

SFPE



Engineering A Fire Safe World

SFPE Research Roadmap

Published in October 2017

- Purpose: Identify research needs for Fire Safety Engineering Profession
- Can be found on SFPE Website at can be found at: <http://www.sfpe.org/?page=SCRI> or Click “Technical Areas/Research and Innovation”











Vision for a Roadmap

- Define future of SFPEs technical initiatives
- Transparency
- What is needed by FSEs
- Be a living document
- Have a long-term focus on advancing FSE
- A means of coordinating research initiatives (Foundation)
- A basis for forming partnerships with research organizations
- Act as a bridge between research and practice
- Become a subtheme of future SFPE conferences

Drafting the Roadmap

- Preliminary List by Subcommittee – Early 2016
- Warsaw Workshop – May 2016
- Denver Workshop – September 2016
- SFPE AOCCG (Taiwan) – November 2016
- SFPE Dubai Conference – March 2016
- Survey
- Other Fire Organizations
- Workshop at IAFSS, Lund – June 2017

Roadmap Matrix

Research Needs for the Fire Safety Engineering Profession		Tools, Applications, & Methods			
		Data	Innovative Technology /Materials	Design Tools	Risk/ Probabilistic Approaches
Threads	Human Behavior				
	Building Fires				
	Resilience/Sustainability				
	Fire Service				
	Fire Dynamics				
	Fire Safety Systems				
	Forensics/Investigations				
	Wildland/WUI Fires				
	Non-Building Fires				

TOOLS, APPLICATIONS, AND METHODS

THREADS

Human Behavior

Data

- Demographics
 - ▶ Vulnerable populations
 - ▶ Anthropometry
 - ▶ Cultural differences

Basis for numbers in codes

Response to notification

Innovative Technology/ Materials

- Smart egress systems
 - ▶ Cameras
 - ▶ Cell phones
 - ▶ Exit usage
 - ▶ Other

LED strobes

Occupant evacuation elevators

Design Tools

Design egress scenarios

- Behavior based models
 - ▶ Cultural
 - ▶ Pre-evacuation time
 - ▶ Actions other than evacuating

Combined fire and evacuation models

Risk/Probabilistic Approaches

Residential buildings

Large populations

Community level

High-challenge environments

Quantify level of “life safety” in a building

Effects of fire

- ▶ Visibility
- ▶ Gases

Impact of public education on fire risk

Building Fires

Combustibility of external cladding systems

Fire loads for structural fire engineering

Material testing data (new materials)

Effectiveness of existing/new fire safety solutions

Quantification of building code performance criteria

Building information modeling

Smart buildings

Big data

Improved test methods

Standardization of design fires and analysis approaches

Best practices for retrofitting existing buildings to achieve equivalent level of safety

