

Exponent®
Engineering & Scientific Consulting

Christopher Buehler, Ph.D., P.E.

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Professional Profile

Dr. Buehler specializes in the application of chemical engineering principles to the scientific investigation and analyses of problems involving the production, processing, storage, transport and use of both hazardous and non-hazardous materials such as chemicals, flammable and toxic gases, petroleum, and various wastes. His work includes investigation of fires, explosions, and process upsets; characterization of atmospheric releases and spills; evaluation of the stability, compatibility and hazard potential of chemicals and chemical mixtures; assessment of facility design, operation, and mechanical integrity practices with respect to their safety, health, and environmental impacts; and process hazards analyses (PHAs).

Dr. Buehler has investigated numerous fires and explosions at petroleum refineries, natural gas and chemical process facilities, and other locations where chemicals were involved such as warehouse storage and containerized transport. He has also investigated incidents involving self-heating or thermal runaway of chemicals and unintentional chemical reactions of incompatible materials. Dr. Buehler has developed chain-of-events scenarios from various sources of evidence including physical artifacts, process measurement data, sample analyses, electronic event logs, eyewitness accounts, surveillance video, and simulations. He has facilitated PHAs using industry accepted methods such as HAZOP, HAZID, and What-If, as well as performed HP/LP (high pressure/low pressure) interface analyses to verify adequate overpressure protection for the low pressure side.

The production and use of hydrogen, biogas, and other alternative sources of energy are also areas of expertise for Dr. Buehler. Of particular interest are gasification systems to convert materials such as coal or organic wastes into hydrogen, syngas, and synthetic fuels.

Prior to joining Exponent, Dr. Buehler has held research positions with academic institutions such as Villanova University and Purdue University and has also worked as a researcher for the ARCO Chemical Company.

Academic Credentials & Professional Honors

Ph.D., Chemical Engineering, Purdue University, 1991

M.S., Chemical Engineering, Purdue University, 1989

B.S., Chemical Engineering, Villanova University, 1984

Phi Lambda Upsilon

Phi Kappa Phi

Tau Beta Pi

Magoon Award for Outstanding Undergraduate Teaching Assistant, 1988

Licenses and Certifications

Professional Engineer Chemical, Arizona, #82568

Professional Engineer, Colorado, #PE.0057198

Professional Engineer Chemical, Louisiana, #PE.0044386

Professional Engineer, New Jersey, #24GE06223500

Professional Engineer, New York, #110994

Professional Engineer, Pennsylvania, #PE090875

Professional Engineer Chemical, Texas, #100498

Professional Engineer, Wyoming, #PE 16855

40-Hour Hazardous Waste Operation and Emergency Response Certification (HAZWOPER)

Confined Space Entry (29 CFR 1910.146)

Professional Affiliations

American Chemical Society—ACS

American Institute of Chemical Engineers—AIChE

• Second Vice Chair, Fuels & Petrochemical Division, 2024 – 2025

• Secretary, Fuels & Petrochemical Division, 2022 – 2024

• Director, Fuels & Petrochemical Division, 2019 – 2022

• Group Chair for the Petrochemicals Topical Conference at the 2025 Spring Meeting

• Group Chair for the Petrochemicals Topical Conference at the 2024 Spring Meeting

• Group Chair for Petrochemicals Programming at the 2023 Spring Meeting

• Group Chair for Petrochemicals Programming at the 2022 Spring Meeting

• Group Co-Chair for Petrochemicals Programming at the 2021 Spring Meeting

• Group Co-Chair for Petrochemicals Programming at the 2020 Spring Meeting

• Session Chair for Developments in Petrochemicals at the 2025 Spring Meeting

• Session Chair for Advances in Ammonia as a Fuel/Hydrogen Carrier at the 2024 Spring Meeting

• Session Chair for Developments in Petrochemicals at the 2024 Spring Meeting

• Session Chair for Sustainability Developments for Refining and Petrochemicals I & II at the 2023 Spring Meeting

• Session Chair for Feedstock Expansion for Energy Transition at the 2023 Spring Meeting

• Session Co-Chair for LNG Safety I & II: 22nd Topical Conference on Gas Utilization at the 2022 Spring Meeting

• Session Co-Chair for Sustainability Developments for Petrochemical Production at the 2022 Spring Meeting

• Session Co-Chair for Revamps, Operability, Reliability I & II: 23rd Topical Conference on Refinery Processing at the 2020 Spring Meeting

• Session Chair for LNG Safety: 20th Topical Conference on Gas Utilization at the 2020 Spring Meeting

• Session Chair for LNG Safety: 19th Topical Conference on Gas Utilization at the 2019 Spring Meeting

