# **Interflam 2010**TABLE OF CONTENTS

## Volume 1

Prefaceiii
Co-organisers and Programme Committeeiv
KEYNOTE
Thirty years of Interflam - How fire research has evolved since 1979  Marc Janssens, Southwest Research Institute, USA
FIRE RESISTANCE AND STRUCTURAL FIRE PERFORMANCE
Evaluating the local fire response of steel beams by comparison to standard fire tests Ann Jeffers, University of Michigan and E Sotelino, Virginia Tech, USA11
Comparison of resultant steel temperatures using travelling fires and traditional methods: Case study for the informatics forum building Anna Jonsdottir, G Rein, University of Edinburgh and J Stern-Gottfried, Arup Fire, UK23
Fire protection of bridge cables Yaping He, University of Western Sydney, D Verghese, Meinhardt Australia Pty Ltd and I Bennetts, Noel Arnold and Associates, Australia
Intermediate detail modelling of structural connections in fire using shell elements  Graeme Flint, L Lim, A Jowsey, H Sarrazin, S Lamont, B Lane, Arup Fire, UK
Structural fire performance of concrete-filled steel hollow sections: State-of-the-art and knowledge gaps  David Rush, L Bisby, University of Edinburgh and A Jowsey, B Lane, Arup Fire, UK
Fire protection ability of wood products – A status report  Birgit Östman, SP Trätek, Sweden
On the fire performance of wood-wood and wood-steel-wood connections using bolts and dowels as fasteners  George Hadjisophocleous, L Peng, Carleton University and J Mehaffey,  M Mohammad, FPInnovations, Canada
Modelling the fire resistance of structural insulated panels: Heat transfer  Danny Hopkin, BRE Global Ltd/Loughborough University, V Silberschmidt,  Wolfson School of Mechanical & Manufacturing Engineering, J El-Rimawi,  Loughborough University and T Lennon, BRE Global Ltd, UK
Thermal and stress analysis of glazing systems under fire conditions Siaka Dembele, R Rosario, J Wen, Kingston University and I Williams, P Warren, Pilkington European Technical Centre, UK
Axial deformation of concrete exposed to fire and loading Elin Jensen, Jacob Van Horn and M Joshi, Lawrence Technological University, USA121
The effect of fire curve on concrete spalling  Lars Boström, R Jansson, SP Fire Technology, Sweden

#### **EXTINGUISHMENT / SUPPRESSION**

Water flows on vertical surface and around corners of corrugated cardboards for sprinkler protection of rack storage  Yibing Xin, J de Vries, S D'Aniello, FM Global, USA	143
A porous media model for sprinkler wetting  Joel Sipe, N Dembsey, Worcester Polytechnic Institute, USA	153
Assessment of the effects of air movement imparted by large diameter high volume low velocity ceiling fans on fire sprinkler operation and effectiveness Martin Pabich, Underwriters Laboratories Inc., and P Gore Willse, Global Asset Protection Services, USA	165
Spray pattern measurements of selected fire sprinklers  Xiangyang Zhou, S D'Aniello, H-Z Yu, FM Global, USA	177
Flame suppression by water sprays: Flame-spray interaction regimes and governing criteria Alexander Snegirev, A Lipjainen, V Talalov, St.Petersburg State Polytechnic University, Russia	
Quantitative assessment of sprinklers on sustainable development Christopher Wieczorek, B Ditch, L Gritzo, R Bill Jr, FM Global, USA	201
Assessment of the gas cooling capabilities of compressed air foam systems in fuel- and ventilation-controlled compartment fires  Jianping Zhang, A O' Neill, M Delichatsios, FireSERT, University of Ulster, UK	213
Simplified models of interactions of foam jets with hot smoke layers in under-ventilated fire conditions according to full-scale experiments  Paul Jourda, M Briffaud, J Hattenberger, D You, CEA, J-P Vantelon, CNRS and G Mitanchez, GIMAEX, France	223
Improvements of test method for water mist systems - CEN/TS 14972:2008, Annex A.3.  Anders Håkansson, D Langenbach, P van Hees, Lund University, Sweden, T Hermodsson, Danish Institute of Fire and Security Technology, Denmark and B Husted, Stord/Haugesund University College, Norway	235
Early detection of cable fires using image processing  Yulianto Nugroho, Suwarno, M Widyanto, Yanuar, E Jakti, G Alif, University of Indonesia, Indonesia	247
Performance evaluation framework for vision-based fire detection Steven Verstockt, Ghent University - IBBT/University College West Flanders, A Vanoosthuyse, University College West Flanders, B Merci, N Tilley, Ghent University, B Sette, Warringtonfiregent (WFRGent NV) and C Hollemeersch, P Lambert, R Van de Walle, Ghent University – IBBT, Belgium	257
FIRE TESTING AND MEASUREMENT TECHNIQUES	
Pyrolysis combustion flow calorimetry: A tool for flame retardant development and fundamental combustion science  Alexander Morgan, University of Dayton Research Institute, USA	269
Convective heat transfer in the cone calorimeter revisited  Marc Janssens, C. Gomez, Southwest Research Institute, USA	281

