

Christopher W. Lautenberger, PhD, PE

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Current Position

Principal Engineer, Reax Engineering, Inc. – Berkeley, CA

Education

PhD – Mechanical Engineering (major field: combustion), University of California, Berkeley, 2007

MS – Fire Protection Engineering, Worcester Polytechnic Institute, 2002

BS – Mechanical Engineering, Worcester Polytechnic Institute, 2000

Professional Engineer Licensure

State of California, Licensed Professional Engineer # FP1676, Fire Protection Engineering

Fire Investigation Training

California State Fire Marshal – Fire Investigation IA (40 hours)

Overview

Chris Lautenberger received an MS in Fire Protection Engineering from Worcester Polytechnic Institute (WPI) with a thesis related to computational fluid dynamics modeling of fires, and a PhD in Mechanical Engineering (major area: Combustion) from the University of California at Berkeley with a dissertation related to materials' flammability and fire modeling. Before joining Reax Engineering, his work experience included fire litigation support as an independent consultant as well as building code consulting and performance-based design of fire and life safety systems at Arup Fire (San Francisco, CA) and Code Consultants, Inc. (St. Louis, MO). In addition to working for Reax Engineering Inc., Chris is a researcher at UC Berkeley's Combustion and Fire Processes Laboratory where he conducts research on materials' flammability and pyrolysis, ignition and flame spread, computer fire modeling, and fire development in buildings.

As a licensed Fire Protection Engineer, Dr. Lautenberger's work combines real-world Fire Protection Engineering experience, including knowledge of fire/building codes and related standards, with technical aspects of fire litigation and fire protection engineering such as fire dynamics, combustion, heat transfer, fluid mechanics, thermodynamics, flammability, ignition, and fire spread. With more than 10 years of experience applying fire models in support of building design, fire litigation, and scientific research, one of Dr. Lautenberger's areas of specialization is modeling of fires and related phenomena, including: smoke, heat, and toxic species transport; sprinkler and smoke detector activation; turbulent flames; condensed-phase pyrolysis/burning processes; piloted and auto ignition of combustible solids; ignition of fuel beds by heated particles, sparks, and fire brands; and flame spread and fire growth.

Experience

8/08 – present **Reax Engineering Inc.** Berkeley, CA *Founding Partner and Principal Engineer*

Representative activities:

- Fire protection engineering – design of fire and life safety systems, performance-based design
- Fire litigation support – theory, analysis, modeling, codes & standards, failure analysis
- Fire dynamics analyses – flames & plumes, flashover, glass breakage, detector activation, etc.
- Forensic fire reconstruction, fire timeline development, fire development modeling
- Prediction of smoke and heat release rates
- Determination of time to untenability or incapacitation by smoke or heat

- Materials and product flammability assessment – ignition, burning, flame spread
- Material pyrolysis property estimation from small-scale fire test data
- Computational fluid dynamics, fire and smoke modeling, heat transfer analysis
- Sizing of smoke exhaust systems
- Fire inspections/origin and cause determination

Selected recent projects:

- Fire modeling for triple-fatality apartment fire: fire timeline development and fire reconstruction, calculation of glass breakage and smoke detector activation times in apartment of fire origin and adjacent apartments (Salem, OR)
- Fire reconstruction for fatal apartment fire: Inter-apartment fire spread, time to smoke detector activation, building code issues (Carrboro, NC)
- Quantification of heat and smoke release rates of Breda Light Rail Vehicles in the San Francisco Central Subway using fire growth modeling and small-scale fire testing (San Francisco, CA)
- Sizing of the required atrium smoke exhaust rate in the new Student Union Building at San Jose State University (San Jose, CA)
- Development of a model for ignition of HEPA filters by embers at the Hanford nuclear waste treatment plant (Richland, WA)
- Design of FM-200 clean agent fire suppression system for PG&E substation (San Mateo, CA)
- Computational Fluid Dynamics (CFD) modeling of blast wave
- Determination of origin of alleged arson fire (Modesto, CA)
- Analysis of code issues related to residential gas explosion (Las Vegas, NV)
- Detailed CFD modeling of fluid flow and heat & mass transfer in a biomass pyrolysis reactor
- Thermodynamic analysis of non-traditional methods for carbon capture and sequestration
- Development of wildland fire threat map for California based on wind and fire modeling

