

RICHARD J. ROBY, P.E., Ph.D.

EDUCATION:

Ph.D., Mechanical Engineering, Stanford University, Palo Alto, CA, Jan. 1988.

M.S., Mechanical Engineering, Cornell University, Ithaca, NY, May 1980.

B.S., Chemical Engineering, Cornell University, Ithaca, NY, May 1977.

A.B., Chemistry, Cornell University, Ithaca, NY, May 1977.

PROFESSIONAL EXPERIENCE:

President and Technical Director, Combustion Science & Engineering, Columbia, MD, 1998 to present. Responsible for day-to day operations of the company and for overseeing technical content of all research and development projects. Project manager for a variety of experimental and analytical combustion and fire science research and development programs including: development of combustion sensors for gas turbine engines; modeling of blow-off and flashback in gas turbine combustors; effects of fuel constituents on combustor performance; development and incorporation of reduced kinetics mechanisms into CFD codes; glass breakage in fires; innovative fire detection devices; fire detector response; fire model development.

Adjunct Professor, Department of Fire Protection Engineering, University of Maryland, College Park, MD, 2003 -. Developed and teach Advanced Fire Dynamics course for FPE Master's Degree program. Served as Advisor/Thesis Committee member for several Masters students and senior research projects. Research projects have included: modeling of smoke detector activation in fires using CFD or water analogies; modeling of CO and other toxic gas uptake in fires; study of fire phenomena in residential wiring and connections; determination of detector activation by acoustic agglomeration.

Adjunct Professor, Mechanical Engineering Department, Virginia Polytechnic Institute & State University, Blacksburg, VA, 1992 -. Served as: Advisor/Thesis Committee member for Masters and Doctoral students; Research projects have included: experimental study of NO to NO₂ conversion at super-atmospheric pressures; experimental study of soot formation in mixed-mode combustion; experimental study of CO generation and transport in compartment fires; Supervisor of engineering co-op student.

Director of Combustion Research, Hughes Associates, Inc., Baltimore, MD, 1992 to 1998. Responsible for determining scope and content of combustion research and development. Manager for variety of combustion and fire R&D programs, combustion-related projects included NO_x control with water addition; catalytic reformation of natural gas for ultra-lean combustion; reduction of soot formation in methane arcjets; fire detection using multiple detection techniques; optical combustion diagnostics for gas turbines. Managed fire-related R&D programs and provided litigation support and expert witness testimony. Fire-related projects included small and large-scale fire testing, fire reconstruction, studies of formation and spread of CO, multi-sensor fire detection, code and code equivalency analyses, fire hazard analysis and fire modeling.

Associate Professor, Mechanical Engineering Department, Virginia Polytechnic Institute & State University, Blacksburg, VA, 1992 (Assistant Professor, 1986 - 1992). Taught both undergraduate and graduate courses in the thermal-fluid sciences including Combustion, Thermodynamics, Internal Combustion Engines, Experimental Methods in Thermal-Fluid Sciences and Heat Transfer. Advised thesis research for MS and PhD students. Research in combustion generated pollutant formation and control, especially NO_x and soot; combustion

diagnostics; compartment fire dynamics, particularly toxic species generation. Applications included spark ignition and diesel engines and aero and stationary gas turbines.

Research Assistant, Mechanical Engineering Department, Stanford University, Palo Alto, CA, 1983-1986.

Research Engineer, Fuels and Lubricants Department, Ford Motor Company, Scientific Research Labs, Dearborn, Michigan, 1979 - 1983.

Research Assistant, Mechanical and Aerospace Engineering Department, Cornell University, Ithaca, NY, 1977-1979.

