NISTIR 6890

Fire Resistance Determination and Performance Prediction Research Needs Workshop: Proceedings

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

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Building and Fire Research Laboratory

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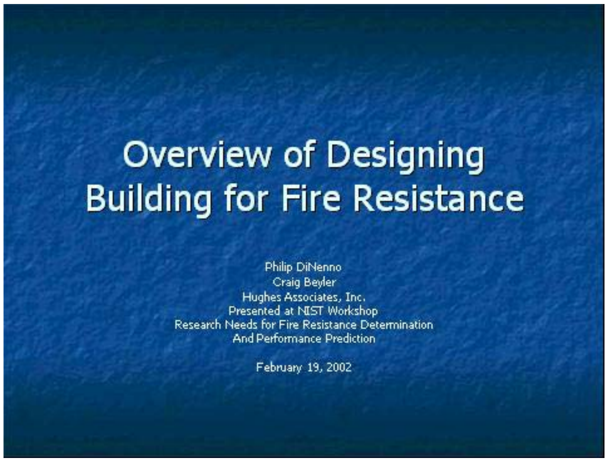
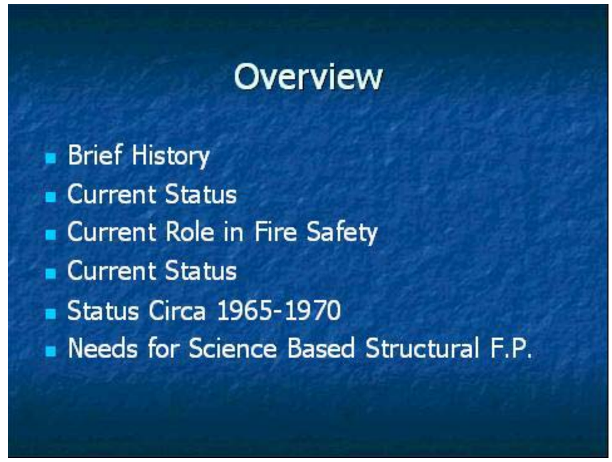
U.S. Department of Commerce
Donald L. Evans, Secretary

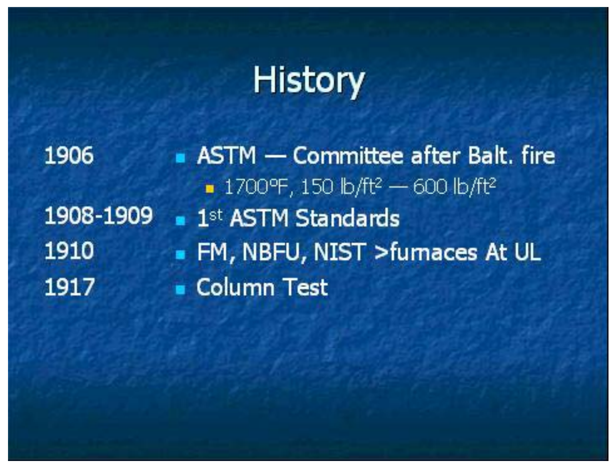
Technology Administration
Phillip J. Bond, Under Secretary of Commerce for Technology

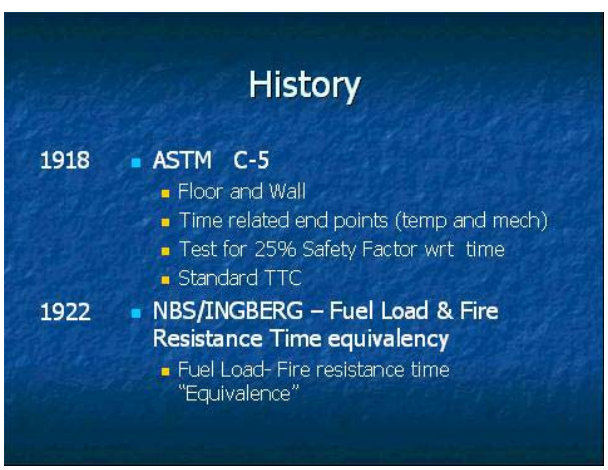
National Institute of Standards and Technology
Arden L. Bement, Jr., Director