12/07 – present **University of California, Berkeley Post Doctoral Researcher**

- Conducting research on NSF Grant 0730556, “Tackling CFD Modeling of Flame Spread on Practical Solid Combustibles”
- Assessing predictive capabilities of Fire Dynamics Simulator (FDS) for simulating flame spread and fire growth in buildings
- Modifying subroutines to improve predictive capabilities of FDS for flame spread modeling
- Further developing pyrolysis model and material property estimation techniques needed to simulate the pyrolysis of real-world solid fuels (<http://code.google.com/p/gpyro>)
- Developing computer model for ignition of fuel beds by hot particles and fire brands to predict ignition of fuel beds and initiation of spot fires

1/03 – 8/08 **Independent technical consultant for fire-related litigation and research Berkeley, CA**

- Provided litigation support services for several fire-related cases involving explosions, wildland fire behavior, ignition by embers, compartment/structure fires, and vehicle fires
- Developed several FDS models in support of expert witness testimony, including fire growth, toxic species (carbon monoxide) production, and smoke detector activation
- Critically analyzed FDS models developed by opposing sides to identify weaknesses

1/02 – 6/08 **Arup Fire San Francisco, CA Fire Protection Engineer**

- Assisted clients with fire safety design and achieving code compliance or performance-based solutions for hospitals, casinos, malls, libraries, schools, museums, airports, office buildings
- Performed egress analyses to determine required exit capacity and estimate Required Safe Egress Time (RSET) in proposed buildings
- Applied FDS to simulate smoke and heat transport from fires in proposed buildings to determine the available safe egress time (ASET)
- Developed and programmed a CFAST-based Monte-Carlo fire simulator
- Performed FDS simulations of flame spread and fire growth in a rail vehicle and used full-scale experimental data to calibrate the model

- 10/00 – 12/01 **FM Global Research** Norwood, MA
- Examined existing soot formation and oxidation models in the literature and used this research to postulate a new engineering soot model that is compatible with FDS
 - Worked with FM Global and NIST personnel to add this new model for soot formation and oxidation to FDS, and performed simulations of laminar and turbulent diffusion flames
- 5/00 – 8/00 **Code Consultants, Inc.** Saint Louis, MO
- Responsible for examining proposed building designs for compliance with relevant codes
 - Performed engineering analyses to support equivalencies

Dissertation and Thesis

- 1/03 – 12/07 **Ph. D. Dissertation** *University of California, Berkeley*
- Developed a pyrolysis/material decomposition model (Gpyro) to simulate the gasification, pyrolysis, and combustion of condensed-phase fuels
 - Developed a novel optimization technique that uses a genetic algorithm to extract the material pyrolysis properties needed for simulation of solid-phase pyrolysis from bench-scale fire tests
 - Performed FDS-based simulations of ignition, flame spread, and fire growth in normal and reduced gravity environments as part of a NASA-sponsored project
- 9/00 – 12/01 **MS Thesis** *Worcester Polytechnic Institute*
- Developed a novel model for soot formation/oxidation in non-premixed flames
 - Implemented model in FDS to calculate soot formation and flame radiation
- 8/98 – 5/99 **Major Qualifying Project (MQP)** *Worcester Polytechnic Institute*
- Developed an experimental program and ran several real-scale room/corner fire tests in WPI's room calorimeter to evaluate the flame spread characteristics of composite wall linings