PROFESSIONAL MEMBERSHIPS:

Member, The Combustion Institute
Member, The Society of Automotive Engineers
Member, International Association for Fire Safety Science
Member, National Fire Protection Association
Member, Society of Fire Protection Engineers
Member, The American Institute for Aeronautics and Astronautics
Member, The American Society of Mechanical Engineers
Member, International Gas Turbine Institute
Member, The Planetary Society
Member, Sigma Xi, The Scientific Research Society

FIRE DEPARTMENT EXPERIENCE:

Member, Van Buren Township Volunteer Fire Department, Belleville, MI, 1980-1981

Member, Ithaca Fire Department, Ithaca, NY, 1973-1979
Lieutenant, Neriton Fire Company No. 9, 1976-1979
Department Instructor, 1976-1979

HONORS AND AWARDS:

Outstanding Faculty Advisor Award – Society of Automotive Engineers, 1991
National Fire Protection Research Foundation's 1999 Harry Bigglestone Award
for Excellence in Communication of Fire Protection Concepts
William M. Carey Award – 5th Fire Suppression & Detection Research Application Symposium, 2001

PATENTS:

Roby, R. J., Gottuk, D. T., and Beyler, C. L., "Multi-Signature Fire Detector," U.S. Patent No. 5,691,703, Issued November 25, 1997.

PROFESSIONAL REGISTRATION:

Registered Professional Engineer, Mechanical Engineering, License Number M 024534 (California 1986).

Special Skills:

Private Pilot, Instrument Rating (>500 hours)
Scuba Diver, PADI Certified

PUBLICATIONS AND PRESENTATIONS:

Ferrino-McAllister, J.M., Carpenter, D.J., and Roby, R.J., "Comparison of Gasoline Weathering on Carpet Samples Exposed to Various Thermal Environments," Presented to the International Symposium on Fire Investigation Science and Technology (ISFI), June 26-28, 2006.

Olenick, S.M., R.J., Roby, M.S., Klassen, W., Zhang, J.A., Sutula, C., Worrell, D., Wu, V., D'Souza, E., Ashley, J., Dubois, J.L., Torero, and L., Streit, "The Role of Smoke Detectors in Forensic Fire Investigation and Reconstruction," Presented to the International Symposium on Fire Investigation Science and Technology (ISFI), June 26-28, 2006.

Gokulatrishnan, P., Kwon, S., Hamer, A.J., Klassen, M. S., and Roby, R.J., "Reduced Kinetic Mechanism for Reactive Flow Simulation of Syngas/Methane Combustion at Gas Turbine Conditions", Submitted to GT2006, AMSE Turbo Expo, Barcelona, Spain.

Gaines, G., Roby, R.J., Klassen, M.S., Zhang, W., Olenick, S., and Torero, J., "An Algorithm to Predict Smoke Detector Activation in a Forced Flow Microgravity Environment" Habitation 2006 Conference, Orlando, February, 2006.

Sutula, J.A., M.S., Klassen, R.J., Roby, S.M., Olenick, G., Gaines, A., Chakraborty, J.L., Torero, "Development of an Engineering Tool for Determination of Suppression Device Placement in Reduced Gravity Environments", Habitation 2006 Conference, Orlando, February, 2006

Ferrino-McAllister, J., and R.J. Roby, "Heating of Electrical Contacts: Characterizing the Effects of Torque, Contact Area, and Movement on the Temperature of Residential Receptacles", Fire Technology, Volume 42, No.1, January, 2006, pp. 49-74.

McAllister, J., and R.J. Roby, "Heating of Electrical Contacts: Characterizing the Effects of Torque, Contact Area, and Movement on the Temperature of Residential Receptacles", Fire Technology, Volume 42, No.1, January, 2006, pp. 49-74.

Zhang, W., M.S. Klassen, and R.J. Roby, "Numerical Prediction of Smoke Detector Activation Accounting for Aerosol Characteristics," submitted to 8th International Symposium on Fire Safety Science, Beijing China, September, 2005.

