

Fire Protection Engineering Twenty Years of Progress

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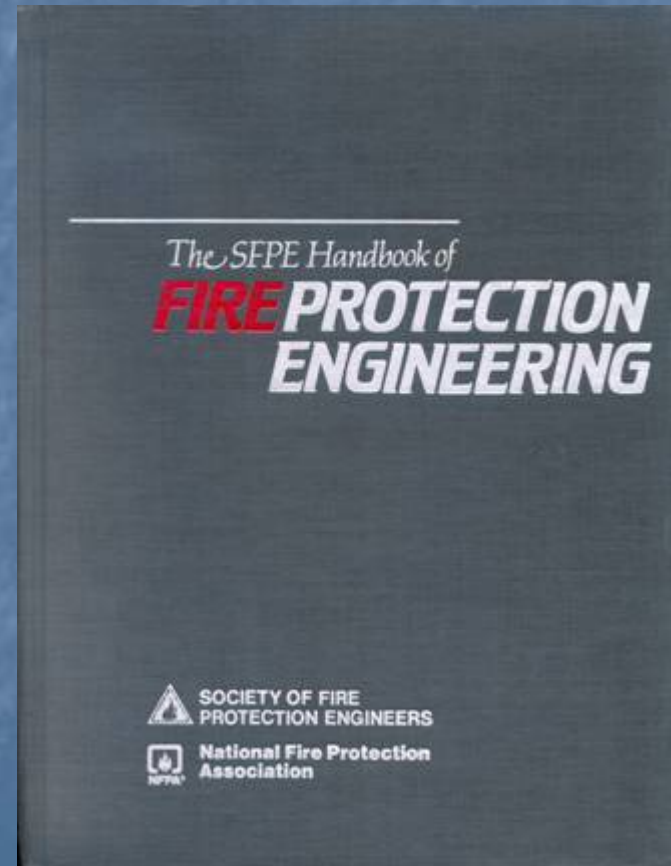
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Outline

- Background/Purpose of SFPE Handbook
- Changes in Fire Science/Technology
- Changes in Practice
- Going Forward

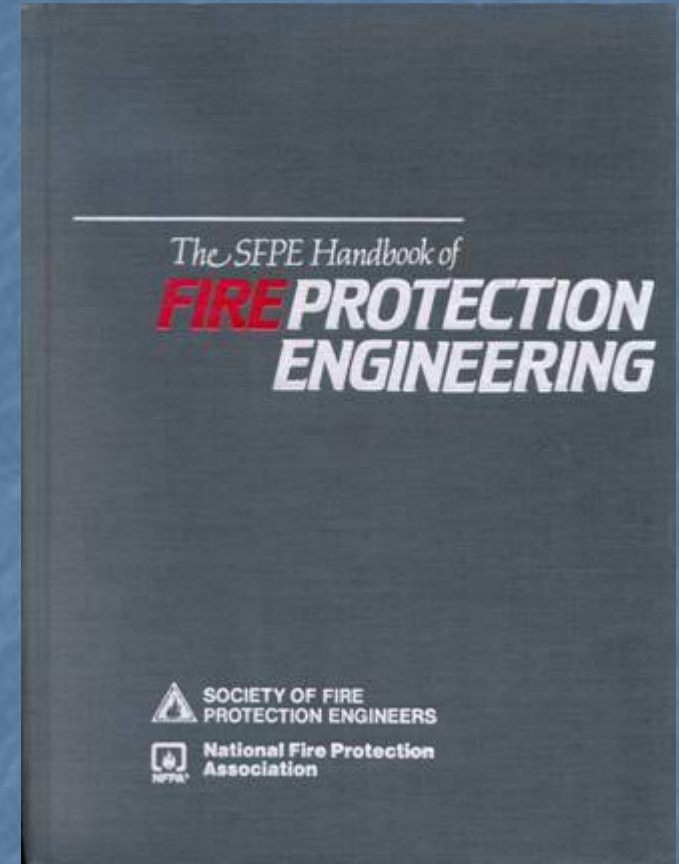
Background to First Edition (1981-1985)