C. Overview of Designing Buildings for Fire Resistance
Craig Beyler and Philip DiNenno
Hughes Associates, Baltimore, MD







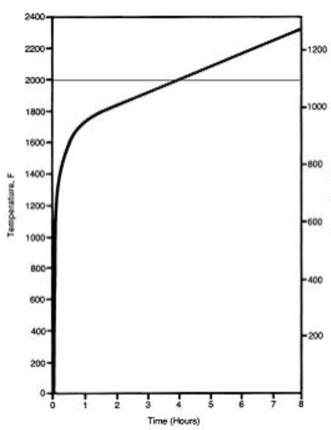


Current Status

- Fire Resistance Requirement
- Established by building code – function of
  - Occupancy
  - Height/area
  - Sprinkler protection
- Testing per UL, NFPA, ASTM
- Listing by UL/FM et al
- Find requirement in hours
- Look it up in a listing book
- Spec it
- Maybe Inspect it

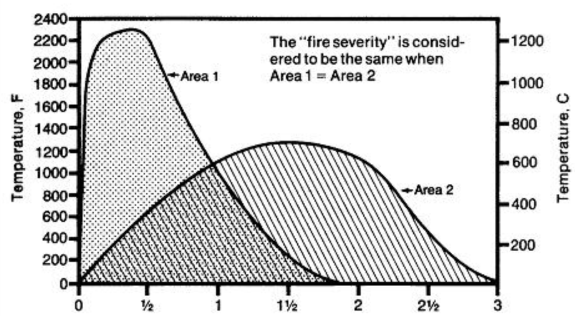
Current

- Fire Exposure:
  - Standard Time Temp Cure (circa 1920) in furnace
- Thermal Response
  - Temperature Measurement from Sample
- Mechanical
  - If loaded, can't open or collapse
  - No current limit on deflection
  - No connections
- Physical Properties
  - Adhesion, cohesion
  - No vibration,impact,hardness,shock,impact,blast etc testing
- Reliability
  - Unknown and variable
  - Implicitly treated though listing/approval
- In-Situ Testing
  - Done in small % of cases
  - Usually when problem is obvious



Time-temperature Curve From "Standard Methods Of Fire Tests Of Building Construction And Materials (ASTM E119-80)

The "Fire Severity" Concept

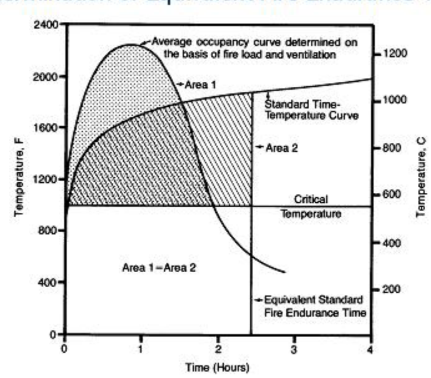


Relationship Between Fire Load and Fire Endurance

Average Fire Load psf*	kg/m²	Equivalent Fire Endurance (hours)
5	24.4	½
7½	36.6	¾
10	48.8	1
15	73.2	1½
20	97.6	2
30	146.5	3
40	195.3	4½
50	244.1	6
60	292.9	7½

* Determined on the basis of a potential heat of approximately 8000 Btu's per pound