Ma, T., Olenick, S.M., Klassen, M.S., Roby, R.J., and Torero, J.L., "Carpet Under Fire: A Forensic View on the Role of Carpet (Porous Media) in Liquid Spill Fires", Harry C. Bigglestone Award

- Presentation, NFPA World Safety Conference and Exposition, Las Vegas, June 2005.
- Olenick, S.M., Zhang, W., Carpenter, D.J., Roby, R.J., and Klassen, M.S., "Verification and Validation of a Smoke Detector Activation Algorithm for the Fire Dynamics Simulator (FDS)", presented to the NFPA Fire Protection Research Foundation Fire Suppression and Detection Research Application Symposium, Orlando, January, 2005.
- Gokulakrishnan, P., Klassen, M.S., and R.J. Roby, (2005), "Development of Detailed Kinetic Mechanism to Study Low Temperature Ignition Phenomenon of Kerosene", *Proceedings of IGTI*, AMSE, Paper #GT2005-68268.
- Zhang, W., S.M. Olenick, R.J. Roby, and J.L. Torero, "The Integration of a Smoke Detector Modeling Algorithm within a Large Eddy Simulation Fire Model," submitted to the *Fire Safety Journal*.
- Ma, T., Olenick, S.M., Klassen, M.S., Roby, R.J., and Torero, J.L., "Burning Rate of Liquid Fuel on Carpet (Porous Media)", *Fire Technology*, 40, 2004. (2005 Bigglestone Award).
- Roby, R.J., W. Zhang, G.C. Gaines, S.M. Olenick, M.S. Klassen, and J.L. Torero, "The Integration of a Smoke Detector Model with Large Eddy Simulation Fire Modeling for Predicting Smoke Detector Activation in Microgravity," proceedings of strategic Research to Enable NASA's Exploration Missions Conference and Workshop Poster Session, NASA, John H. Glenn Research Center, Lewis Field, Cleveland, Ohio, June 22-23, 2004.
- Zhang, W., D.J. Carpenter, R.J. Roby, D.S. Viehe, and A.J. Hamer, "The Prediction of Thermal Loading for Structural Analysis Under Fire Exposure," proceedings of the SEI/SFPE Specialty Conference on Designing Structures for Fire, Baltimore, MD, September 30, 2003.
- Zhang, W., M.S. Klassen, and R.J. Roby, "Turbulent Structure of the Flow Field in a One-Meter Diameter Methane Fire by Large Eddy Simulation," 3rd joint meeting of the U.S. Sections of the Combustion Institute, University of Illinois at Chicago, Chicago, Illinois, March 16-19, 2003.
- Olenick, S.M., J.A. Sutula, R.J. Roby, and V. D'Souza, "Modeling of Smoke Detector and Sprinkler Activation," presented at the Fire Suppression & Detection Research Application Symposium, Orlando, FL, January 23, 2003.
- Worrell, C.L., J.A. Lynch, G. Jomaas, R.J. Roby, L. Streit, and J.L. Torero, "Effect of Smoke Source and Horn Configuration on Enhanced Deposition, Acoustic Agglomeration, and Chladni Figures in Smoke Detectors," *Fire Technology*, Vol. 39, pp. 309-346, 2003.
- Klassen, M.S., J.A. Sutula, M.M. Holton, R.J. Roby, and T. Izbicki, "Transmission Through and Breakage of Multi-Pane Glazing Due to Radiant Exposure," submitted to *Fire Technology* 2002.
- Olenick, S.M., M.S. Klassen, and R.J. Roby, "Validation Study of FDS for a High-Rack Storage Fire Involving Pool Chemicals," presented to the NFPA 430 (Storage of Liquid and Solid Oxidizers) Technical Task Group, January, 2002.
- Zhang, W., A.J. Hamer, M.S. Klassen, D.J. Carpenter and R.J. Roby, "Turbulence Statistics in a Model Fire Room
by Large Eddy Simulation," *Fire Safety Journal*, Vol. 37, No. 8, pp. 721-752, 2002.
- D'Souza, V.T., J.A. Sutula, S.M. Olenick, W. Zhang, and R.J. Roby, "Predicting Smoke Detector Activation Using the Fire Dynamics Simulator," proceedings of 7th International Symposium on Fire Safety Science, Worcester Polytechnic-Institute, Worcester, MA, June 16-21, 2002.
- Ma, T., S. M. Olenick, M.S. Klassen, R.J. Roby and J. Torero, "Burning Rate of Liquid Fuel on Carpet (Porous Media)", submitted to the Fire Tech 7th International Symposium of Fire Safety Science (2002).