- Concept arose from Engineering Education Committee (DiNenno, Walton, Beyler, Watts, Custer)
- Relatively rapid changes in quantifiable methods
 - Harvard Fire Model (78-79)
 - Annual NIST CFR conferences
- Lack of textbooks (Drysdale – 1985)
- A lot of effort and reference material to do a simple calculation
- Need for base document for NCEES exam
- Institutionalize a different vision of profession
- Pre-requisite for engineering analysis



Background

- Intended primarily as handbook summarizing
- calculation methods
- Work on 1st Edition begun in 1985
- \$5K funding from SFPE BOD (not all spent)
- Basic structure: Four sections
 - Section 1: Fundamentals
 - Craig Beyler (27 chapters)
 - Section 2: Hazard Analysis Calculations
 - Doug Walton (7 chapters)
 - Section 3: Design Calculations
 - Dick Custer (9 chapters)
 - Section 4: Fire Risk Calculations
 - Jack Watts (11 chapters)
- 54 chapters, 809 pages
- Leap of Faith by Authors
- Publisher selection
 - NFPA – Jim Linville (Managing Editor)



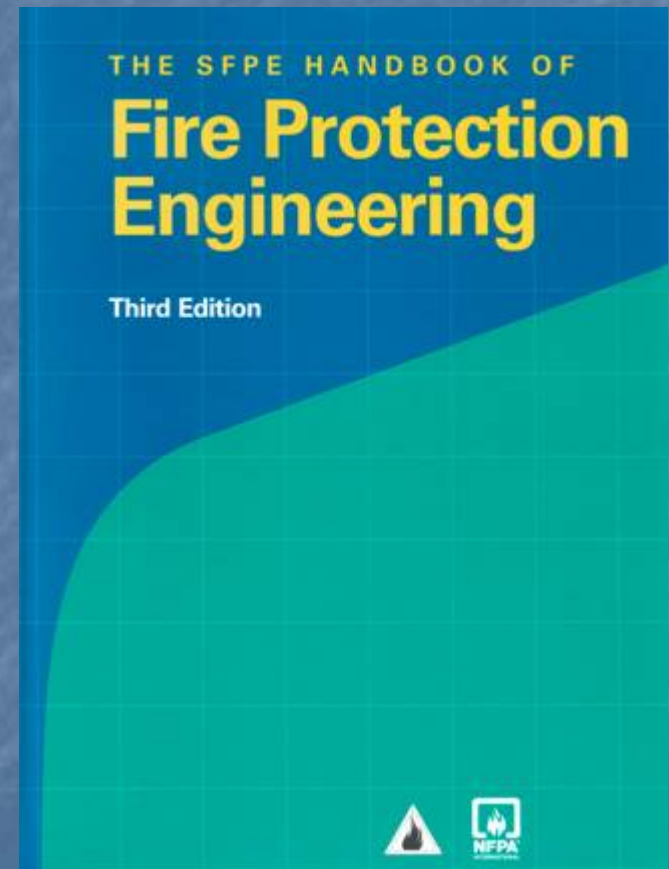
Second Edition (Published 1995)

- Added two new editors
 - Dougal Drysdale, Univ. of Edinburgh
 - John Hall, NFPA
- Reorganized book
 - Section 1: Fundamentals
 - Section 2: Fire Dynamics
 - Section 3: Hazard Calculations
 - Section 4: Design Calculations
 - Section 5: Fire Risk Analysis
 - 61 chapters, 1067 pp
- View expanded beyond calculation methods
- More material on modeling
 - Application areas of risk assessment
 - Expanded appendices
 - New technology



Third Edition (Published 2002)

