

# **15th International Conference and Exhibition on Fire and Materials 2017**

San Francisco, California, USA  
6 – 8 February 2017

Volume 1 of 2

ISBN: 978-1-5108-4674-6

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2017) by Grayson Franks Ltd  
All rights reserved.

Printed by Curran Associates, Inc. (2017)

For permission requests, please contact Grayson Franks Ltd  
at the address below.

Grayson Franks Ltd  
1 West Yard  
Guilford Grove Greenwich  
London SE10 8JT  
United Kingdom

Phone: 44 208 692 5050  
Fax: 44 208 692 5155

[office@intersciencecomms.co.uk](mailto:office@intersciencecomms.co.uk)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

To select a paper click on title, or use "Page Thumbnails" on the left hand navigation bar

## TABLE OF CONTENTS



### ELECTRO TECHNICAL

Fire Safety Requirements for Wires & Cables ..... 2  
*Marcelo Hirschler, GBH International, USA*

Effects of Cable Tray Configuration on Fire Spread ..... 17  
*Pascal Zavaleta, S Suard, S Bascou, IRSN, France*

Fire-Induced Re-Radiation Underneath Photovoltaic Arrays on Flat Roofs ..... 34  
*Jens Steemann Kristensen, G Jomaas, Technical Univ of Denmark, Denmark, B Merci, Ghent Univ, Belgium*

Modeling the Conditions Produced during a Lithium Battery Reaction..... 44  
*Gerard Back, Jensen Hughes, USA*

### FIRE TESTING

Particle Finite Element Modelling and Advanced Experiments on Dripping-V-0-Classified Polypropylene .....57  
*B Schartel, Melissa Matzen, BAM, Germany, J Marti, E Onate, S Idelsohn, Tech Univ of Catalonia, Spain*

Predicting UL 94 Ratings for Plastics Based on MCC Measurements ..... 63  
*Mahmood Tabaddor, Priyansu Panda, T Fabian, UL LLC, USA Modifications to Cone Calorimetry Instrumentation and*

Procedures to Facilitate Generation of Fire Safety  
Engineering Data in Standardised Tests ..... 72  
*Sandra Pasantes, S Gregory, FTT, S Grayson, Interscience Communications, UK*

Heat Release Measurement at Oxygen Rich Atmosphere .....985  
*Koichi Yoshida, Yokohama National Univ, A Hosogai, Japan Aerospace Exploration Agency, T Hatayakawa, Tokyo Systems Vac, Japan*

Dynamic Study of Polymer Mass Loss under High and Fast Radiative Heat Fluxes ..... 81  
*Guillaume Rambaud, CEA-Gramat, M Gillet, DGA Aeronautical Systems, France*

### MATERIAL FLAMMABILITY

Calorimetric Study of Standard Commodity Fuels ..... 94  
*Gaurav Agarwal, Y Wang, FM Global, M Chaos, Lawrence Livermore National Laboratory, USA*

Influence of Plastic Formula on Flammability Properties ..... 108  
*Thomas Fabian, J Shih, L Chen, S MacLeod, R Messing, P Moore, UL LLC, USA*

A Methodology for Predicting and Comparing the Full-scale Fire Performance of Similar Materials..... 122  
*Chad Lannon, Holmes Fire LLP, S Stoliarov, Univ of Maryland, J Lord, ATF, I Leventon, NIST, USA.*

Scale Reduction: How to Play with Fire? ..... 137  
*Serge Bourbigot, P Bachelet, J Sarrazin, F Samyn, M Jimenez, S Duquesne, ENSCL, France*

### HAZARDOUS MATERIALS

Analysis of Fire Barriers with respect to Fires with Combustible Gases and Liquids ..... 146  
*Patrick Van Hees, J Wahlqvist, Lund Univ, Sweden, B Andres Valiente, K Wilkens, A Bhargava, K Livkiss, Lund Univ, Sweden/DBI, Denmark*