Alternate substrates for measuring cigarette ignition propensity using ASTM E 2187  Richard Gann, E Hnetkovsky, W Guthrie, NIST, USA	. 291
Measurement and prediction of smoke deposition in fires Craig Beyler, Hughes Assocs, S Riahi, Hughes Assocs/The George Washington University and J Hartman, United States Naval Academy, USA	. 303
A new rapid analysis method for fire retardants in polymers Gary Stevens, P Baird, H Herman, W Mortimore, GnoSys UK Ltd, University of Surrey, UK	. 315
Measurement of incident radiant heat flux with the plate thermometer  Ulf Wickström, SP Technical Research Institute, Sweden	. 327
Comparison of furnace temperature and incident heat flux in wall and floor furnaces controlled by six different temperature sensors  Mohamed Sultan, Institute for Research in Construction, National Research  Council Canada, Canada	. 341
Repeatability of instrument measurements in large-scale fire reconstruction experiments David Sheppard, US Dept of Justice, Bureau of Alcohol Tobacco Firearms and Explosives, USA	. 353
Chemical species and temperature mapping in full scale underventilated compartment fires Andrew Lock, M Bundy, E Johnsson, K Opert, A Hamins, NIST, USA and C Hwang, Daejeon University, K Yong Lee, Andong National University, South Korea	. 365
FIRE PERFORMANCE OF MATERIALS AND PRODUCTS	
A study of fire performance of textile membranes used as building components Per Blomqvist, P Andersson, SP Technical Research Institute, Sweden	. 375
Use of fire blocking and barrier systems to comply with fire tests for furnishings  Gordon Damant, Damant and Assocs, USA	. 387
Effect of rack mounted PV modules on flammability of roofing assemblies Mahmood Tabaddor, R Backstrom, P Gandhi, Underwriters Laboratories, Inc., USA	. 397
Multi-scale simulation of the fire behaviour of a FRP sandwich composite – Comparison of model results with experimental data.  Damien Marquis, E Guillaume, C Chivas-Joly, L Bustamante-Valencia, LNE, M Pavageau, EMAC, J Gutierrez, DCNS, CESMAN, C Cueff, DCNS, France	. 407
Euroclass predictions for developing wood based products with improved fire performance Lazaros Tsantaridis, B Östman, SP Trätek / Wood Technology, Sweden and T Hakkarainen, VTT Technical Research Centre, Finland	. 419
Electrical circuit and cable testing Gabriel Taylor, Nuclear Regulatory Commission, K McGrattan, NIST, S Nowlen, Sandia National Laboratories, USA	. 429
Prediction of fire classification of cables - Extended application of test data Björn Sundström, M Försth, P Johansson, SP Technical Research Institute, Sweden and S Grayson, Interscience Communications Ltd, T Journeaux, Europacable, UK	. 439

#### **PYROLYSIS MODELLING**

Numerical simulation of polymer materials in standard fire tests: Pyrolysis and the impact of residue formation

Florian Kompal, B. Schottel, A. Hofmann, PAM Fodoral Institute for Materials

Florian Kempel, B Schartel, A Hofmann, BAM Federal Institute for Materials Research and Testing, Germany and G Linteris, NIST, R Lyon, R Walters,

Federal Aviation Association, S Stoliarov, University of Maryland, USA451
The role of thermal decomposition kinetics in the burning of polymers  Richard Lyon, Federal Aviation Administration, N Safronava, SRA International,  S Stoliarov, University of Maryland, USA
Thermal degradation kinetics modeling for pyrolysis modeling using fire retarded thermoset polymer resins  Esther Kim, S Shivkumar, N Dembsey, WPI, USA
Measurement and modelling of thermochemical properties of porous materials as a function of temperature during multi-stage decomposition processes  Lucas Bustamante Valencia, E Guillaume, D Marquis, C Chivas-Joly, B Hay,  V Scoarnec, LNE, T Rogaume, Institut Prime, France and G Rein, J Torero,  University of Edinburgh, UK
On the effect of dimensional and morphological changes in cellular plastics during combustion – cone calorimeter and gasification testing Roland Krämer, J Gilman, NIST, USA and N Witten, Zotefoams PLC, UK
A model of burning for charring polymers Stanislav Stoliarov, University of Maryland and S Crowley, R Walters, R Lyon, Federal Aviation Administration, USA
Heat transfer, foam decomposition, and container pressurization: Comparison of experimental and modeling results Kenneth Erickson, A Dodd, R Hogan, K Dowding, Sandia National Laboratories, USA
Examination of the spontaneous transition from smoldering to flaming: Comparison of simulations and experiments  Amanada Dodd, Sandia National Laboratories, C Lautenberger, A Fernandez-Pello, University of California at Berkeley and O Putzeys, Exponent Failure Analysis Associates, USA
MATERIALS FLAMMABILITY
Nondimensional commodity classification and an analysis of upward flame spread  Michael Gollner, F Williams, University of California, K Overholt, A Rangwala,  Worcester Polytechnic Institute and J Perricone, Creative FPE Solutions, USA
Combustibility characterization of oxidizer-fuel mixtures using the fire propagation apparatus Elizabeth Buc, Fire and Materials Research Laboratory and M Khan, FM Global, USA 557
Burning behaviour of intumescent coating and nanoparticles applied on flaxboard Jianping Zhang, M Delichatsios, M McKee, S Ukleja, FireSERT, University of Ulster, UK 569
Melting rate of polyurethane foam in a vertical orientation  Charles Fleischmann, D Pau, University of Canterbury, New Zealand
FLAME RETARDANTS
The relationship of sustainability to flammability of construction materials Robert Bill Jr, K Meredith, N Krishnamoorthy, S Dorofeev, L Gritzo, FM Global, USA593
Fire safety versus environmental concerns – how can we achieve sustainable solutions for flame retardants?  Adrian Beard, Clariant Produkte (Deutschland) GmbH, Germany