Determination of Equivalent Fire Endurance Time

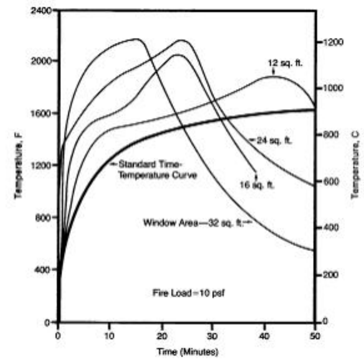



South
R4429-1
South
R4429-1
R4188-1
R4188-1

Materials/Systems Currently Used

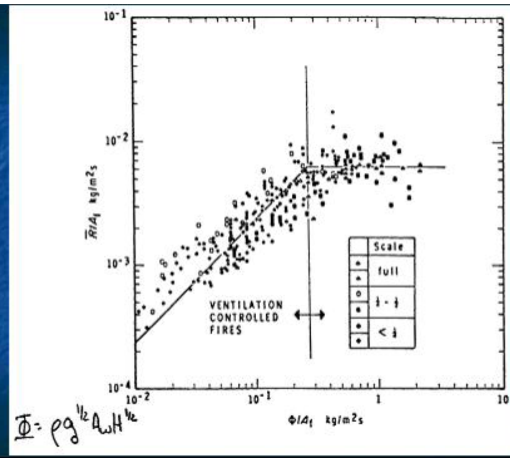
- Sprayed Fiber
- Cementitious
- Mastic
- Intumescent Paint
- Membrane
  - Suspended ceilings
  - Drywall assemblies
- Concrete encasement
- Tile
- Plaster/lath

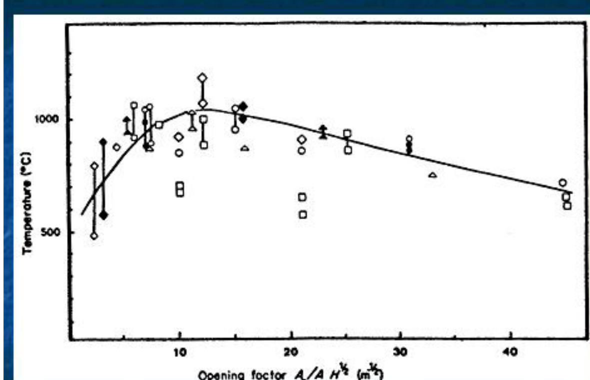
Effect of Window Area on Fire Temperatures During Burnout Tests with Natural Ventilation

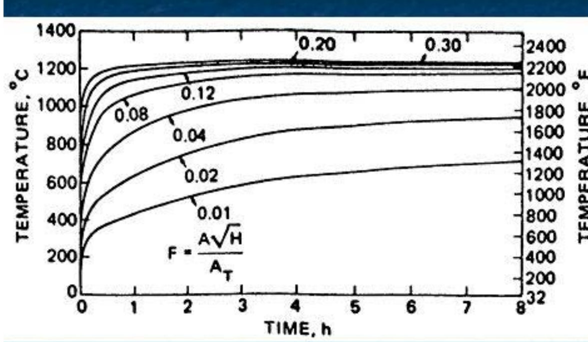


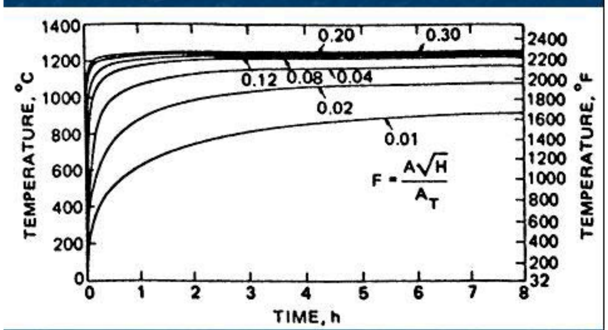
State of Art (circa 1965–1975)

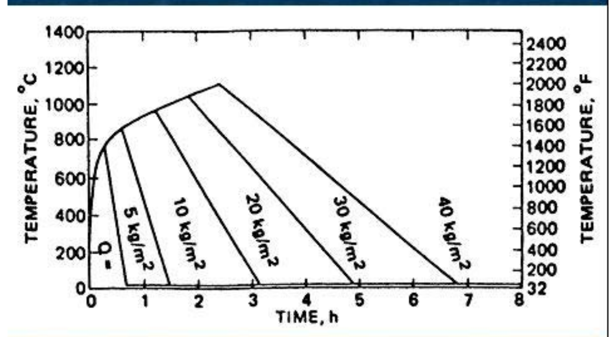
- **Fire Exposure**
  - Design exposure curves
  - Post-flashover
  - Ventilation controlled
  - Insulation properties of wall linings
- **Thermal Response**
  - Critical temperature
    - Columns, beams
    - 1-D analytical
    - 2-D finite differences schemes