Indoor Fire Testing of Transportation Container Systems to Meet DOT Hazardous Material Classification Requirements .....	158
<i>Walt Gill, D Finfrock, Anay Luketa, B Servantes, Sandia National Labs, USA</i>	
Charaterisation of a Vehicle Fire on a 7 Tonne LPG Road Tanker .....	169
<i>Lorraine Jenney, DNV GL, UK</i>	
<b>FIRE DYNAMICS</b>	
Limiting Oxygen Concentration of Thin Materials in Opposed Flow under Microgravity Conditions .....	181
<i>Shuhei Takahashi, K Maruta, Gifu Univ, Japan</i>	
Effect of Oxygen Depletion on the Radiative Characteristics of Buoyant Turbulent Diffusion Flames .....	195
<i>Dong Zeng, Y Wang, FM Global, USA</i>	
A Method for Measurement of Spatially Resolved Radiation Intensity and Radiative Fraction of Laminar Flames of Gaseous and Solid Fuels.....	210
<i>Catherine Hamel, AcuTech Consulting Group/Univ of Maryland, F Raffan-Montoya, S Stoliarov, Uni of Maryland, USA</i>	
Temperature and Velocity Field Measurements for a Pure Buoyancy Driven Plume in an Enclosure .....	225
<i>Alexander Belt, L Arnold, L Rommeswinkel, A Tscherniewski, Research Centre Juelich, Germany</i>	
<b>UPHOLSTERED FURNITURE</b>	
Experimental and Numerical Investigation on Fire Behaviour of Foam/Fabric Composites .....	240
<i>Konrad Wilkens, K Livkiss, DBI/Lund Uni, Denmark, P van Hees, Lund Univ, Sweden</i>	
Experimental Evaluation of Fire Barriers Exposed to Open Flame Ignition on Full Scale Upholstered Furniture.....	254
<i>Andrew Lock, L Fansler, D Miller, US Consumer Product Safety Commission, USA</i>	
Fire-blocking Performance of Laminated Barrier Fabrics: Cone Calorimetric Characterization .....	265
<i>Shonali Nazare, W Pitts, J Shields, NIST, USA</i>	
Influence of Modern Furniture on the Fire Development in Fires in Homes: Large Scale Fire Tests in Living Rooms,	
<i>Anja Hofmann, F Rabe, S Kaudelka, T Gnutzmann, BAM, A Klippel, Otto von Guericke Univ, Germany .....</i>	280
<b>COMPARTMENT FIRES</b>	
An Analytical Model for Flashover to Reveal Mechanisms .....	296
<i>Jim Quintiere, Univ of Maryland, USA</i>	
Vertical Flame Spread in Wooden Corners as a Function of Fuel Moisture Content .....	307
<i>Torgrim Log, A Kraaijeveld, Western Norway University of Applied Sciences, Norway</i>	
Numerical Modelling of Thermal Conditions During Fires in Cave-Like Geometry .....	319
<i>Virginie Drean, G Auguin, S Sarfati, Efectis France, C Ferrier, PACEA Univ of Bordeaux, J-C Leblanc, TRACES Univ of Toulouse, D Lacanette, J-C Mindeguia, I2M Univ of Bordeaux, A Bellivier, LCPP, France</i>	
RABOT2012 Multi-Compartment Fire Tests - A Comparative Study with CFD .....	334
<i>Andrea Klippel, F Rabe, U Krause, Otto-von-Guericke Univ, A Klippel, A Hofmann, BAM, Germany</i>	
Repeatability of Underventilated Compartment Fire Testing with Complex Fuel Packages .....	349
<i>Peter Senez, P Mulherin, Jensen Hughes, USA, E Weckman, Univ of Waterloo, Canada</i>	