Lein Tange, R Borms, ICL-IP Europe, The Netherlands and P Georlette, ICL-IP, Israel	. 615
Characterizing particle emissions from burning polymer nanocomposites  Marc Nyden, M Zammarano, R Harris, R Kramer, N Uddin, N Marsh, NIST, USA	. 623
Synergistic flame retardant halogen-free combination of aluminium phosphinate and metal oxides in PBT  Emanuela Gallo, University of Naples, Italy / BAM, Germany, B Schartel, U Braun, BAM, Germany and P Russo, D Acierno, University of Naples, Italy	629
Improvement of thermal and fire retardancy properties of a (ammonium polyphosphate/melamine polyphosphate/ metal oxide nanoparticles/) ternary system in PMMA by experimental design Blandine Friederich, Centre de Recherche Public Henri Tudor, Luxembourg / Université Paul Verlaine Metz, France, A Laachachi, D Ruch, V Toniazzo, Centre de Recherche Public Henri Tudor, Luxembourg and M Ferriol, M Cochez, Université Paul Verlaine Metz, France	641
New phosphorus-based flame retardant for engineering thermoplastics and styrenics Robert Stenekes, S Goebelbecker, ICL-IP Europe, The Netherlands, S Levchik, P Moy, ICL-IP America, USA and I Finberg, ICL-IP, Israel	653
Prominent effect of smooth carbon layer on flame retardancy Erika Nakashima, M Yukumoto, K Takeda, Chubu University, T Ihara, Ihara Gosei Co Ltd and T Ueno, The University of Tokyo, Japan	. 661
Combustion and flammability behaviour of unsaturated polyester / phenolic resin blends Baljinder Kandola, P Luangtriratana, University of Bolton, UK	. 673
IGNITION AND FLAME SPREAD MODELLING	
IGNITION AND FLAME SPREAD MODELLING  Numerical investigation of the ignition delay time in PMMA at high heat fluxes  Nicolas Bal, G Rein, University of Edinburgh, UK	. 685
Numerical investigation of the ignition delay time in PMMA at high heat fluxes	
Numerical investigation of the ignition delay time in PMMA at high heat fluxes Nicolas Bal, G Rein, University of Edinburgh, UK	697
Numerical investigation of the ignition delay time in PMMA at high heat fluxes Nicolas Bal, G Rein, University of Edinburgh, UK	697
Numerical investigation of the ignition delay time in PMMA at high heat fluxes Nicolas Bal, G Rein, University of Edinburgh, UK	709
Numerical investigation of the ignition delay time in PMMA at high heat fluxes Nicolas Bal, G Rein, University of Edinburgh, UK	709
Numerical investigation of the ignition delay time in PMMA at high heat fluxes Nicolas Bal, G Rein, University of Edinburgh, UK	709 721 731

framework  Jason Floyd, Hughes Associates and R McDermott, NIST, USA	755
Coupling a network HVAC model to a computational fluid dynamics model using large eddy simulation  Jason Floyd, Hughes Associates, USA	765
CFD simulation of radiative heat transfer between a buoyant turbulent fire and inert parallel panels  Prateep Chatterjee, N Krishnamoorthy, Y Wang, J de Ris, S Dorofeev, FM Global, USA	777
	7 7 7
CFD study of flow field phenomena in scaling up of small-scale smoke extraction ` experiments  Nele Tilley, P Rauwoens, B Merci, Ghent University, Belgium	789
HUMAN BEHAVIOUR: EVACUATION AND EGRESS	700
Study on the influence of smoke and exit signs on fire evacuation - analysis of evacuation	
experiments in a real and virtual hotel  Margrethe Kobes, Netherlands Institute for Safety / VU University Amsterdam,  I Helsloot, VU University Amsterdam, B de Vries, Eindhoven University of	
Technology and J Post, N Oberijé, K Groenewegen, Netherlands Institute for Safety, The Netherlands	801
Uncontrolled vs controlled emergency procedures in high speed passenger trains  Jorge Capote, D Alvear, A Cuesta, University of Cantabria, Spain	813
Quantitative validation of simulated visibility in smoke laden environments Qihui Zhang, Geodata SpA, Italy and P Rubini, University of Hull, UK	825
Human behavior in road tunnel fires: Comparison between egress models (FDS+Evac, STEPS, Pathfinder) Enrico Ronchi, N Berloco, P Colonna, Polytechnic of Bari, Italy and D Alvear, J Capote, A Cuesta, University of Cantabria, Spain	837
A study on risk-based evacuation safety design method in fire for office buildings T Tanaka, Kyoto University, D Nii, National Institute for Land and Infrastructure Management, J-i Yamaguchi, Obayashi Corporation, H Notake, Shimizu Corporation and Y Ikehata, Taisei Corporation, Japan	849
Fire response performance model for a systematic analysis of evacuation safety in buildings – A case study of a fire in a football stadium Jos Post, M Kobes, N Oberijé, J Weges, Netherlands Institute for Safety, The Netherlands	861
Microscopic modelling of crowd movement at major events  Volker Schneider, R Könnecke, IST GmbH, Germany	873
Investigating the impact of culture on evacuation behaviour Edwin Galea, S Deere, G Sharp, L Filippidis, L Hulse, University of Greenwich, UK	879
FIRE AND EMERGENCY RESPONSE	
Quantifying efficiency in fire fighting operations Stefan Svensson, Swedish Civil Contingencies Agency, Sweden	893
Developments in positive pressure ventilation Stephen Kerber, Underwriters Laboratories Inc, USA and Stefan Svensson, Swedish Civil Contingencies Agency, Sweden	905