High-rise building design

Risk-informed PBD

Single family homes

Risk assessment/management systems

Structural FP performance

TOOLS, APPLICATIONS, AND METHODS

THREADS

	Data	Innovative Technology/ Materials	Design Tools	Risk/Probabilistic Approaches
Resilience/Sustainability	<ul style="list-style-type: none"> Environmental impact of fire and fire suppression activities Cost of fire events Cost/benefit of different types and multiple levels of FP measures Environmental impact of fire testing Quantification of structural fire resilience Flame retardant toxicity 	<ul style="list-style-type: none"> Assess fire hazard of new sustainable building materials/practices Identify/quantify sustainability benefits of smoke control systems and natural ventilation Evaluate fire hazards of new sustainable energy technologies Evaluate fire hazards of flammable refrigerants Life expectancy of installed fire protection systems Determine appropriate suppression systems for new technologies 	<ul style="list-style-type: none"> Development of design tools/best practices for fire safety engineering for resilient systems/buildings Analysis of impact of climate change on fire safety Cost-effective and resilient FP practices for developing countries Post-fire seismic behavior Identification of critical fire protection aspects for disaster reliability 	<ul style="list-style-type: none"> Development of risk-based analysis to compare hazards of fire to long-term health impacts of fire mitigation measures Risk- and reliability-based methods for ITM of fire protection systems <ul style="list-style-type: none"> ► Preventative and predictive maintenance ► Human impact on ITM reliability ► Reliability of water supplies ► Reliability of installed equipment
Fire Service	<ul style="list-style-type: none"> Exposure tracking from incidents Data-driven fire inspection scheduling Improved injury, holistic fatality data collection and economic analysis Impact of WUI on fire service Naturally occurring events <ul style="list-style-type: none"> ► Rate, severity ► Fire as a secondary impact 	<ul style="list-style-type: none"> Smart firefighting <ul style="list-style-type: none"> ► IoT integration ► Mechanical augmentation ► Fire department communication with BIM ► Firefighter tracking and location Automated, quantifiable exposure monitoring Firefighting PPE and tools <ul style="list-style-type: none"> ► Firefighting and fire apparatus cameras for investigation/debrief 	<ul style="list-style-type: none"> Model fire department response leading to better models of <ul style="list-style-type: none"> ► Reverse evacuation ► Egress/ingress ► Duration of water for FP systems ► Structural collapse ► Firefighter response recreation and training aids Compare/contrast tactics internationally to determine impact of firefighting/construction differences on fire growth/severity 	<ul style="list-style-type: none"> Evolving building technology and fire suppression tactics (effect of smoke/heat ventilation) Firefighter injuries <ul style="list-style-type: none"> ► Effect of understaffed apparatus on individual personnel ► Fire ground safety ► Long-term exposures on individual personnel Effect of firefighting interventions on occupant risk New vehicle technology and fire suppression tactics Lessons learned to reduce risks in developing countries Tactics and training for emerging technologies

TOOLS, APPLICATIONS, AND METHODS

		Data	Innovative Technology/ Materials	Design Tools	Risk/Probabilistic Approaches
THREADS	Fire Dynamics	<ul style="list-style-type: none"> Material properties Fire dynamics of large compartments Test data archiving Model stewardship Toxicity data Sprinkler data 	<ul style="list-style-type: none"> Standardized/accepted approach for developing material properties Retardant behavior Massively parallel computing Mesoscale Extreme ambient conditions 	<ul style="list-style-type: none"> Practical models for: <ul style="list-style-type: none"> ▶ Pyrolysis of complex materials ▶ Extinction and reignition ▶ Sprinkler suppression ▶ Underventilated combustion ▶ Glass breakage ▶ Human consequences ▶ Deflagrations/detonations Realism in test standards 	<ul style="list-style-type: none"> Ignition frequencies Probabilistic distributions of heat-release rate curves Fire spread models Fire frequencies
	Fire Safety Systems	<ul style="list-style-type: none"> Impact of ITM requirements on system reliability FP systems performance data Evaluation of new and existing active FP systems efficacy <ul style="list-style-type: none"> ▶ Suppression of unique and emerging hazards ▶ System design criteria ▶ Smoke control system Evaluation of passive FP systems efficacy Evaluation of durability of FP systems Gaseous fire suppression systems applied to high air flow environments 	<ul style="list-style-type: none"> Integrated FP systems and building connectivity Efficacy of detection, alarm, communication systems Protection of storage <ul style="list-style-type: none"> ▶ Automated ▶ High challenge Reliability of detection/alarm/communication <ul style="list-style-type: none"> ▶ False positives ▶ Failure on demand ▶ Failure modes due to extreme environments 	<ul style="list-style-type: none"> Corrosion protection design best practices Guidelines on suppression effectiveness at various heights FP System design <ul style="list-style-type: none"> ▶ Atrium protection and modeling ▶ Smoke control systems ▶ Passive FP system design and test methods 	<ul style="list-style-type: none"> Adequacy of passive fire resistive construction Evaluation of <ul style="list-style-type: none"> ▶ Smoke control systems impact on reduction of risk of losses ▶ Adequacy of passive fire resistive construction ▶ Effectiveness of fire stop installation by multiple trades versus certified technicians ▶ Life quality indices to assess FP performance Reliability of <ul style="list-style-type: none"> ▶ Water supplies ▶ Suppression systems failure modes, aging, and complex systems Relationship between safety, security, and routine operations Matching reliability of installed systems with risk assessment