Peer Reviewed Publications

1. Lautenberger, C., de Ris, J., Dembsey, N.A., Barnett, J.R. & Baum, H.R., "A Simplified Model for Soot Formation and Oxidation in CFD Simulation of Non-premixed Hydrocarbon Flames," *Fire Safety Journal* **40** 141-176 (2005).
2. Lautenberger, C., Zhou, Y.Y. & Fernandez-Pello, A.C., "Numerical Modeling of Convective Effects on Piloted Ignition of Composite Materials," *Combustion Science and Technology* **177** 1231-1252 (2005).
3. Lautenberger, C. & Fernandez-Pello, A.C., "Approximate Analytical Solutions for the Transient Mass Loss Rate and Piloted Ignition Time of a Radiatively Heated Solid in the High Heat Flux Limit," *Fire Safety Science* **8** 445-456 (2005).
4. Lautenberger, C., Rein, G. & Fernandez-Pello, A.C., "The Application of a Genetic Algorithm to Estimate Material Properties for Fire Modeling from Bench-Scale Fire Test Data," *Fire Safety Journal* **41** 204-214 (2006).
5. Rein, G., Lautenberger, C., Fernandez-Pello, A.C., Torero, J.L. & Urban, D.L., "Application of Genetic Algorithms and Thermogravimetry to Determine the Kinetics of Polyurethane Foam in Smoldering Combustion," *Combustion and Flame* **146** 95-108 (2006).
6. Rich, D., Lautenberger, C., Torero, J.L., Quintiere, J.G. & Fernandez-Pello, C., "Mass Flux of Combustible Solids at Piloted Ignition," *Proceedings of the Combustion Institute* **31** 2653-2660 (2007).
7. Kwon, J.-W., Dembsey, N.A., & Lautenberger, C.W., "Evaluation of FDS v4: Upward Flame Spread," *Fire Technology* **43** 255-284 (2007).
8. Avila, M.B., Dembsey, N.A., Kim, M.E., Lautenberger, C., & Dore, C., "Fire Characteristics of Polyester FRP composites with Different Glass Contents," *Composites Research Journal* **2** 1-14 (2008).
9. Lautenberger, C., Kim, E., Dembsey, N. & Fernandez-Pello, C., "The Role of Decomposition Kinetics in Pyrolysis Modeling – Application to a Fire Retardant Polyester Composite," *Fire Safety Science* **9** 1201-1212 (2008).
10. Dodd, A.B., Lautenberger, C. & Fernandez-Pello, A.C., "Numerical Examination of Two-Dimensional Smolder Structure in Polyurethane Foam," *Proceedings of the Combustion Institute* **32** 2497-2504 (2009).
11. Lautenberger, C. & Fernandez-Pello, A.C., "Generalized Pyrolysis Model for Combustible Solids," *Fire Safety Journal* **44** 819-839 (2009).

12. Lautenberger, C. & Fernandez-Pello, A.C., "A Model for the Oxidative Pyrolysis of Wood," *Combustion and Flame* **156** 1503-1513 (2009).
13. Hadden, R., Scott, S., Lautenberger, C., & Fernandez-Pello, A.C., "Ignition of Combustible Fuel Beds by Hot Particles: an Experimental and Theoretical Study," submitted to *Fire Technology* (2010).
14. Dodd, A.B., Lautenberger, C., & Fernandez-Pello, A.C., "Computational Modeling of Smolder Combustion and Spontaneous Transition to Flaming," to be submitted to *Combustion and Flame* (2010).
15. Fereres, S., Lautenberger, C., Fernandez-Pello, C., Urban, D.L., & Ruff, G.A., "Mass Loss Rate at Ignition in Reduced Pressure Environments," to be submitted to *Combustion and Flame* (2010).

Book Chapters

1. Lautenberger, C., Torero, J.L. & Fernandez-Pello, A.C., "Understanding Materials Flammability," in *Flammability Testing of Materials Used in Construction, Transport and Mining*, Edited by V. Apte, Woodhead Publishing, Cambridge, UK pp. 1-21, 2006.
2. Lautenberger, C. & Fernandez-Pello, A.C., "Pyrolysis Modeling, Thermal Decomposition, and Transport Processes in Combustible Solids," in *Transport Phenomena in Fires*, Edited by M. Faghri and B. Sunden, WIT Press, Billerica, MA pp. 209-248, 2008.
3. Lautenberger, C. & Fernandez-Pello, A.C., "Spotting Ignition of fuel beds by firebrands," in *Computational Methods and Experimental Measurements XIV*, Edited by C.A. Brebbia and G.M. Carlomango, WIT Press, Billerica, MA pp. 603-612, 2009.
4. Lautenberger, C. & Hostikka, S., "Large Scale Fire Modeling," in *Flame Retardancy of Polymeric Materials*, Second Edition, Edited by C.A. Wilkie and A.B. Morgan, Marcel Dekker pp. 551 – 585, 2010.