- Holton, M.M., S.M. Olenick, M.S. Klassen, and R.J. Roby, "A Study of the Effectiveness of Passive Infrared Burglar Alarms to Detect Fires and Smoke," presented at NFPA's 6th *Fire Suppression & Detection Research Application Symposium*, Tampa, FL, January 2002.
- Worrell, C.L., R.J. Roby, L. Streit, and J.L. Torero, "Enhanced Deposition, Acoustic Agglomeration, and Chladni Figures in Smoke Detectors," *Fire Technology*, Vol. 37, pp. 343-362, 2001.
- Zhang, W., N. Ryder, R.J. Roby, and D.J. Carpenter, "Modeling of the Combustion in a Compartment Fire by Large Eddy Simulation Approach" proceedings of the "Chemical and Physical Processes in Combustion," Eastern States Section of The Combustion Institute Fall Technical Meeting, Hilton Head, SC, December 3-5, 2001.
- D'Souza, V.T., J.A. Sutula, S.M. Olenick, W. Zhang, and R.J. Roby, "Use of the Fire Dynamics Simulator to Predict Smoke Detector Activation," presented at the Fall Technical Meeting of the Eastern States Section of the Combustion Institute, December 2001.
- Zhang, W., A.J. Hamer, M.S. Klassen, D.J. Carpenter, and R.J. Roby, "Verification of the Turbulence Statistics for Fire Dynamic Simulator in a Room Fire," presented at 3rd Technical Symposium on Computer Applications in Fire Protection Engineering, Baltimore, MD, September 2001.
- Olenick, S.M., M.S. Klassen, and R.J. Roby, "Validation Study of FDS for a High-Rack Storage Fire Involving Pool Chemicals," presented at 3rd Technical Symposium on Computer Applications in Fire Protection Engineering, Baltimore, MD, September 2001.
- Sutula, J.A., D.J. Carpenter, and R.J. Roby, "Use of the FDS Model to Analyze Two Competing Scenarios in an Alleged Arson Case," presented at 3rd Technical Symposium on Computer Applications in Fire Protection Engineering, Baltimore, MD, September 2001.
- Zhang, W., A.J. Hamer, M.S. Klassen, D.J. Carpenter, and R.J. Roby, "Turbulence Statistics in a Fire Room Model By Large Eddy Simulation," presented at 2nd Joint Meeting of the U.S. Sections of the Combustion Institute, Oakland, CA, March 2001.
- Worrell, C.L., R.J. Roby, L. Streit, and J.L. Torero, "Enhanced Deposition, Acoustic Agglomeration, and Chladni Figures in Smoke Detectors," presented at 5th NFPA Fire Suppression and Detection Research Application Symposium, February 2001, Orlando, FL
- Gottuk, D.T., M.J. Peatross, R.J. Roby, and C.L. Beyler, "Advanced Fire Detection Using Multi-Signature Alarm Algorithms," presented at the 11th International Conference on Automatic Fire Detection – AUBE'99, March 16-18, 1999, Duisburg, Germany (also presented at the NFPA Research Foundation Meeting, Feb. 24-26, 1999, Orlando, FL.).
- Lattimer, B.Y., U. Vandsburger, and R.J. Roby, "Carbon Monoxide Levels in Structure Fires: Effects of Wood in the Upper Layer of a Post-Flashover Compartment Fire," *Fire Technology*, Vol. 34, No. 4, 1998.
- Roby, R.J., J.E. Reaney, and E.L. Johnsson, "Detection of Temperature and Equivalence Ratio in Turbulent Premixed Flames using Chemiluminescence," presented at ASME International Joint Power Generation Conference, Baltimore, MD, August 23-26, 1998.
- Hamer, A.J., Roby, R.J., and Klassen, M.S., "Comparison of Reduced Chemical Kinetics Mechanisms for Pollutant Emissions Predictions in Gas Turbines," presented at the ASME International Joint Power Generation Conference, Baltimore, MD, August 23-26, 1998.
- Nicol, D. G., Malte, P. C., Hamer, A. J., Roby, R. J. and Steele, R. C., "Development of a Five-Step Methane Oxidation-NO Formation Mechanism for Lean-Premixed Gas Turbine Combustion," Paper No. 98-GT-185, ASME/IGTI Turbo Expo, Stockholm, Sweden, June 1998.