Simulation of the flow induced by positive pressure ventilation fan under wind driven conditions	
Arun Mahalingam, M Patel, E Galea, University of Greenwich, UK913	
Wind driven fires in structures  Daniel Madrzykowski, S Kerber, NIST, USA	
Chemical exposure and protection of fire site workers  Tuula Hakkarainen, K Tillander, H Järnström, T Paloposki, VTT Technical Research  Centre of Finland and J Laitinen, M Mäkelä, P Oksa, Finnish Institute of Occupational  Health, Finland	
Residential building fire test scenarios to investigate firefighter exposure to smoke Jacob Borgerson, T Fabian, P Gandhi, Underwriters Laboratories Inc., USA	
Predicting inward leakage for negative pressure conditions in a firefighter respirator  Rodney Bryant, NIST, USA	
CODES AND REGULATIONS	
The quest for performance-based building regulation: From Hammurabi to the IRCC Richard Bukowski, Rolf Jensen and Associates, USA	
Fire test standards used in US codes and regulations  Marcelo Hirschler, GBH International, USA	
Developments in fire safety engineering methodology for classifying products on European trains	
Peter Briggs, C Dean, C Hughes, Exova Warringtonfire, UK	
Fire compartment sizes and the benefit of sprinklers - A risk based approach using Monte Carlo simulations.  Craig English, S Bennett, Interscience Communications Limited (Hoare Lea Fire), UK	7
Active fire protection measures and probabilistic system analysis as a basis for a national fire safety concept in Germany Christoph Klinzmann, hhpberlin - Ingenieure für Brandschutz GmbH and D Hosser, Technische Universität Braunschweig, Germany	)
A risk-informed framework for performance-based structural fire protection according to the Eurocode fire parts  Cornelius Albrecht, D Hosser, Technische Universität Braunschweig, Germany	1

#### Author Index

### Volume 2

#### COMPARTMENT FIRE EXPERIMENTS AND MODELLING

Validation of numerical simulations of compartments with forced or natural ventilation using the fire and smoke simulator (FSSIM), CFAST and FDS  Justin Williamson, C Beyler, J Floyd, Hughes Associates, Inc., USA
Smoke movement induced by buoyancy and total pressure between two confined and mechanically ventilated compartments  Hughes Pretrel, L Audouin, IRSN, France
Comprehensive data set for validation of fire growth models: Experiments and modeling Chris Lautenberger, C Fernandez-Pello, University of California, W Wong, N Dembsey, Worcester Polytechnic Institute, A Coles, Arup Fire, USA
Experimental review of the homogeneous temperature assumption in post-flashover compartment fires  Jamie Stern-Gottfried, University of Edinburgh / Arup Fire, G Rein, J Torero, University of Edinburgh, UK
TRANSPORTATION AND TUNNEL FIRES
Modelling factors that influence CFD fire simulations of large tunnel fires  Fuchen Jia, Z Wang, E Galea, University of Greenwich, UK
Modelling the interaction between suppression and ventilation systems in tunnel fires George Hadjisophocleous, Y Ko, Carleton University, Canada
Use of computer modeling for the interpretation of midscale tunnel fire test results  Elizabeth Blanchard, LEMTA / CSTB, P Boulet, LEMTA, S Desanghere, E Cesmat,  CSTB, France
Fire spread in car parks: The contribution of materials on the exterior of modern vehicles  David Crowder, R Cullinan, BRE Global, UK
Experimental and numerical investigations of the burning behavior of vehicle materials:  Small, intermediate and large scale investigations  Anja Hofmann, S Krüger, A Klippel, BAM, Germany
On the fire and explosion risk profile of alternative fuels to kerosene in civil transportation aircrafts  Guy Marlair, A Vignes, A Janès, J-P Bertrand, B Tribouilloy, N Eynaud, INERIS, France
URBAN AND WILDLAND FIRES
A model for post-earthquake fire spread considering the damage of structural members caused by seismic motion and heating of fire  Keisuke Himoto, T Tanaka, Kyoto University, K Mukaibo, Ritsumeikan University,  Y Akimoto, Mitsubishi UFJ Research & Consulting, R Kuroda, Ichijo Corporation and  A Hokugo, Kobe University, Japan
Evaluation of the fire safety performance of Kyoto City in post-earthquake fire Tomoaki Nishino, S-i Tsuburaya, K Himoto, T Tanaka, Kyoto University, Japan1175
Quantifying wind driven firebrand penetration into building vents using full scale and

