LOG OF MEETING

DIRECTORATE FOR ENGINEERING SCIENCES

SUBJECT: The Smoke Alarm Research Project

DATE OF MEETING: February 1, 2001

DATE OF LOG ENTRY: February 12, 2001

SOURCE OF LOG ENTRY: Arthur Lee and Margaret Neily, ESME

LOCATION: CPSC headquarters, Room 410 A/B/C

CPSC ATTENDEES: See attached list of attendees.

NON-CPSC ATTENDEES: See attached list of attendees.

SUMMARY OF MEETING: A presentation on the first quarter progress of the Smoke Alarm Project was given by Richard Bukowski, NIST (see attachment). The order of testing in the manufactured home and the site (field) testing was to be swapped. Tests will begin in the manufactured home so that instrumentation and testing procedures can be refined before smoke alarms are tested in field homes. John Hall stressed the need for an analysis plan to be developed prior to testing. This will include making choices of scenarios, test conditions, and contents to be used for the evaluations. Expected concluding statements to be drawn from the test data should be planned in advance (e.g. x time is available for escape for scenario A with sensor/sensor combination 4, given specific tenability criteria and specific location of the victim). Mr. Bukowski mentioned that similar goals and testing/measurement needs exist between the Smoke Alarm Project and the Study of Sublethal Effects of Fire Smoke.

Following Mr. Bukowski's presentation, Richard Gann from NIST gave a presentation on the International Study of Sublethal Effects of Fire Smoke (see attachment). The steering committee members for the Smoke Alarm Project agreed that it could be in the best interest of the Smoke Alarm Project to share resources between both projects. The Sublethal Effects group met on February 2 to consider this option.

A status briefing for the larger group that helped plan the smoke alarm research effort will be scheduled for April.

ATTENDANCE

Smoke Alarm Research Project Steering Committee
February 1, 2001

NAME	COMPANY	PHONE NUMBER
Margaret Neily	CPSC/Engineering	(301) 504-0508, x1293
John Ottoson	US Fire Administration	301-447-1272
Richard Bulowski	NIST	301-975-6853
Bob McCarthy	USFA	301-447-1130
Treye Thomas	CPSC	301-504-0994 x1204
Jim Milke	UMD	301-405-3995
Joseph Su	NRC	613-993-9616
Arthur Lee	CPSC	301-504-0508 x1393
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Isaac Papier	UL	847-272-8800 x42686
Patsy Semple	ComG/CPSC	301-504-0530
John Hall	NFPA	617-984-7460
Pam Weller	Moore/CPSC	301-504-0290
Richard Gann	BFRL/NIST	301-975-6866
Paul Patty	UL	847-272-8800 x42752

Home Smoke Alarm Tests
Steering Committee Briefing
February 1, 2001

Richard W. Bukowski, P.E., FSFPE
NIST Building and Fire Research Lab
Gaithersburg, MD 20899 USA

Project Status (1)

- Start date October 1, 2000
- Year 1 funding of $500k in hand
- First quarterly report delivered
- Work is (mostly) on schedule and on budget
- Four tasks scheduled for first quarter
  - Acquire and characterize test articles
  - Identify test sites
  - Plan for long term site at NIST
  - Develop test scenarios

Acquire and Characterize Test Articles

- Agreement with industry to supply analog samples – 12 each ion, CO, and photo
- 2 sets of ion and one CO received and evaluated in the FE/DE
- Remaining ion and another photo to be delivered next week
- Photos especially presented a significant engineering challenge
- Mechanical heat detectors
- Sprinkler Industry participation

Characterization Procedure

- Calibration with flaming and smoldering smoke against obscuration beam and MIC
- Sufficient replicates to allow repeatability and activation uncertainty to be quantified

Identify Test Sites

- North Carolina (150 homes)
- Atlanta (backup)
- Site visit in February
- Local fire department looking for best candidates

- 1 floor, split, and 1 story
- 1200 sq ft (or 800 per floor)
- Reasonable shape with utilities

Long Term Site at NIST

- Procurement of 3 bedroom Fleetwood home
  - Manufactured home
  - Apartment/condo
- Delivery expected in February
- Testing crew prefers starting here to allow shakeout "at home"
- Could begin tests in March or April

Develop Test Scenarios

- John Hall analysis presented at 11/22/99 Planning Meeting
- Use to determine ignition source and first item ignited
- Spread to nearby objects
- Continue until tenability limits are exceeded
- Flashover tests
- Sprinkler effects

Collaboration with Sublethal Toxicity Project

- Compatible objectives and parallel plan
- No identified compromises for either project
- Additional resources to address flashover effects and replicates
- No money from CPSC regulated industries
- Gann presentation

INTERNATIONAL STUDY OF SUBLETHAL EFFECTS OF FIRE SMOKE ON SURVIVABILITY AND HEALTH (SEFS)

Richard G. Gann, Ph.D.
Project Leader

Residential Smoke Alarm Tests Committee Meeting
February 1, 2001

Today's Outline

- Purpose of SEFS
- Accomplishments under Phase I
- Next SEFS Task: Measurement Methodology for Yields of Smoke Components