State of Art (circa 1965–1975)

- Mechanical Response
  - Column buckling
  - Beam deflection
  - Truss deflection
- Physical properties
  - Transport & Mechanical properties as a F (T)

Question: Capability for 30-35 years...integrated into design guides and never utilized in US regulations

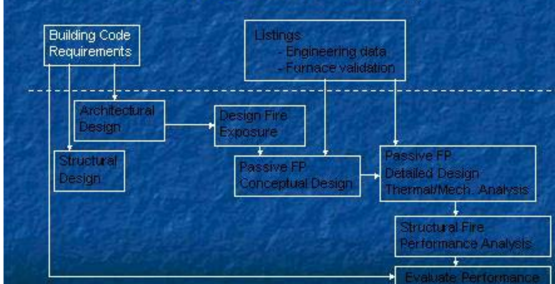
1975-1980

- 3-D Finite Element Heat Transfer Model
- Structural Response Model (FASBUS)
- Model of Post Flashover Fires (COMPF)

Needs for Science-Based Structural Fire Protection Design

- Design fire exposure
- Thermal/Mechanical Response of Insulation Systems
- Structural Performance in Fire
- Test methods
- Performance Criteria
- Technology Transfer

Science-Based Structural Fire Protection Design



Design Fire Exposure

- Modern fire load survey data
- Combined local/global fire exposure characterization, i.e. beyond well stirred

Thermal/Mechanical Response of Insulation Systems

- Institutionalized thermal properties test methods
- Test methods and performance criteria for mechanical response; non-fire, impact loading, fire exposure
- Fire barrier performance- must address along with structural frame performance

Structural Performance in Fire

- Assess needs for full structural frame analysis vs more detailed local deformation analysis
- Assessment of connection performance

Test Methods

- Need full compliment of test methods for engineering properties
- Revisit furnace testing methods:
  -exposure should be severe (1709)
  -test should be a validation of engineering methods
  -revisit the relationship between the test and real structural frames

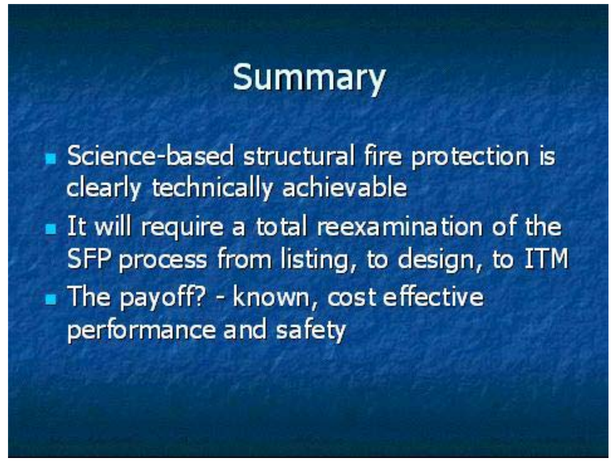
Performance Criteria

- What are we trying to achieve?
- Acceptable local performance
- Acceptable global performance
- Risk, reliability, and relationship to the total fire protection design
- Inspection, Testing, and Maintenance (ITM)

Technology Transfer "The Real Problem"

- Develop a broad consensus for the need to change how we do SFP
- Codify SFP design practice
- Formulate building code requirements
- Educate engineers, architects, AHJ's


Needs for Science-Based Structural Fire Protection Design
Design fire exposure
Thermal/Mechanical Response of Insulation Systems
Structural Performance in Fire
Test methods
Performance Criteria
Technology Transfer


Summary
Science-based structural fire protection is clearly technically achievable
It will require a total reexamination of the SFP process from listing, to design, to ITM
The payoff? - known, cost effective performance and safety