## TOXICITY

- An Investigation into the Relevance of the Contribution to Toxicity of different Construction Products in a Furnished Room Fire..... 352  
*Roy Weghorst, Kingspan Insulation, UK/Netherlands, E Antonatus, S Kahrmann, BASF, Germany, C Lukas, Dow Chemical Co, UK, Julian Bulk, CURRENTA, Germany*
- Polymer Combustion Products at Constant Fuel/Oxygen Ratios in the Microscale Combustion Calorimeter with FTIR..... 364  
*Louise Speitel, R Walters, R Lyon, FAA, USA*
- Use of FTIR Combined with Small-scale Fire Tests as Screening Test to Toxicity Test..... 378  
*Hideki Yoshioka, NILIM, T Hayakawa, TSV, S Fujimotos, Utsunomiya Univ, T Naruse, BRI, X Zhao, T Noguchi, Y Tanaike, Univ of Tokyo, K Yoshida, Yokohama National Univ, Y Hase, Mitsubishi Plastics, Japan*
- Fire Toxicity of Aircraft Seat Covers and Seat Foam..... 391  
*Gordon Andrews, L Witty, A Alarifi, I Obot, H Phylaktou, Univ of Leeds, UK*
- Real-Time Measurements Of Particulate And Toxic-Gas Concentrations ..... 409  
*Fumiaki Takahashi, Case Western Reserve Univ, P Greenberg, G Hunter, M Kulis, NASA Glenn Research Center, S Carranza, Makel Engineering, G Berger, Universities Space Research Assoc, USA*

## FIRE AND THE ENVIRONMENT

- Office Equipment Fire Safety: The Implications of Environmentally Preferable Purchasing Programs on Flame Retardant Usage and Fire Safety..... 422  
*Tim Earl, GBH International, USA*
- Assessment of the Environmental Impact of Warehouse Fires and Fire Service Response..... 433  
*Francine Amon, J Gehandler, SP Fire Research, Sweden*
- Wood Stove Chimney Smoke Monitoring and Opacity and Odor Reductions..... 443  
*Noel Putaasuu, IAAI-CFI, USA*

## FLAME RETARDANTS

- Polystyrene Foam Insulation with a Sustainable Flame Retardant: Transforming the Market .....986  
*Christine Lukas, Dow Chemical Company UK, L Ross, Intech Consulting Inc, USA, I Beulich, H Hollnagel, Dow Europe, Switzerland, M Beach, J Davis, J Hull, B King, S Kram, T Morgan, M Porter, W Stobby, The Dow Chemical Company, USA*
- Epoxy Flame Retardant Approaches – A Review for Transportation and New Flame Retardant Additives ..... 454  
*Alexander Morgan, V Benin, M Galaska, Univ of Dayton, USA.*
- Using Nature to Flame Retard Polyolefins ..... 464  
*David Schiraldi, T Deans, Case Western Reserve Univ, USA*
- Plant Based Flame Retardant Coatings for Flexible Polyurethane Foam ..... 472  
*Douglas Fox, H Khalfan, N Kaufman, American Univ, J Shields, R Davis, NIST, USA*
- Physical Characterization of Carbonaceous Products from Fire and Fire Retardants: Assessment of the Impact on Fire Performance ..... 478  
*Gizem Okyay, A Naik, P Tranchard, S Bellayer, M Jimenez, F Samyn, S Bourbigot, Univ of Lille, France*