- Fire integration of SFPE Design Guide/Engineering Method "Fire Hazard Calculations for Large, Open Hydrocarbon Fires", Craig Beyler
- Further integration of Fire Dynamics & Hazard Calculations
 - "Heat Fluxes from Fires to Surfaces", Brian Lattimer
 - "Liquid Fuel Fires", Dan Gottuk & Derek White
 - "Visibility and Human Behavior In Smoke", Tadahisa Jin
- New Material
 - "Modeling Enclosure Fires Using CFD", Geolf Cox and Suresh Kumar?
 - "Movement of People: The Evacuation Timing", Guylene Proulx
 - "Water Mist Fire Suppression Systems", Jack Mawhinney
 - Pam Powell, Managing Editor



Summary of Evolution of SFPE Handbook

Edition	Date	# Chapters	# Pages
1 st	1988	54	809
2 nd	1995	61	1067
3 rd	2002	72	1560

Approximately 5000 copies of 1st and 2nd edition

Section 1 – Fundamentals

Chapter 1-1	Introduction to Mechanics of Fluids, <i>B.S. Kandola</i>
Chapter 1-2	Conduction of Heat in Solids, <i>John A. Rockett and James A. Milke</i>
Chapter 1-3	Convection Heat Transfer, <i>Arvind Atreya</i>
Chapter 1-4	Radiation Heat Transfer, <i>C. L. Tien, K. Y. Lee, and A. J. Stretton</i>
Chapter 1-5	Thermochemistry, <i>D. D. Drysdale</i>
Chapter 1-6	Chemical Equilibrium, <i>Raymond Friedman</i>
Chapter 1-7	Thermal Decomposition of Polymers, <i>Craig L. Beyler and Marcelo M. Hirschler</i>
Chapter 1-8	Structural Mechanics, <i>Robert W. Fitzgerald</i>
Chapter 1-9	Premixed Burning, <i>Robert F. Simmons</i>
Chapter 1-10	Properties of Building Materials, <i>V. K. R. Kodur and T. Z. Harmathy</i>
Chapter 1-11	Probability Concepts, <i>John R. Hall, Jr.</i>
Chapter 1-12	Statistics, <i>John R. Hall, Jr.</i>

Section 2 – Fire Dynamics

Chapter 2-1	Fire Plumes, Flame Height, and Air Entrainment, <i>Gunnar Heskestad</i>
Chapter 2-2	Ceiling Jet Flows, <i>Ronald L. Alpert</i>
Chapter 2-3	Vent Flows, <i>Howard W. Emmons</i>
Chapter 2-4	Visibility and Human Behavior in Fire Smoke, <i>Tadahisa Jin</i>
Chapter 2-5	Effect of Combustion Conditions on Species Production, <i>D.T. Gottuk & B.Y. Lattimer</i>
Chapter 2-6	Toxicity Assessment of Combustion Products, <i>David A. Purser</i>
Chapter 2-7	Flammability Limits of Premixed and Diffusion Flames, <i>Craig L. Beyler</i>
Chapter 2-8	Ignition of Liquid Fuels, <i>A. Murty Kanury</i>
Chapter 2-9	Smoldering Combustion, <i>T.J. Ohlemiller</i>
Chapter 2-10	Spontaneous Combustion and Self-Heating, <i>Brian Gray</i>
Chapter 2-11	Flaming Ignition of Solid Fuels, <i>A. Murty Kanury</i>
Chapter 2-12	Surface Flame Spread, <i>James G. Quintiere</i>
Chapter 2-13	Smoke Production and Properties, <i>George M. Mulholland</i>
Chapter 2-14	Heat Fluxes from Fires to Surfaces, <i>Brian Y. Lattimer</i>
Chapter 2-15	Liquid Fuel Fires, <i>D.T. Gottuk & D.A. White</i>

Section 3 – Hazard Calculations

Chapter 3-1	Heat Release Rates, <i>Vytenis Babrauskas</i>
Chapter 3-2	Calorimetry, <i>Mark Janssens</i>
Chapter 3-3	The Cone Calorimeter, <i>Vytenis Babrauskas</i>
Chapter 3-4	Generation of Heat and Chemical Compounds in Fires, <i>Archibald Tewarson</i>
Chapter 3-5	Compartment Fire Modeling, <i>James G. Quintiere</i>
Chapter 3-6	Estimating Temperatures in Compartment Fires, <i>William D. Walton & Philip H. Thomas</i>
Chapter 3-7	Zone Computer Fire Models for Enclosures, <i>William D. Walton</i>
Chapter 3-8	Modeling Enclosure Fires Using CFD, <i>Geoff Cox & Suresh Kumar</i>