Selected Conference Publications and Technical Reports

1. Beyler, C., Hunt, S., Lattimer, B., Iqbal, N., Lautenberger, C., Dembsey, N., Barnett, J., Janssens, M., & Dillon, S. "Prediction of ISO 9705 Room/Corner Test Results". United States Department of Transportation. United States Coast Guard Research and Development Center. Washington, DC. 1999.
2. Lautenberger, C., Stevanovic, A., Rich, D., & Torero, J., "Effect of Material Composition on Ignition Delay of Composites," *Composites 2003*, Anaheim CA, October 2003.
3. Lautenberger, C., Stevanovic, A., Rich, D., Torero, J. & Fernandez-Pello, A.C., "An Experimental and Theoretical Study on the Ignition Delay Time of Composite Materials," *Western States Section/The Combustion Institute*, Los Angeles CA, October 2003.
4. Rein, G., Lautenberger, C., Fernandez-Pello, A.C., Torero, J.L. & Urban, D.L., "Derivation of the Kinetics Parameters of Polyurethane Foam Using Genetic Algorithms," *Fourth Joint Meeting of the US Sections of the Combustion Institute*, Philadelphia PA, March 2005.
5. Rein, G., Lautenberger, C. & Fernandez-Pello, A.C., "On the Derivation of Polyurethane Kinetics Parameters Using Genetic Algorithms and its Application to Smoldering Combustion," *Fourth International Conference on Computational Heat and Mass Transfer*, Paris France, Vol. 1 pp. 578-584, May 2005.
6. Rein, G., Lautenberger, C. & Fernandez-Pello, A.C., "Using Genetic Algorithms to Derive the Parameters of Solid-Phase Combustion from Experiments," *20th International Colloquium on the Dynamics of Explosions and Reactive Systems*, Montreal, Canada, August 2005.
7. Rich, D., Lautenberger, C., McAllister, S. & Fernandez-Pello, A.C., "Microgravity Flame Spread Rates Over Samples of Polymer and Polymer/Glass Composites," *Western States Section/The Combustion Institute*, Boise ID, March 2006.
8. Coles, A., Wolski, A., Lautenberger, C.W., & Dembsey, N.A., "Building Code Requirements for Performance Based Designs and Fire Modeling", *Composites 2006*, St. Louis, MO, October 2006.
9. Lautenberger, C., McAllister, S., Rich, D., & Fernandez-Pello, C., "Modeling the Effect of Environmental Variables on Opposed-Flow Flame Spread Rates with FDS," *International Congress on Fire Safety in Tall Buildings*, Santander, Spain, October 2006.
10. McAllister, S., Rich, D., Lautenberger, C., & Fernandez-Pello, C., "Modeling Microgravity and Normal Gravity Opposed Flame Spread over Polymer/Glass Composites," *45th AIAA Aerospace Sciences Meeting and Exhibit*, Reno, NV, January 2007, AIAA Paper 2007-740.
11. Lautenberger, C., McAllister, S., Rich, D., & Fernandez-Pello, C., "Effect of Environmental Variables on Flame Spread Rates in Microgravity," *45th AIAA Aerospace Sciences Meeting and Exhibit*, Reno, NV, January 2007, AIAA Paper 2007-383.
12. Chatterjee, P., de Ris, J.L., & Lautenberger, C.W., "A General Combustion Model for Radiation Dominated Non-premixed Flames," *Fifth International Seminar on Fire and Explosion Hazards*, Edinburgh, UK, 2007.