## **FIRE RESISTANCE**

Determination of Thermochemical Properties of Mineral Wool Insulation Materials.....	491
<i>Beth Weckman M DiDomizio, E Weckman, Univ of Waterloo, R Roos, Roxul Inc, Canada</i>	
Experimental Analysis of Stone Wool Sandwich Composites Exposed to Constant Incident Heat Fluxes and Simulated Parametric Fires .....	503
<i>Blanca Andres Valiente, DBI, Denmark/Lund Univ, Sweden, J Hidalgo, L Bisby, Univ of Edinburgh, UK, P van Hees, Lund Univ, Sweden</i>	
The Fire Behaviour of Gypsum Boards Incorporating Phase Change Materials for Energy Storage in Building Applications .....	517
<i>Baljinder Kandola, A Alkhazaleh, G Milnes, Univ of Bolton, UK</i>	
Decomposition of Large-Scale Multicomponent Construction Assemblies Exposed to Real Fires .....	528
<i>Matthew DiDomizio, E Weckman, Univ of Waterloo, R Roos, Roxul Inc, Canada</i>	
Field Test Methods for Aluminum Alloy Residual Strength Follow Fire .....	543
<i>Brian Lattimer, M McKinnon, Jensen Hughes, R Mills, S Case, Virginia Tech, USA</i>	
Comparing Timber Adhesive Shear Strength Properties after Fire Damage .....	556
<i>Hailey Quiquero, J Gales, Carleton Univ, Canada</i>	
Using CFAST and FDS to Evaluate the Response of CLT in Natural and Standard Fires .....	567
<i>Marc Janssens, J Huczek, SwRI, USA</i>	
Fire-Structure Simulations using Fully Coupled Thermo-Mechanical Shell Elements .....	579
<i>Paul Beata, A Jeffers, Univ of Michigan, USA</i>	
FDS-FEM Simulation Method for Structural Fire Engineering Design: Validation and a Case Study.....	592
<i>Chao Zhang, NIST, USA /Tongji Univ, China, H Yu, Arup International, Hong Kong, China</i>	
<b>ENGINEERED WOOD PRODUCTS</b>	
Laminated Veneer Lumber Plated Connections in Fire .....	604
<i>Arlin Otto, J Gales, G Hadjisophocleous Carleton Univ, Canada</i>	
Full Scale Tests on the Performance of Hybrid Timber Connections in Real Fires .....	613
<i>Samuel Boadi, G Hadjisophocleous, Carleton Univ, Canada</i>	
Performance of Beam-to-Column Concealed Connections in Standard Fires.....	629
<i>Christian Gonzalez, G Hadjisophocleous, Carleton Univ, O Salem, Lakehead Univ, Canada</i>	
Rationalization of Cross-laminated Timber Design Standards .....	643
<i>Steve Craft, CHM Fire Consultants, I Van Zeeland, Canadian Wood Council, Canada</i>	
<b>WILDLAND</b>	
Statistical Analysis on Firebrand Generation from Structural Fuels .....	656
<i>Faraz Hedayati, A Zhou, Univ of North Carolina at Charlotte, USA</i>	
Laboratory Studies on the Generation of Firebrands from Cylindrical Wooden Rods .....	668
<i>Sara Caton, R Hakes, M Weston-Dawkes, M Gollner, A Tohidi, Univ of Maryland, N Bryner, NIST, USA</i>	

Wind Effects on Flame Spread and Ember Spotting Near a Structure .....	681
<i>Kathryn Butler, E Johnsson, M Fernandez, M Zarzecki, E Auth, G Forney, NIST, USA</i>	
Exposing Fencing Assemblies to Firebrand Showers Characteristic of Burning Structures .....	694
<i>Samuel Manzello, NIST, USA, S Suzuki, NRIFD, I Hagiwara, BRI, Japan</i>	
Accumulation and Characterization of Embers Deposited Adjacent to Buildings .....	705
<i>Stephen Quarles, Christine Standohar-Alfano, M Morrison, Insurance Institute for Business &amp; Home Safety, USA</i>	
Understanding Ignition Susceptibility of Wildland-Urban Interface Fuels to Firebrand Attack .....	716
<i>Raquel Hakes, S Caton, M Weston-Dawkes, M Gollner, Univ of Maryland, J Yang, NIST, USA</i>	
Ignition of Attic Insulation Foams Subjected to Firebrands .....	727
<i>Jacob Kadel, M Stickles, E Hamann, B Bahrani, A Zhou, Univ of North Carolina at Charlotte, USA</i>	
Ignition of Wildland Fuels by Hot Metal Particles and Droplets .....	740
<i>James Karnesky, E Christiansen, Exponent Failure Analysis Assoc, USA</i>	
Statistical Analysis on the Effects of Natural Weathering on the Performance of Intumescent Coatings using ANOVA .....	751
<i>Vahid Hemmati, B Bahrani, A Zhou, Univ of North Carolina at Charlotte, S Quarles, IBHS, USA</i>	
Modelling in WFDS of a Wildfire Scenario .....	765
<i>Johan Anderson, D Lange, A Lonnermark, P Mindykoski, SP Technical Research Inst, Sweden</i>	
<b>FIRE HAZARD</b>	
Recommendations for Documentation of Reaction-to-Fire Properties of Materials In the Oil and Gas Industry .....	778
<i>Karolina Storesund, A Steen-Hansen, SP Fire Research, Norway</i>	
Unregulated Combustibles: Decorative Materials .....	790
<i>Marcelo, Hirschler, GBH International, D Evans, DHE FPE LLC, USA</i>	
Fire Hazard Analysis of Indoor Large-Screen Digital Media System .....	803
<i>Xiaolei Chen, California State Univ, F Wang, Jensen Hughes, USA</i>	
Travelling Fire Spread between Vehicles in Car Parking Buildings .....	815
<i>Mohd Zahirasri Bin Mohd Tohir, Univ Putra Malaysia, Malaysia, M Spearpoint, Univ of Canterbury, New Zealand</i>	
Flammability Properties and Radiant Fraction of FRT Wood Plastic Composites using Mass Loss Calorimeter under HRR Hood .....	988
<i>Mark Dietenberger, C Boardman, N Stark, USFS Forest Products Lab, USA</i>	
<b>IGNITION AND PYROLYSIS MODELING</b>	
Determining Ignition Temperature Using Dynamic Thermal Analysis .....	827
<i>Richard Lyon, FAA, N Safronava, Technology and Management International, USA</i>	
Identification of the Solid Fuel Auto-Ignition Characteristics: Direct Numerical Simulation of the PMMA Auto-Ignition under Cone Calorimeter Configurations .....	840
<i>Simon Roblin, F Richard, T Rogaueme, Institut Pprime, France, A Trouve, Univ of Maryland, USA</i>	