INTERNATIONAL STUDY OF SUBLETHAL EFFECTS OF FIRE SMOKE ON SURVIVABILITY AND HEALTH

Purpose of SEFS

Impetus

- Inaccurate/inconsistent representations in the marketplace
- Continued difficulty in addressing smoke toxicity in standards and codes
  - Have dealt with this for 30 years - no closure yet
  - Continuing product liability
  - Lethality addressed in NFPA 269, ASTM E1678
  - ISO has taken up the cause in a potentially damaging way
  - Sublethal effects formalized in ISO draft 13571
  - Potential in ASTM, Int'l Building Code, Life Safety Code
- Underestimation → not providing intended degree of safety
- Conservative → bias markets, increase construction costs

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

FPRF/NIST Project

- 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
- Began May, 2000

Sponsors

SPI
SPI Fluoropolymers
Vinyl Institute
Polyurethanes Performance Council
DuPont
Lamson & Sessions
Solvay
NIST
U.S. Access Board
Swiss Institute of Safety and Security
NASA

INTERNATIONAL STUDY OF SUBLETHAL EFFECTS OF FIRE SMOKE ON SURVIVABILITY AND HEALTH

Accomplishments

Demographics

- Estimated number of U.S. people receiving smoke exposures
  - 310,000 - 670,000 exposed in homes annually
  - cf. 3300 deaths and 11,500 injuries from smoke, in whole or in part
  - Ratio is large most likely because most exposures are to dilute smoke
- Estimated half of the deaths and two-thirds of the injuries are affected by sublethal exposures

Toxic Potency Data

- Compiled best information available on the lethal and incapacitating potency of smoke generated from materials and products
  - Data on *gases* to be done later
  - Generic LC_{50} value: 32 ±18 g/m^3 (rats, 30-minute exposure)
  - $IC_{50}/LC_{50} = 0.50 \pm 0.17$
- Estimate toxic potency of smoke for people
  - IC_{sens} (people) ≈ 1/3 LC_{50} (rats)
  - Scaling with exposure time: C^2t = constant
  - Generic value for incapacitation of smoke-sensitive people in 15 minutes: $IC_{sens} \approx 15$ g/m^3; uncertainty ≈ factor of 3

Hazardous Fire Scenarios

- Used HAZARD I to identify limiting hazard for prime scenarios
  - 0.5 • lethal (incapacitation)
  - 0.01 • lethal (conservative limit for no effect on escape)
- Post-flashover fires: potential for sublethal exposure given
- Pre-flashover fires
  - in buildings with large rooms, smoke threshold occurs after incapacitation from heat
  - in other buildings, near the fire, incapacitation from heat is first; remote from the fire, the exposure threshold can be first
  - in small occupancies, incapacitation from inhalation is not of prime concern unless the person is and remains intimate to the fire

Generation and Transport of Smoke

- Most smoke aerosol is respirable (diameter ≤ 3 μm)
- Wall loss of aerosol is only < 10 % - 30 % over 10-30 min
- Gas losses are likely < 25 % for fires of importance (>200 kW)
- Water droplets (d ≤ 3 μm) are ≈ 65 times as effective as soot at transporting HCl deep into lungs
  - not as important for escape as gas inhalation

INTERNATIONAL STUDY OF SUBLETHAL EFFECTS OF FIRE SMOKE ON SURVIVABILITY AND HEALTH

Next SEFS Task:

Measurement Methodology
for
Yields of Smoke Components

Motivation

- Smoke toxicity provisions in codes will be determined by:
  - the chosen effects on people to be mitigated
  - the formalism used to represent those effects
  - the exposure constants for toxicants in that formalism
  - the measurement method used to generate toxicant yields for commercial products
  - equations for any losses of the toxicants
- The fourth bullet can overwhelm the others
  - NFPA 269/ASTM E1678 can be used to generate product data for estimating lethal exposures to smoke
  - For sublethal effects, no *valid* device exists

Objective

- Establish accurate reduced-scale measurement methodology for obtaining smoke (component) yield data for commercial products
- Generate a set of reference data

Approach

- Perform a series of real-scale, multi-room fire tests
  - examine finished products
  - vary fuel and ventilation conditions, fuel location
  - follow fire from small to ventilation-limited
  - assess repeatability
- Combust same products in bench-scale apparatus
- Opportunity to combine with project on residential smoke alarm testing
  - similar multi-room test facility and fuels
  - common measurements

Bench-scale Tests: Radiant Furnace

- NFPA 269/ASTM E1678
  - sample size ~ 75 x 125 mm; in-use exposure
  - Q_{max} ~ 50 kW/m^2)
  - Vary oxygen (possible)
- Measure gases *in situ*
- No animals
- Triplicate tests

Bench-scale Tests: Tube Furnace

- Purser version
  - flow tube: 1 m long, 50 mm in diameter
  - cylindrical furnace: 0.5 m long, > 50 mm in diameter; T_{max} ~ 650 °C (Q_{rad} ~ 40 kW/m^2)
  - Semi-cylindrical sample boat: 0.4 m long, 25 mm in diameter
- Vary sample preparation (strips, chunks, etc.)
- Vary air flow
- Measure gases at downstream exit
- Triplicate tests

Outcome

- Validated method for obtaining toxic species yields from burning products
  - known accuracy

  - comparison of species yields
  - effect of test conditions on yields
- Relative times to potential escape/survival effects and initiation of safety measures
  - provides information on differences in toxic potency that matter