- Hamer, A.J. and Roby, R.J., "CFD Modeling of a Gas Turbine Combustor Using Reduced Chemical Kinetic Mechanisms", Paper No. 97-3242, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Seattle, WA, July, 1997.
- Lattimer, B.Y., U. Vandsburger, and R.J. Roby, "Developing Scale Parameters for Estimating Carbon Monoxide in Structure Fires," *2nd International Symposium on Scale Modeling*, University of Kentucky, Lexington, Kentucky, June 23-27, 1997.
- Lattimer, B.Y., U. Vandsburger, and R.J. Roby, "The Transport of Carbon Monoxide from a Burning Compartment Located on the Side of a Hallway," *26th Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1997.
- Hunderup, J.W., and R.J. Roby, "An Experimental Investigation of the Conversion of NO to NO₂ at High Pressure," Paper No. 95-GT-306, presented at the IGTI meeting of ASME, Houston, TX, June 5-8, 1995 (accepted for publication in *ASME Journal of Engineering for Gas Turbines and Power*).
- Blevins, L.G., and R.J. Roby, "An Experimental Study of NO_x Reduction in Laminar Diffusion Flames by Addition of High Levels of Steam," Paper No. 95-GT-327, presented at the IGTI meeting of ASME, Houston, TX, June 5-8, 1995.
- Gottuk, D.T., and Roby, R.J., "Effect of Combustion Conditions on Species Production," Section 2/Chapter 7, *The SFPE Handbook of Fire Protection Engineering*, P.J. DiNenno (ed.), Second Edition, National Fire Protection Association, Quincy, MA, June 1995.
- Roby, R.J., A.J. Hamer, E.L. Johnsson, S.A. Tilstra, and T.J. Burt, "Improved Method for Flame Detection in Combustion Turbines," *ASME Journal of Engineering for Gas Turbines and Power*, **117** (2), 1995.
- Gottuk, D.T., R.J. Roby, and C.L. Beyler, "The Role of Temperature on Carbon Monoxide Production in Compartment Fires," *Fire Safety Journal*, **24** (4), 1995.
- Lattimer, B.Y., D.S. Ewens, U. Vandsburger, and R.J. Roby, "Transport and Oxidation of Compartment Fire Exhaust Gases in an Adjacent Corridor," *Journal of Fire Protection Engineering*, **6** (4), 1994, pp. 163-181.
- Becker, W.J., R.J. Roby, W.F. O'Brien and G.K. Bensing, "Dynamic Turbine Blade Temperature Measurement," *Journal of Propulsion and Power*, **10** (1), 1994, also AIAA Paper #89-2689, presented at the AIAA/SAE/ASME/ASEE 25th Joint Propulsion Conference, Monterey, CA, July 1989.
- Foss, D.T., R.J. Roby, and W.F. O'Brien, "Development of a Dual-frequency Microwave Burn-rate Measurement for Solid Rocket Propellant," *Journal of Propulsion and Power*, **9** (4), 1993, pp. 497-498.
- Ewens, D.S., U. Vandsburger, and R.J. Roby, "Oxidation of Exhaust Gases from a Burning Compartment in a Remote Location," Paper No. 69, presented at the Eastern States Section Meeting of The Combustion Institute, Princeton, NJ, October 1993.
- Aftel, R., U. Vandsburger, and R.J. Roby, "Soot Formation in Dual-mode Counterflow Flames," Paper No. 61, presented at the Eastern States Section Meeting of The Combustion Institute, Princeton, NJ, October 1993.
- Blevins, L.G., and R.J. Roby, "Effects of High Levels of Steam Addition on NO_x Reduction in Laminar Opposed Flow Diffusion Flames," WSS/CI Paper No. 92-16, presented at the Western States Section Meeting of The Combustion Institute, Corvallis, OR, March 1992.
- Gottuk, D.T., Roby, R.J. and Beyler, C.L., "A Study of Carbon Monoxide and Smoke Yields from Compartment Fires," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1993.