TOOLS, APPLICATIONS, AND METHODS

THREADS	TOOLS, APPLICATIONS, AND METHODS			
	Data	Innovative Technology/ Materials	Design Tools	Risk/Probabilistic Approaches
Forensics/Investigations	<ul style="list-style-type: none"> Persistence of burn patterns under different compartment fire conditions Building material properties as inputs for fire models Fire effects on building electrical systems/components Evaluation of incident heat-flux profiles from non-standard fuels Damage resulting from heat radiation and blast waves on buildings, industrial assets, etc. Digital recordings of distributed control systems and programmable logic controllers Digital data collection (black boxes) Status and data related to availability of FP measures during event 	<ul style="list-style-type: none"> Improved tools for obtaining building dimensions and fire sizes from photographs and video Use of cloud-based home/consumer devices to pinpoint fire origin Linking of 3D scanning technology with computer fire models Overview of large scenes from drones Data mining to identify chemical process deviations Methods to preserve evidence Tools to extract data from digital sources 	<ul style="list-style-type: none"> Improved software to create multiple-source dynamic event timelines Tools to evaluate impact of ventilation on compartment fires Simulation tools to recreate process conditions in chemical plants Advanced calculation methods to evaluate hypothesis Tools to estimate damage effects Virtual reality/augmented reality to describe and test scenarios 	<ul style="list-style-type: none"> Improved guidance for quantifying measurement and calculation uncertainty Repeatability of fire test measurements Root cause analysis methods and tools Causes and causal mechanism analysis Human error assessment methods and tools
Wildland/WUI Fires	<ul style="list-style-type: none"> Impact of firebrands Fire hazard identification and quantification Ignition of WUI materials Fire behavior and fire spread Emissions and health effects Fire ecology and long-term effect Data to support WUI codes and standards 	<ul style="list-style-type: none"> Building fire protection in WUI Wildland/WUI fire damage mitigation Warning and notification Remote sensing and communications 	<ul style="list-style-type: none"> Design against exterior building fires Wildland/WUI fire modeling Firebrand ignition prevention Fire behavior prediction tools Resilience design tools Landscape planning tools 	<ul style="list-style-type: none"> Risk assessment of WUI structures Risk of combustible fuels in WUI/wildland Assessment of risk, effectiveness, and economics

TOOLS, APPLICATIONS, AND METHODS

Data

- Data for hazard identification/reliability/severity/frequency (industrial)
- Alternative energy generation
- PV installation fire spread
- Petrochemical fire incident frequency
- Causes of vehicle fires

Innovative Technology/ Materials

- Energy Storage**
 - ▶ Containment for new products/damaged products
 - ▶ Higher reliability manufacturing/more resilient product design
 - ▶ Safer energy storage chemistries
 - ▶ New inspection techniques
 - ▶ Self-monitoring of equipment
 - ▶ Safe transportation
- Improvements to petrochemical equipment safety
- Tunnel fire suppression

Design Tools

- Product safety standards
- Installation Standards
 - ▶ ESS
 - ▶ Oil/gas drilling
- CFD fire models (tunnels/underground, tank fires)
- Design considering first responders (ESS, vehicles, tunnels)
- Heat transfer models for energy storage cell design
- Tunnel evacuation/fire models
- Models for use in siting and design of tank farms
- Tunnel design fires

Risk/Probabilistic Approaches

- Improved identification of high-risk industrial facilities
- Improvement of risk management practices at chemical facilities