Simulation of Micro-Scale Fiber Reinforced Polymer Resin and Additive Specimens for Kinetic Modeling .....	853
<i>Nick Dembsey, K Anderson, WPI, W Kreysler, Kreysler &amp; Associates, USA</i>	
Numerical Study on the Influence of In-depth Radiation in the Pyrolysis of Medium Density Fibreboard .....	863
<i>Guoxiang Zhao, T Beji, B Merci, D Zeinali, Ghent Univ, Belgium</i>	
Modified Heat of Combustion as a Tool for Evaluation of Building Products Combustibility .....	878
<i>Jagwiga Fangrat, Instytut Techniki Budowlanej, Poland, M Janssens SwRI, USA</i>	
<b>FIRE INVESTIGATION</b>	
Arc Mapping: New Science, or New Myth? .....	890
<i>Vytenis Babrauskas, Fire Science and Technology Inc, USA</i>	
Beware the Hidden Wood Particle Board .....	906
<i>Hervé Breulet, ISSeP, S Brohez, Univ of Mons, Belgium</i>	
Signature Recognition of Energetic Materials .....	918
<i>June Bott, Kevin Lewis, S Scheiff, Case Forensics Corp, J McCary, Novinium Inc, USA</i>	
Fire Testing of Aerosols and Propane Bottles .....	924
<i>Dan Madsen, J Barton, S Svensson, P van Hees, Lund Univ, Sweden</i>	
Electronic Ballast Fire Analysis .....	937
<i>Sebastian Scheiff, K Lewis, C Rice, K Rayment, M McClelland, J Bott, Case Forensics Corp, USA</i>	
Case Study: Pyrophoric Iron Reactions in Refinery and Petroleum Industries .....	948
<i>Isabelle Murray, CEP Forensic, R Gauvin, McGill Univ, Canada</i>	
Measurements on Smoke Generated from an Office Fire: Soot Mass Concentration, Wall Deposition and Particle Characterization .....	958
<i>Francois Xavier Ouf, IRSN, L Decoster, A Thiry, LCPP, A Coppalle, CORIA, France</i>	
On-site Investigation Exercise Based on Six Full-Scale Live Burnings .....	971
<i>Aurélien Thiry, E Faure, M Suzanne, N Dreuille, Laboratoire Central de la Préfecture de Police, B Poutrain, Paris Fire Brigade, C Remillon, Insttit de Recherché Criminelle de la Gendarmeries Nationale, V Vidotto, Inst National de Police Scientifique, France, O Delemont, Univ de Lausanne, Switzerland, K Pasedag, Buro fur Brandschutz, Germany</i>	

## **Author Index**