- Gottuk, D.T., R.J. Roby, M.J. Peatross, and C.L. Beyler, "Carbon Monoxide Production in Compartment Fires," *J. Fire Protection Engineering*, **4** (4), 1992, pp. 133-150.
- Gottuk, D.T., Roby, R.J. and C.L. Beyler, "The Effect of External Burning on Carbon Monoxide and Smoke Yields from Hexane-Fueled Compartment Fires," paper no. 87, Presented at the Eastern States Section Meeting of the Combustion Institute, Ithaca, New York, 1991.
- Skelly, M.J., R.J. Roby, and C.L. Beyler, "Window Breakage in Compartment Fires," *J. Fire Protection Engineering*, **3** (1), 1991, pp. 25-34.
- Gottuk, D.T., Roby, R.J. and C.L. Beyler, "Carbon Monoxide Yields from Hexane-Fueled Compartment Fires," paper no. 65, presented at the Eastern States Section Meeting of the Combustion Institute, Orlando, FL, December 1990.
- Roby, R.J., "Review of Principles of Fire Protection Chemistry," *Fire Technology*, May 1990.
- Tobin, K.W., M.R. Cates, D.L. Beshears, J.D. Muhs, G.J. Capps, D.B. Smith, W.D. Turley, W. Lewis, B.W. Noel, H.M. Borella, W.F. O'Brien, R.J. Roby and T.T. Anderson, "Engine Testing of Thermographic Phosphors," Oak Ridge National Laboratory Report #ORNL/ATD-31, 1990.
- Wirth, D.A. and R.J. Roby, "Soot Formation in Staged Combustion," paper no. 61, presented at the Eastern States Section Meeting of the Combustion Institute, Albany, NY, October 1989.
- Foss, D.T., R.J. Roby and W.F. O'Brien, "A Dual-Frequency Microwave Burn-Rate Measurement System for Solid Rocket Motors," AIAA Paper #89-2530, presented at the AIAA/SAE/ASME/ASEE 25th Joint Propulsion Conference, Monterey, CA, July 1989.
- Stouffer, S.D., R.J. Roby, and W.F. O'Brien, "Improved Plasma Torch for Ignition and Flame Holding in Supersonic Combustion," AIAA Paper #89-2945, presented at the AIAA/SAE/ASME/ASEE 25th Joint Propulsion Conference, Monterey, CA, July 1989.
- Roby, R.J. and C.T. Bowman, "Formation of N₂O in Laminar, Premixed, Fuel-Rich Flames," *Combustion and Flame*, **70**, 119-123, 1987.
- Roby, R.J. and C.T. Bowman, "Effects of Hydrocarbons on NO Removal in Rich, Premixed Hydrogen-Oxygen Flames," WSS/CI Paper 86-42, 24p., Presented at the Joint Meeting of the Western States and Canadian Sections of the Combustion Institute, Banff, Alberta, Canada, April 1986.
- Freeman, L.E., G.K. Chui, D. Crowl and R.J. Roby, "A Comparative Study of the Effects of Fuel Properties of Non-Petroleum Fuels on Diesel Engine Combustion and Emissions," *Transactions SAE*, Vol 93, Paper #841334, pp 35-50 of SP-587, also presented at the Fall Meeting of the Fuels and Lubricants Section of the Society of Automotive Engineers, Baltimore, Maryland, October 1984.
- Otto, C. and R.J. Roby, "Nitric Oxide Formation from Fuel Nitrogen Studied with a Pulse-Flame Combustor," *J.A.P.C.A.*, Vol. 34, No. 1, pp 38-41, January 1984.