Research Roadmap Moving Forward

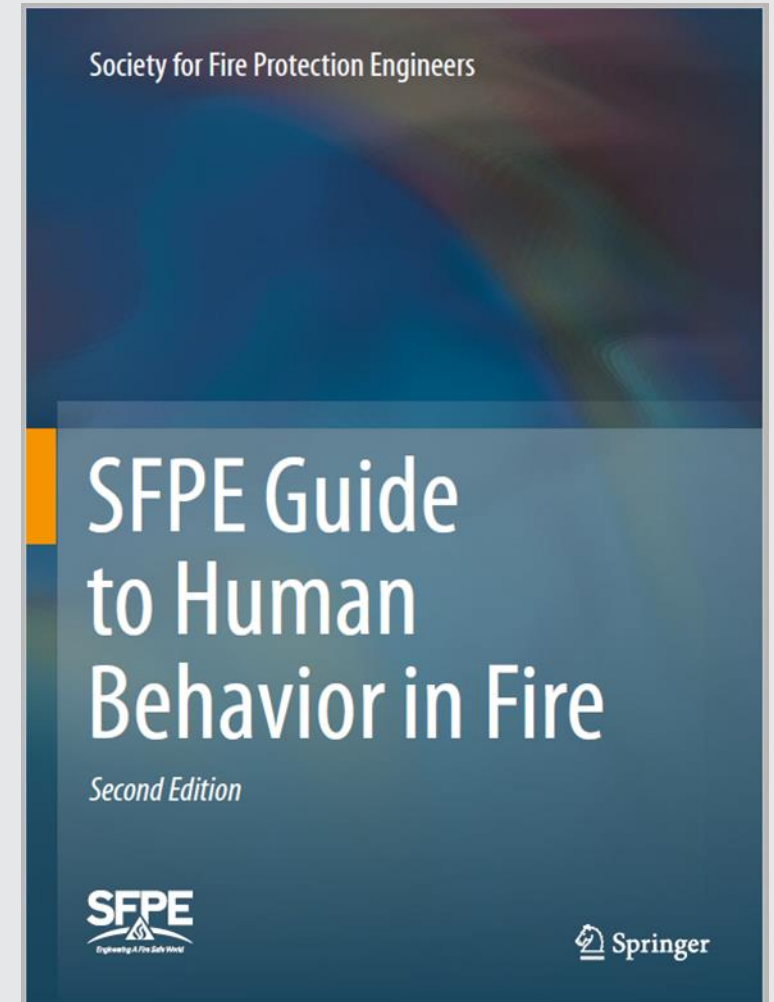
- Coordinating with the SFPE Foundation
- Presentations at international FSE conferences
- Publish Articles in fire safety publications
- Publicize on social media sites
- Engagement with funding organizations
- Targeting research providers

SFPE Foundation

- Mission -- advance the science and practice of fire protection engineering internationally by advocating and supporting engineering research, technology transfer and education.
- Working on New Strategic Plan
- Linking the SFPE Roadmap to Future Activities
- Current Grants/Awards:
 - Proulx Scholarship
 - Chief Donald Burns Grant
 - London Imperial College -- Computational Investigation of Timber Response to Fire
 - University of Maryland -- Introduction to Math and Physics through Fire Dynamics
 - Arthur B. Guise, Student Scholar & Jack Bono Awards

SFPE Technical Documents

- Currently Develop Guides and Standards
- Under Direction of Subcommittee for Standards Oversight
- Became ANSI Standards Developer
- SFPE Handbook



Coming Soon -- Guide to Human Behavior in Fire, 2nd Edition

New Information on:

- Incapacitating Effects of Fire Effluent & Toxicity Analysis Methods
- Occupant Behavioral Scenarios
- Movement Models and Behavioral Models
- Egress Model Selection, Verification, and Validation
- Estimation of Uncertainty and Use of Safety Factors
- Enhancing Human Response to Emergency Notification and Messaging
- Incapacitating Effects of Fire Effluent & Toxicity Analysis Methods

Current Project -- Standards on Fire Scenarios/Design Fires

Using a Risk-Informed Approach:

- **SFPE Standard on Design Fire Scenarios**

Scope: The scope of this standard is the determination of the design fire scenarios to be used in performance-based design for building design for fire safety

