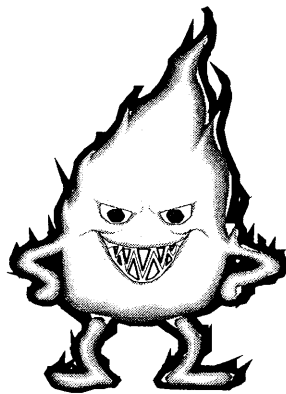
- Go to www.bfrl.nist.gov/866
- Go to "Highlights"
- Go to "NIST and NFPA's second report on the sublethal effects of fire smoke...."
- Click on "Final Report" for a copy in .pdf format

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



International Study of the Sublethal Effects of Fire Smoke on Survivability and Health (SEFS)



Thank you for your
interest

NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