Section 3 – Hazard Calculations (cont'd)

Chapter 3-9	Smoke and Heat Venting, <i>Leonard Y. Cooper</i>
Chapter 3-10	Compartment Fire-Generated Environment and Smoke Filling, <i>Leonard Y. Cooper</i>
Chapter 3-11	Fire Hazard Calculations for Large, Open Hydrocarbon Fires, <i>Craig L. Beyler</i>
Chapter 3-12	Behavioral Response to Fire and Smoke, <i>John L. Bryan</i>
Chapter 3-13	Movement of People: The Evacuation Timing, <i>Guylene Proulx</i>
Chapter 3-14	Emergency Movement, <i>Harold E. "Bud" Nelson & Frederick W. Mowrer</i>
Chapter 3-15	Stochastic Models of Fire Growth, <i>G. Ramachandran</i>
Chapter 3-16	Explosion Protection, <i>Robert Zalosh</i>

Section 4 – Design Calculations

Chapter 4-1	Design of Detection Systems, <i>Robert P. Schifilliti, Brian J. Meacham, & Richard L.P. Custer</i>
Chapter 4-2	Hydraulics, <i>John J. Titus</i>
Chapter 4-3	Automatic Sprinkler System Calculations, <i>Russell P. Fleming</i>
Chapter 4-4	Foam Agents and AFFF System Design Considerations, <i>Joseph L. Scheffey</i>
Chapter 4-5	Foam System Calculations, <i>Joseph L. Scheffey & Harry E. Hickey</i>
Chapter 4-6	Halon Design Calculations, <i>Casey C. Grant</i>
Chapter 4-7	Halon Replacement Clean Agent Total Flooding Systems, <i>Philip J. DiNenno</i>
Chapter 4-8	<u>Fire Temperature-Time Relations</u> , <i>T.T. Lie</i>
Chapter 4-9	Analytical Methods for Determining Fire Resistance of Steel Members, <i>James A. Milke</i>
Chapter 4-10	Analytical Methods for Determining Fire Resistance of Concrete Members, <i>Charles Fleischmann & Andy Buchanan</i>
Chapter 4-11	Analytical Methods for Determining Fire Resistance of Timber Members, <i>Robert H. White</i>
Chapter 4-12	Smoke Control, <i>John H. Klote</i>
Chapter 4-13	<i>Smoke Management in Covered Malls and Atria</i> , <i>James A. Milke</i>
Chapter 4-14	<i>Water Mist Fire Suppression Systems</i> , <i>Jack R. Mawhinney & Gerard G. Back, III</i>

Section 5 – Fire Risk Analysis

Chapter 5-1	Introduction to Fire Risk Analysis, <i>John M. Watts, Jr. & John R. Hall, Jr.</i>
Chapter 5-2	Decision Analysis, <i>H.A. Donegan</i>
Chapter 5-3	Reliability, <i>Mohammad Modarres & Francisco Joglar-Billoch</i>
Chapter 5-4	Uncertainty, <i>Kathy A. Notarianni</i>
Chapter 5-5	Data for Engineering Analysis, <i>John R. Hall, Jr. & Martha J. Ahrens</i>
Chapter 5-6	Measuring Fire Consequences in Economic Terms, <i>G. Ramachandran, revised by John R. Hall, Jr.</i>
Chapter 5-7	Engineering Economics, <i>John M. Watts, Jr. & Robert E. Chapman</i>
Chapter 5-8	Extreme Value Theory, <i>G. Ramachandran</i>
Chapter 5-9	Computer Simulation for Fire Protection Engineering, <i>William G.B. Phillips, revised by Douglas K. Beller & Rita F. Fahy</i>
Chapter 5-10	Fire Risk Indexing, <i>John M. Watts, Jr.</i>
Chapter 5-11	Product Fire Risk, <i>John R. Hall, Jr.</i>
Chapter 5-12	Building Fire Risk Analysis, <i>Brian J. Meacham</i>
Chapter 5-13	Quantitative Risk Assessment in Chemical Process Industries, <i>Thomas F. Barry</i>
Chapter 5-14	Fire Risk Assessment for Nuclear Power Plants, <i>Nathan Siu</i>