reduced scale experimental methods Samuel Manzello, S-H Park, S Suzuki, J Shields, NIST, USA	. 1189
Effectiveness of pre-applied wetting agents in prevention of wildland urban interface fires Joe Urbas, P Desai, University of North Carolina-Charlotte, USA	. 1201
FIRE ENGINEERING	
A holistic approach to fire risk management for buildings in the UK Selda Konukcu, D Bouchlaghem, Loughborough University, UK	. 1213
Pool fires – toward a general correlation Benjamin Ditch, J de Ris, FM Global and T Blanchat, Sandia National Laboratories, USA	. 1225
Making the biggest difference: Selecting priorities for fire safety science and engineering John Hall, NFPA, USA	. 1237
Tenability analysis for fire experiments conducted in a full-scale test house with basement fire scenarios  Joseph Su, N Bénichou, A Bwalya, G Lougheed, B Taber, P Leroux, National Research Council Canada, Canada	. 1247
Towards an integrated performance-based design approach for life safety across different building use groups  Alberto Alvarez, B Meacham, Worcester Polytechnic Institute, USA	. 1259
Semi-quantitative analysis of the need for fire-resistance of façades in a sprinklered high rise building  Michael Haas, P van de Leur, DGMR Consulting Engineers, The Netherlands	. 1271
FIRE INVESTIGATION AND DECONSTRUCTION	
FIRE INVESTIGATION AND RECONSTRUCTION	
Electric arc explosions  Vytenis Babrauskas, Fire Science and Technology Inc., USA	. 1283
Electric arc explosions	
Electric arc explosions  Vytenis Babrauskas, Fire Science and Technology Inc., USA  Thermal malfunction criteria of fire safety electrical equipment in nuclear power plants	. 1297
Electric arc explosions  Vytenis Babrauskas, Fire Science and Technology Inc., USA  Thermal malfunction criteria of fire safety electrical equipment in nuclear power plants  Laurent Gay, R Gracia, EDF R&D and E Wizenne, EDF SEPTEN, France  Target compound ratios and chemometric analyses for the individualization of neat ignitable liquids and residues from fire debris  J Graham Rankin, A Bondra, C Trader, Marshall University and W Lu, P Harrington,	. 1297 . 1305
Electric arc explosions  Vytenis Babrauskas, Fire Science and Technology Inc., USA  Thermal malfunction criteria of fire safety electrical equipment in nuclear power plants  Laurent Gay, R Gracia, EDF R&D and E Wizenne, EDF SEPTEN, France  Target compound ratios and chemometric analyses for the individualization of neat ignitable liquids and residues from fire debris  J Graham Rankin, A Bondra, C Trader, Marshall University and W Lu, P Harrington, Ohio University-Athens, USA  A study of the effect of high temperature on the physicomechanical properties of natural building limestones  Kyriacos Kyriakides, G Hadjisophocleous, Carleton University, Canada and L Petrou,	. 1297 . 1305 . 1321
Electric arc explosions  Vytenis Babrauskas, Fire Science and Technology Inc., USA	. 1305 . 1321 . 1329
Electric arc explosions  Vytenis Babrauskas, Fire Science and Technology Inc., USA	. 1305 . 1321 . 1329 . 1341