13. McAllister, S., Rich, D., Lautenberger, C., Fernandez-Pello, C. & Yuan, Z.G., "Modeling Microgravity and Normal Gravity Flame Spread Rates over Samples of Polymer and Polymer/Glass Composites," *Fifth International Seminar on Fire and Explosion Hazards*, Edinburgh, UK, April 2007.
14. Lautenberger, C. & Fernandez-Pello, C., "A Generalized Pyrolysis Model for Combustible Solids," *Fifth International Seminar on Fire and Explosion Hazards*, Edinburgh, UK, April 2007.
15. Coles, A., Wolski, A., & Lautenberger, C., "Using Fire Dynamics Simulator for Fire Growth Modeling," *Interflam 2007*, London, UK, September 2007.
16. Dembsey, N., Avila, M., Kim, E., Lautenberger, C., & Dore, C., "Fire Characteristics of Polyester FRP Composites with Different Glass Contents," *Composites & Polycon 2007* Tampa, FL, October 2007.
17. Lautenberger, C. & Fernandez-Pello, A.C., "Modeling Ignition of Combustible Fuel Beds by Embers and Heated Particles," *Forest Fires 2008*, 2008.
18. Coles, A., Lautenberger, C., Wolski, A., Smits, B., & Wong, K., "Using Computer Fire Modeling to Reproduce and Predict FRP Composite Fire Performance," *Composites & Polycon 2009*, 2009.
19. Kim, E., Dembsey, N., & Lautenberger, C., "Parameter Estimation for Pyrolysis Modeling Applied to Polyester FRP Composites with Different Glass Contents," *Fire and Materials 2009*, 2009.
20. Lautenberger, C., Wong, W., Dembsey, N., Coles, A., & Fernandez-Pello, C., "Large-Scale Turbulent Flame Spread Modeling with FDS5 on Charring and Noncharring Materials," *Fire and Materials 2009*, 2009.
21. Coles, A., Wolski, A., & Lautenberger, C., "Predicting Design Fires in Rail Vehicles," *13th International Symposium on Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT 13)*, 2009.
22. Dodd, A.B., Lautenberger, C., & Fernandez-Pello, A.C. "Numerical Modeling of Smoldering Combustion and Transition to Flaming," *Sixth US National Combustion Meeting*, University of Michigan, Ann Arbor, MI, 2009.
23. Scott, S, Hadden, R., Fereres, S., Lautenberger, C., & Fernandez-Pello, A.C., "Ignition of Combustible Fuel Beds by Embers and Heated Particles," *Western States Section/The Combustion Institute*, Irvine, CA, October 2009.
24. Fereres, S., Lautenberger, C., Fernandez-Pello, C., Urban, D., & Ruff, G., "Effect of Ambient Pressure on Mass Loss Rate at Piloted Ignition," *Western States Section/The Combustion Institute*, Boulder, CO, March 2010.
25. Lautenberger, C., Wong, W.C., Coles, A., Dembsey, N., & Fernandez-Pello, C., "Comprehensive Data Set for Validation of Fire Growth Models: Experiments and Modeling," *Interflam 2010*, Nottingham, UK, July 2010.
26. Thiry, A., Suzanne, M., Bellivier, A., Bazin, H., Coppalle, A., & Lautenberger, C., "Different Approaches for Fire Source Modeling – Application to Arcueil Experiments," *Interflam 2010*, Nottingham, UK, July 2010.
27. Dodd, A., Lautenberger, C., Fernandez-Pello, C., & Putzeys, O., "Examination of the Spontaneous Transition from Smoldering to Flaming: Comparison of Simulations and Experiments," *Interflam 2010*, Nottingham, UK, July 2010.

Selected Presentations and Invited Lectures

1. "A Practical CFD Model for Soot Formation and Flame Radiation," *International Conference on Engineered Fire Protection Design*, San Francisco, CA, June 13, 2001.
2. "Effect of Material Composition on Ignition Delay of Composites," *Composites 2003 Convention and Trade Show*, Anaheim, CA, October 2, 2003.
3. "Experimental and Theoretical Study on Ignition Delay of Composites," *Western States Section of the Combustion Institute Fall 2003 Meeting*, Los Angeles, CA, October 20, 2003.
4. "Approximate Analytical Solutions for the Transient Mass Loss Rate and Piloted Ignition Time of a Radiatively Heated Solid in the High Heat Flux Limit", *The Eighth International Symposium on Fire Safety Science*, Beijing, China, September 20, 2005.
5. "Effect of Environmental Variables on Flame Spread Rates in Microgravity", *45th AIAA Aerospace Sciences Meeting and Exhibit*, Reno, NV, January 8, 2007.
6. "Generalized Pyrolysis Model for Combustible Solids," *2007 Annual Fire Conference*, National Institute of Standards and Technology, Gaithersburg, MD, April 4, 2007.
7. "Generalized Pyrolysis Model for Combustible Solids," *5th International Seminar on Fire and Explosions Hazards*, Edinburgh, UK, April 24, 2007.
8. "Generalized Pyrolysis Model for Combustible Solids," FM Global Research, Norwood, MA, June 19, 2007 (invited seminar).
9. "Pyrolysis Modeling – What Level of Accuracy is Needed to Match Current Gas-Phase Accuracy?," *The Ninth International Symposium on Fire Safety Science*, Fire Spread Modeling Workshop, Karlsruhe, Germany, September 21, 2008 (invited presentation).