Challenges

- How to deal effectively with computer-based modeling?
- Additional Subjects? (and related authors)
- Additional reference material – ?
- Further integration of SFPE design guides
- Relationship with NFPA's "Fire Protection Handbook"

Summary

- Handbook has filled the role anticipated
- Prerequisite for PBD and related approaches
- Move toward consensus methods and assumptions?
- Work has begun on Fourth Edition, we are always looking for suggestions.
- Special Thanks and Recognition of Authors

Planned New Material

SFPE Handbook: 4th Edition

- Chemical Kinetics
- Forensic Analysis (1-4 new chapters)
- Electrical Ignition
- Performance-Based Design
- Sprinkler Design Requirements
- Structural Fire Protection (1-5 new chapters)
- Egress & Evacuation Modeling
- Organic Pollutants from Fires
- Fire Scenarios
- Fire Risk Management

Improvements in Predictive Capability

- Structures and Fire? 1960's
- Plumes/Jets
- Toxicity/Visibility
- Egress/Behavior
- Burning Rates
- Detection
- Suppression (Very Important and almost no capability)
- Some topics reduced to practice (Radiation)

Improvements in Fire Science/Technology

- Flame spread on walls and ceilings
- FDS (smoke movement and platform)
 - Potentially most significant progress
- Some incremental progress in each field

Changes in Practice

- Widespread use of computers for modeling (FDS, CFAST, CONTAM, Egress, etc., etc.)
- Calculations routine (e.g., smoke exhaust in atrium)
- NRC Widespread Use of Methods
- More sophisticated methods used
- More methods used more frequently
- Wrong questions asked and semi-answered
- No recognition of when we are guessing

Changes in Practice

- Educational Infrastructure dramatically improved
- Research Base and Infrastructure Reduced
- Clear need to integrate quantitative risk analysis into decision processes

Recent Events

- "There is nothing to learn" syndrome
- Station Night Club
- WTC

NIST

NCST WTC Investigation

Recommendations

- 30 Recommendations
- Fire-Structural: 8 recommendations
- Rec. 8: "*NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled fires result in burnout without local or global collapse*".
- Should be made a building code requirement:
 - "Irrespective of compliance with prescriptive requirements of this code, an analysis shall be performed that demonstrates that uncontrolled fires result in burnout without local or global collapse."

- Is there societal value in using the best available design and analysis methods to ensure public safety?
 - Irrespective of code requirements
 - Neutral (Status Quo) to commercial interests
 - Demonstrated risk, unknown scale
 - Code Requirements too far removed from any rational basis
- Contrasted with PBD/PBC

Analogies

- Atria smoke control system design
- Smoke movement in networks
- "Timed" evacuation analysis
- Exposed steel fire exposure analysis

Station Night Club

- Egress design
 - Need to understand very quickly how to avoid crushes
- Control of interior finish/combustibles
- Should some level of egress system performance be required given sprinkler system failure?
 - If so,
- Should it be required to be proven?

Summary

The Engineering Community should take steps to require the use of engineering methods to prove and demonstrate that critically important safety objectives are being met **irrespective of compliance with prescriptive requirements. Where**

- 1. Code basis is lacking or unclear**
- 2. Some evidence for problems**

Summary

- Significant progress in 20 years in application and process of FPE
- Knowledge base and predictive capability is now a more critical limiting factor
- Need to fund relevant research
 - leverage
- SFPE leadership in Engineering requirements in Codes