2005 Buncefield vapor cloud explosion: Unraveling the mystery of the blast Scott Davis, P Hinze, O Hansen, K van Wingerden, GexCon, USA	65
SMOKE AND TOXICITY	
Influence of carbon nanotubes on fire behavior and on decomposition products of thermoplastic polymers  Carine Chivas-Joly, E Guillaume, S Ducourtieux, L Saragoza, D Lesenechal, LNE,  J-M Lopez-Cuesta, C Longuet, R Sonnier, CMGD, S Duplantier, JP Bertrand, D Calogine,  INERIS, B Minisini, ISMANS and D Parisse, PlasticsEurope, France	75
Assessment of environmental effects of simulated fires in waste recycling centres Tuomo Rinne, K Tillander, VTT Technical Research Centre of Finland, P Yli-Pirilä, J Ruuskanen, University of Eastern Finland and J Jäntti, T Väisänen, Emergency Services College, Finland	87
Fire emissions from products with and without BFRs and the hazard of exposure for fire fighters and clean-up crews  Margaret Simonson McNamee, P Blomqvist, P Andersson, SP Technical Research Institute,  Sweden and M van den Berg, R Fernandez Canton, Utrecht University, The Netherlands 139	99
Fire hazard analysis of hetero-organic fuels – source characteristics from experiments  Berit Andersson, Lund University, Sweden	11
Transport of toxic products – comparison of experimental and numerical results part one: Non-sprinklered scenarios Robert Accosta Jr, Ove Arup & Partners, Zachary Magnone, J Crocker, B Xiao, Tyco Fire Suppression & Building Products and N Dembsey, B Meacham, Worcester Polytechnic Institute, USA	23
Simulation of critical evacuation conditions for fire scenarios involving cables and comparison of different cables  Patrick van Hees, D Nilsson, Lund University, Sweden	35
POSTERS144	43
HUMAN BEHAVIOUR: EVACUATION AND EGRESS	
PeMMA (People Movement Modelling Analysis): A new methodology for helping to address people's safety in open and enclosed spaces Rodrigo Machado, S Marshall, Mark Anderson, Capita Symonds, UK	45
The use of serious gaming in training of team decision making in life threatening situations  Margrethe Kobes, E Didderen, Netherlands Institute for Safety, The Netherlands and  M van Wijngaarden, ETC Simulation, USA	49
Data collection and analysis of evacuation scenarios in Finland  Tuomo Rinne, K Tillander, P Grönberg, VTT Technical Research Centre of Finland,  Finland	55
Study on phased evacuation through the analysis of total evacuation drill in a high-rise office building  Ai Sekizawa, T Sano, H Kadokura, D Ooiwa, Tokyo University of Science, Japan	61
Implications of computer simulation and experimental studies of evacuation behaviour in the simple-shaped room  Tomonori Sano, Waseda University, Y Yoshida, N Takeichi, Y Minegishi, Takenaka  Corporation and T Kimura, A & A Co., Ltd., Japan	

The faults with default

Steve Gwynne, Hughes Associates, Inc and E Kuligowski, NIST, USA	. 1473
Study on the visual environment designs for effective evacuation guidance - Measurement and evaluation of sign installation in escape routes  Yuki Akizuki, S Okuda, M Iwata, T Tanaka, University of Toyama, Japan	1479
Building egress flow rates – Research, application & limitation  Matthew Salisbury, M Slattery, A Slattery, Michael Slattery Associates Fire Engineers,  UK & Ireland and T Denby, Axiomatic Technology Limited, UK	. 1487
FIRE AND EMERGENCY RESPONSE	
The provision of a risk information system for the English fire and rescue service David Berry, FARMSS, UK	. 1493
Modeling issues in backdraft incident fire reconstruction Fabio Alaimo Ponziani, A Tinaburri, Ministry of the Interior, Italy	. 1499
Fire behavior of the wooden heritage building: Tripitaka Storage Hall  Ji-Hee Lee, W-J Kim, Kyungpook National University and S-J Park, K-I Kim,  Inje University, Korea	. 1505
The role and function of lift landing doors in a fire Chris Marriner, P Jackman, International Fire Consultants Ltd, UK	. 1511
Rationalizing design requirements for stair pressurization systems  Jamie Stern-Gottfried, S Winter, P Williams, Arup Fire, UK	. 1517
Supporting integrated risk management planning for the UK fire and rescue services: Evaluation of prevention and protection activities on commercial, public and heritage buildings	
Stefan Raue, C Johnson, University of Glasgow and D Bouchlaghem, S Konukcu, Loughborough University, UK	. 1523
Image quality evaluations for fire service thermal imaging cameras: Subjective vs objective testing	
Francine Amon, D Leber, NIST and J Rowe, Hughes Associates, Inc., USA	. 1531
WPI precision personnel location and tracking system for first responders  R. James Duckworth, D Cyganski, WPI, USA	. 1537
CFD MODELLING	
FDS and OpenMP – A new parallelization approach for fire modelling software Christian Rogsch, Fire Protection Engineer, Germany	. 1543
Quantitative risk assessment of shipboard fire by first-principles tools  Camille Azzi, A Pennycott, D Vassalos, University of Strathclyde, UK	. 1549
Simulations of two-way fluid-structure interactions during a fire with the ANSYS software Yehuda Sinai, HeatAndFlow Consultancy Limited and J Penrose, ANSYS UK Limited, UK	. 1557
Best practice in the use of CFD for fire simulation Bjarne Husted, B Hagen, Stord/Haugesund University College, Norway and K Sommerlund-Thorsen, Danish Institute of Fire and Security Technology, Denmark	. 1563
Realistic smoke visualisation from computer fire simulations  Richard Chitty, BRE Global Ltd, UK	. 1569