10. "Estimating Material Properties for Numerical Pyrolysis Modeling from Laboratory Experiments," *The Ninth International Symposium on Fire Safety Science*, Karlsruhe, Germany, September 21, 2008 (invited presentation).
11. "The Role of Decomposition Kinetics in Pyrolysis Modeling – Application to a Fire Retardant Polyester Composite," *The Ninth International Symposium on Fire Safety Science*, Karlsruhe, Germany, September 26, 2008.
12. "Fire Growth Modeling in Buildings – Where We Are and Where We Need to Be," IIE Seminar, University of Edinburgh, Edinburgh, UK, October 30, 2008 (invited seminar).
13. "Some Unsolved Problems in Fire Dynamics: The Needed Physics and Mathematics," *Mathematical Problems in Fire Safety Engineering Joint Workshop*, Edinburgh, UK, October 31, 2008 (invited seminar).
14. "Large-Scale Turbulent Flame Spread Modeling with FDS5 on Charring and Noncharring Materials," *Fire and Materials 2009*, San Francisco, CA, January 26, 2009.
15. "Fire Growth Modeling: Small-Scale Flammability Tests to Large Scale Fire Behavior," *ASTM E5 Research Review*, Vancouver, BC, June 15, 2009 (invited presentation).

Publication and Presentation Awards

- Best Paper Overall at *Composites & Polycon 2007*, Tampa, FL, October 2007 for Dembsey, N. *et al.*, "Fire Characteristics of Polyester FRP Composites with Different Glass Contents," presented by N. Dembsey.
- Best paper (second prize) at the *Fifth International Seminar on Fire and Explosion Hazards*, Edinburgh, UK, April 2007 for Lautenberger, C. & Fernandez-Pello, C., "Generalized Pyrolysis Model for Simulating Charring, Intumescent, Smoldering, and Noncharring Gasification," presented by C. Lautenberger.

Journal Referee / Peer Review

- *Combustion and Flame*
- *Combustion Science and Technology*
- *Experimental Thermal and Fluid Science*
- *Fire and Materials*
- *Fire Safety Journal*
- *Fire Safety Science* (IAFSS Symposia)
- *Fire Technology*
- *International Journal of Wildland Fire*
- *Journal of Fire Protection Engineering*
- *Proceedings of the Combustion Institute*

Conference Advisory Boards/Technical Committees

- Member of Scientific Advisory Board for *International Congress on Combustion and Fire Dynamics*, Santander, Spain, October 2010
- Member of Technical Program Committee (Compartment Fires) for the *Tenth International Symposium on Fire Safety Science* (IAFSS Symposium), College Park, MD, June 2011

Honors, Scholarships, and Fellowships

- NASA Graduate Student Researcher Program Grant #NNC-04HA08H, "Piloted Ignition and Flame Spread on Composite Materials in Partial and Normal Gravity," 2004 – 2007
- Society of Fire Protection Engineers (St. Louis Chapter) Scholarship, 2001
- Salamander Honorary Fire Protection Engineering Society, 2000
- Marsh Risk Consulting Scholarship, 2000
- A.L. Brown Society of Fire Protection Engineers Scholarship, 2000
- Skull Senior Honorary Society, 1998

Professional Societies

- Society of Fire Protection Engineers (SFPE)
- National Fire Protection Association (NFPA)
- International Association of Fire Safety Science (IAFSS)
- American Society for Testing and Materials (ASTM)