- **SFPE Standard on Design Fires**

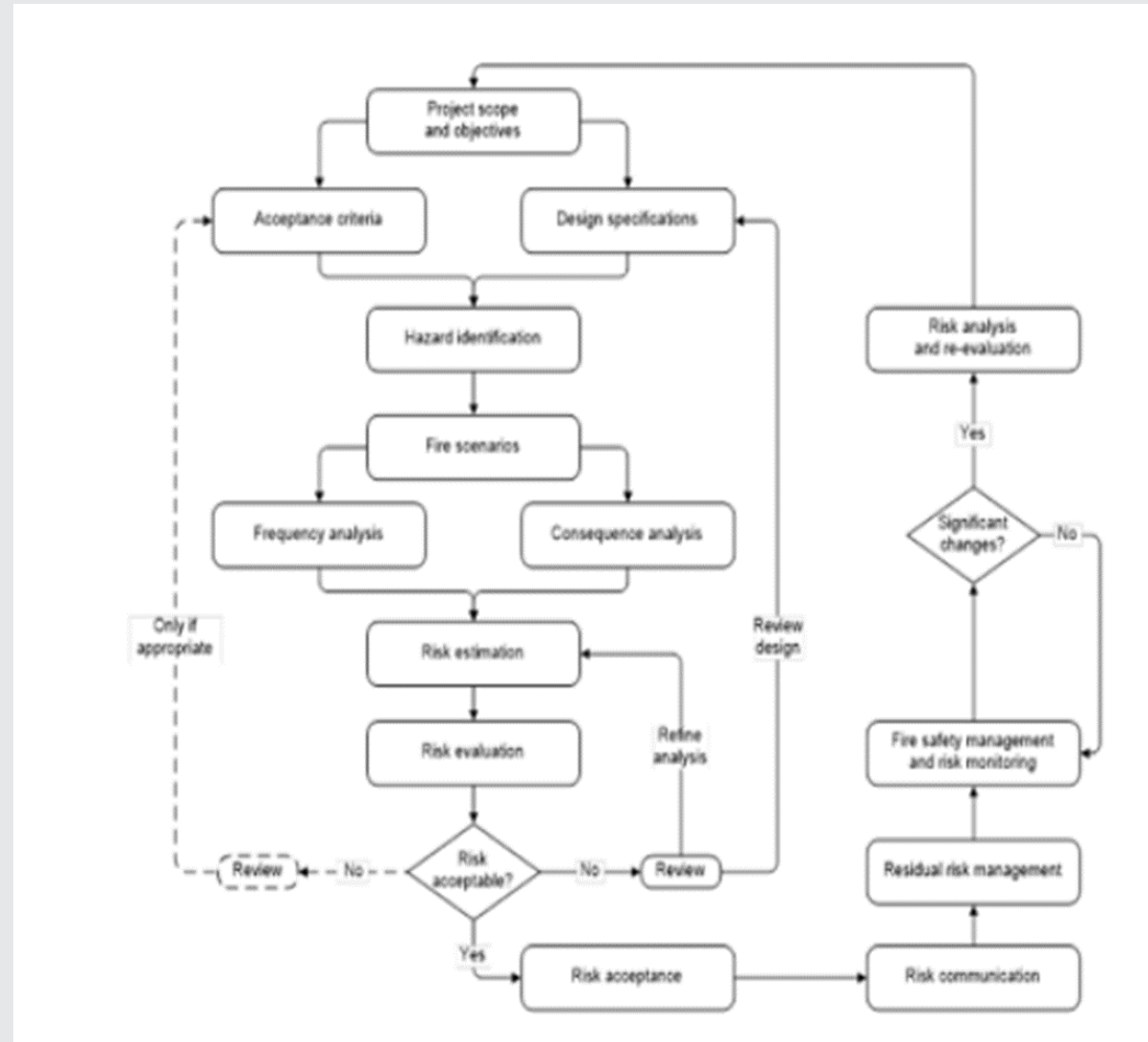
Scope: The scope of this standard is the determination of the design fires to be used in conjunction with the fire scenarios in the SFPE Design Fire Scenarios Standard. The design fires are intended to be used in performance-based design for building design for fire safety.

Current Project -- Standard on Fire Exposures to Structures

Four working groups:

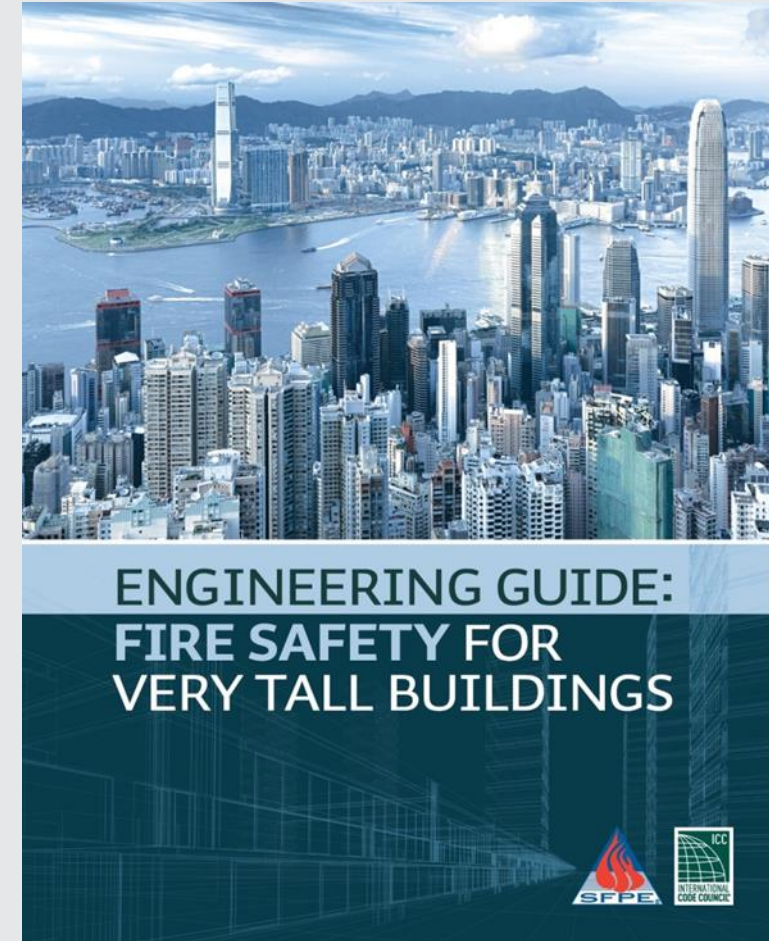
- Database – SFPE Intern working with Committee to analyze data
- Risk – Completed draft White Paper on developing a risk methodology
- Local Exposures – Working in White paper on expressing Heat Flux vs Adiabatic Surface Temperature in Standard.
- Traveling Fires – Working on White Paper on how to express traveling fires in standard

Current Project – Updating Guide to Fire Risk Assessment

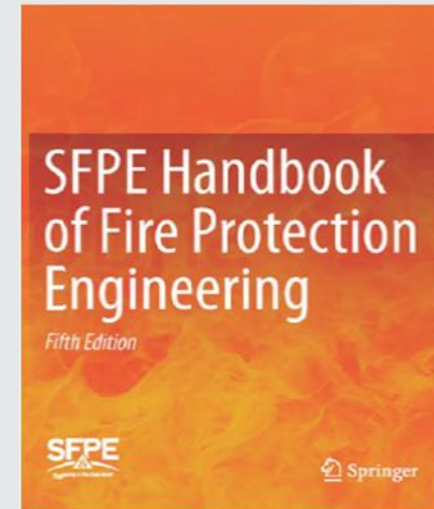
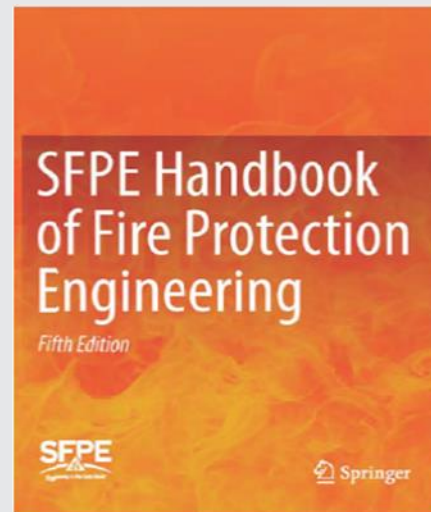
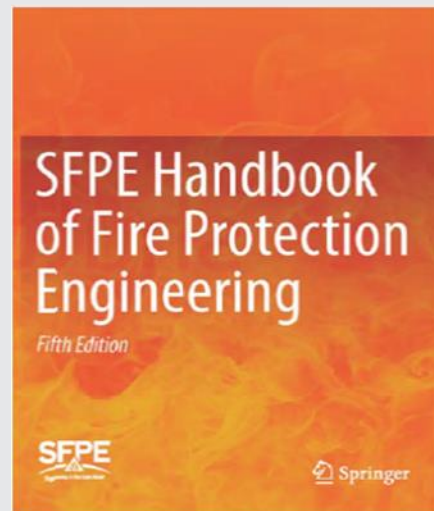


New Projects to Start in November 2018

- Guide to Fire Safety in Tall Buildings
- Guide to Peer Review



SFPE Handbook of Fire Protection Engineering



Thank you for your time.

Questions?



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