Simulations of upward flame spread by coupling a pyrolysis model with a CFD calculation Pieter Rauwoens, J Degroote, S Wasan, J Vierendeels, B Merci, Ghent University, Belgium	5
A method of quantifying user uncertainty in FDS by using Monte Carlo analysis  Tor Lindström, D Lund, Lund University, Sweden	1
Spreading fires in FDS5 modelling (case studies)  Victor Shestopal, Fire Modelling & Computing, M Foley, J Hewitt, E Yii, Arup Fire and  F Bakker, Norman Disney & Young, Australia	7
Towards large eddy simulation of LNG pool fires  Jennifer Wen, Z Chen, S Dembele, Kingston University, UK	3
SUPPRESSION / EXTINGUISHMENT	
Experimental investigation of an office fire with a partially impaired sprinkler system  Min-sheng Chiu, C-T Tzeng, T-H Lin, National Cheng-Kung University, Taiwan	9
Water mist systems for the fire protection of prison cells  Kelvin Annable, BRE Global Ltd, UK	5
FIRE PERFORMANCE OF MATERIALS AND PRODUCTS	
Development of expandable flame-retardant plastic tube and its application  Yuichi Nakagawa, AIST, Y Kumagai, Y Tomita, SGC Company Limited, K Saito,  Ibaraki Prefectural Government and K Nihei, Industrial Technology Institute of Ibaraki  Prefecture, Japan	1
Assessment of the impact of upholstered furniture on the severity of home fires  Lindsay Osborne, E Zalok, G Hadjisophocleous, Carleton University, Canada	7
Different approaches for fire source modeling application to Arcueil experiments  Aurélien Thiry, Laboratoire Central de la Préfecture de Police, M Suzanne, Laboratoire  Central de la Préfecture de Police / Université de Rouen, A Bellivier, H Bazin, A Coppalle,  Université de Rouen, France and C Lautenberger, University of California, USA	3
Ignition and burning behaviour of plastic sheathing of a steel pipe lan Bennetts, Noel Arnold and Associates, K Moinuddin, Victoria University of Technology, Y He, University of Western Sydney, D Verghese, Meinhardt Australia Pty Ltd, Australia 1629	9
Testing and modeling reaction-to-fire performance of pultruded fiber reinforced polymer composites  Aixi Zhou, Z Yu, University of North Carolina at Charlotte, USA	5
MATERIALS FLAMMABILITY	
Causes and consequences of sparks on the surface of insulators of middle voltage lines C D Halevidis, S Anagnostatos, A Polykrati, P Bourkas, National Technical University of Athens and E Koufakis, Public Power Corporation. Greece	1
FIRE TESTING AND MEASUREMENT TECHNIQUES	
Fire behavior comparison of compartment tests conducted in full and partial structures  Brian Grove, United States Department of Justice, Bureau of Alcohol Tobacco  Firearms and Explosives Fire Research Lab, USA	7

Experimental charring rates for cross-laminated timber panels compared to calculated	
charring rates Kathinka Friquin, Norwegian University of Science and Technology (NTNU), Norway168	59
FLAME RETARDANTS	
Flame retardancies of olefins and polystyrene with controlled molecular weights  Erika Nakashima, M Yukumoto, K Takeda, Chubu University, T Ihara, Ihara  Gosei Co. Ltd. and T Ueno, The University of Tokyo, Japan	65
FIRE RESISTANCE AND STRUCTURAL FIRE PERFORMANCE	
Comparison of gypsum board fall-off in wall and floor assemblies exposed to furnace heat Mohamed Sultan, National Research Council of Canada, Canada	i77
Numerical modelling to determine appropriate levels of glazing fire resistance  Stewart Miles, C Marriner, International Fire Consultants Ltd., UK	83
The role of moisture in fire spalling of concrete  Robert Jansson, L Boström, SP Fire Technology, Sweden	89
Failure times of gypsum plasterboards  Alar Just, Resand Ltd, Estonia and J Schmid, J König, SP Trätek, Sweden169	95
An investigation into the fire protection of domestic floors containing timber 'l' joists, at service penetrations  William Hay, Falkirk Council and M Cullen, I Sanderson, Glasgow Caledonian  University, UK	'01
IGNITION AND FLAME SPREAD MODELLING  Experimental investigations of fire spread from movable to fixed fire loads in office fires  Ko-Jen Chen, C-T Tzeng, T-H Lin, C-m Lai, National Cheng-Kung University and M-J Tsai,  Ministry of the Interior, Taiwan	'07
Upward flame spread and ignition on inclined surfaces of thin and thick solids  Nina Schjerve, U Schneider, University of Technology Vienna, Austria	'13
Thermal stresses over glass panel under fire WK Chow, The Hong Kong Polytechnic University, China, C Chow, The Hong Kong Polytechnic University, China / University of Cambridge, UK and Y Gao, Harbin Engineering University, China	'19
Simulating a rail car fire using a flame spread model  Xiaoqin Hu, Z Wang, F Jia, E Galea, University of Greenwich, UK	'25
TRANSPORTATION AND TUNNEL FIRES	
Motorcoach tire fire passenger compartment penetration experiments  Erik Johnsson, J Yang, NIST, USA	'31
Parameter study on the global and local flow field in case of fire and forced ventilation in a closed car park  Xavier Deckers, M Jangi, S Haga, B Merci, Ghent University, Belgium	'37
	51
Experimental and computational study on the fire test for railway vehicle seats in a room corner facility  Dong-Chan Lee, D-H Lee, W-S Jung, C-K Lee, Korea Railroad Research Institute, Korea 174	'43
TRANSFEU (Transport Fire Safety Engineering in the European Union)	
Alain Sainrat, LNE, France175	51

#### **SMOKE AND TOXICITY**

Investigations of smoke gas composition during a car fire Simone Krüger, A Berger, A Hofmann, U Krause, BAM, Germany
On-line FTIR measurements applied for real electrical cabinet fires  Pascal Zavaleta, D Kaifas, G Basso, L Audouin, IRSN and A Lacoste, BMPM, France
Predicting concentrations of hydrogen cyanide in full scale enclosure fires  Zhaozhi Wang, F Jia, E Galea, University of Greenwich, UK
COMPARTMENT FIRE EXPERIMENTS AND MODELLING
Determination by a CFD code and a global model of the fuel mass loss rate in a confined and mechanically-ventilated compartment fire Ayoub Nasr, S Suard, IRSN, H El-Rabii, JP. Garo, LCD and L Gay, EDF R&D, France 1775
Fire containment by vent opening protectives in the open state  Reidar Stølen, SINTEF NBL, Norway and A Tamim, COWI Gulf, Oman
Numerical simulation of fire spreading in a two-storey residential building  Dionysios Kolaitis, E Asimakopoulou, M Founti, National Technical University of  Athens, Greece
Behavior of fire plume ejected from an opening in consideration of side walls near building openings Yoshifumi Ohmiya, Tokyo University of Science, Japan
FIRE ENGINEERING
FIRE ENGINEERING  Agent based risk assessment of fire safety systems with automated event tree analysis Farid Akashah, J Zhang, M Delichatsios, FireSERT and H Wang, University of Ulster, UK 1805
Agent based risk assessment of fire safety systems with automated event tree analysis
Agent based risk assessment of fire safety systems with automated event tree analysis Farid Akashah, J Zhang, M Delichatsios, FireSERT and H Wang, University of Ulster, UK 1805
Agent based risk assessment of fire safety systems with automated event tree analysis Farid Akashah, J Zhang, M Delichatsios, FireSERT and H Wang, University of Ulster, UK 1805  FIRE INVESTIGATION AND RECONSTRUCTION  Use of case studies to determine technical deficiencies with respect to fire spread in school buildings subjected to arson fires
Agent based risk assessment of fire safety systems with automated event tree analysis Farid Akashah, J Zhang, M Delichatsios, FireSERT and H Wang, University of Ulster, UK 1805  FIRE INVESTIGATION AND RECONSTRUCTION  Use of case studies to determine technical deficiencies with respect to fire spread in school buildings subjected to arson fires Nils Johansson, P van Hees, Lund University, Sweden
Agent based risk assessment of fire safety systems with automated event tree analysis Farid Akashah, J Zhang, M Delichatsios, FireSERT and H Wang, University of Ulster, UK 1805  FIRE INVESTIGATION AND RECONSTRUCTION  Use of case studies to determine technical deficiencies with respect to fire spread in school buildings subjected to arson fires  Nils Johansson, P van Hees, Lund University, Sweden
Agent based risk assessment of fire safety systems with automated event tree analysis Farid Akashah, J Zhang, M Delichatsios, FireSERT and H Wang, University of Ulster, UK 1805  FIRE INVESTIGATION AND RECONSTRUCTION  Use of case studies to determine technical deficiencies with respect to fire spread in school buildings subjected to arson fires  Nils Johansson, P van Hees, Lund University, Sweden

LATE PAPERS1843
The costs and benefits of sprinklers in schools  Jeremy Fraser-Mitchell, BRE Global, UK
Electrical cable failure—experiments and simulation  Jason Dreisbach, Nuclear Regulatory Commission, S Nowlen, Sandia National  Laboratories, K McGrattan, NIST, USA and S Hostikka, VTT Technical Research  Centre of Finland, Finland
Influence of magnesium hydroxide as flame retardant in filled polypropylene used in industrial Plasticollar®  Daniela Enescu, A Frache, M Lavaselli, G Camino, Politecnico Di Torino and C Campia, S Novara, G Gualtieri, Campia Imballaggi Srl, Italy
Community risk assessment modeling: Results of residential fireground field experiments Adam Barowy, J Averill, BFRL/NIST, Kathy Notarianni, WPI, L Moore-Merrell, International Association of Firefighters and R Santos, Urban Institute, USA
Observations on the generation of toxic products in the NFPA/ISO smoke density chamber Nathan Marsh, R Gann, M Nyden, NIST, USA
Modeling thermoplastic melt spread over different flooring materials  Kathryn Butler, NIST, USA and E Oñate, R Rossi, J Marti, S Idelsohn, CIMNE, Spain
Characterization of Combustion Products from Flaming Materials  Thomas Z. Fabian, J L. Borgerson, P D. Gandhi, Underwriters Laboratories Inc., USA
Burning Behavior of Live and Dead <i>Pinus Halepensis</i> Needles Using Small Scale Calorimetry Experiments  F. Jervis, G. Rein, J. L. Torero, BRE Centre For Fire Safety Engineering,  University Of Edinburgh, UK A. Simeón, University of Corsica, France
Author Index