• Session Chair for LNG Safety: 18th Topical Conference on Gas Utilization at the 2018 Spring Meeting

• Session Chair for Refining Process Safety I & II: 20th Topical Conference on Refinery Processing at the 2017 Spring Meeting

• Session Co-Chair for Refinery Safety I & II: 19th Topical Conference on Refinery Processing at the 2016 Spring Meeting

• Session Chair for Process Safety in Refineries: 18th Topical Conference on Refinery Processing at the 2015 Spring Meeting

• Committee Member: Center for Chemical Process Safety - CCPS Project 270 responsible for the development of the CCPS book Guidelines for Process Safety in Upstream Oil, Gas and Shale Operations (Wiley 2021)

• Committee Member: Center for Chemical Process Safety - CCPS Project 250 responsible for the development of the CCPS book Guidelines for Integrating Process Safety into Engineering Projects (Wiley 2018)

• Committee Member: Center for Chemical Process Safety - CCPS Project 248 responsible for the development of the CCPS book Guide for Making Acute Risk Decisions (Wiley 2020)

• Committee Member: Center for Chemical Process Safety – CCPS Project 224 responsible for the development of the e-Learning Course Hazard Identification for Operators and Maintenance Workers

ASTM International—ASTM

• Subcommittee Member: ASTM D18.26, Hydraulic Fracturing

• Member of the D18.26.01 Site Investigation and Monitoring Section

• Subcommittee Member: ASTM D22.03, Ambient Atmospheres and Source Emissions

National Fire Protection Association—NFPA

• Principal Member: Technical Committee on Gas Process Safety responsible for NFPA 56 Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping

• Principal Member: Technical Committee on Confined Space Safe Work Practices responsible for NFPA 350 Guide for Safe Confined Space Entry and Work

Publications

Dee SJ, Buehler CS, Ogle RA, Reding N, Zanganeh N. The Dogma of Process Safety. Chem Eng Prog 2024; March: 28-33.

Wechsung A, Buehler C, James J, Morrison AM. Carbonomics: introduction to carbon pricing, regulations, and frameworks. Chem Eng Prog 2022; September.

Wechsung A, Wikramanayake E, Banning M. Stern M, Buehler C, Long T, Kytömaa H. Hydrogen fire safety – An old acquaintance in new roles. Fire Protection Engineering 2022; Q2, Issue 94.

Gunaseelan P, Buehler C, Chan WR. Greenhouse gas emissions: Characterization and management. Hydrocarbon Process 2009; September.

Gunaseelan P, Buehler C. Changing US crude imports are driving refinery upgrades. Oil Gas J 2009; August.

Buehler CS, Caruthers JM, Franses EI. Spectroturbidimetry theory for determining orientation distributions of spheroidal particles in the Rayleigh-Debye-Gans and Rayleigh scattering regimes. J Chem Phys 1994; 100:2422-2428, February.

Buehler CS, Caruthers JM, Franses EI. Theory and measurements of orientation distributions of spheroidal particles by Rayleigh-Debye-Gans light scattering. J Chem Phys 1993; 98:3600-3611, March.

Buehler CS. Measurement of orientation distributions of spheroidal particles by light scattering. Ph.D. Dissertation, Purdue University, 1991.

Buehler CS, Caruthers JM, Franses EI. Light scattering theory from monodisperse spheroidal particles in the Rayleigh-Debye-Gans regime. J Chem Phys 1990; 92:140-156, January.

Buehler CS. Light scattering determination of size, shape, and orientation of spheroidal particles in the Rayleigh-Debye-Gans regime. Master's Thesis, Purdue University, 1989.

Selected Reports

Pottenger D, Baer M, Bruce S, Buehler C, Chavda B, Clark S, Cooke D, Horton M, Laughlin C, Mattison D, Quinonez D, Smith M. Richmond Refinery 4 Crude Unit incident - August 6, 2012, Chevron U.S.A. Inc., April 12, 2013.

McCarthy R, Buehler C. Investigation of the CONTSHIP FRANCE casualty supplemental report. Exponent, Inc., July 2004.

McCarthy R, Buehler C. Investigation of the CONTSHIP FRANCE casualty. Exponent, Inc., February 2004.

McCarthy R, Buehler C, McDonough W. Investigation of the DG HARMONY casualty. Exponent, Inc., December 2003.

Eiselstein L, Belanger J, Buehler C, Reza A, Ogle R, Adan M. Investigation of the explosion at Ultem monomer production plant. Exponent Failure Analysis Associates, December 2003.

Zannetti P, Buehler C, Rouson D, Goodman M. Investigation of the off-site impact of an herbicide

application at A-1 Auto Body, Inc., Racine, WI. Exponent, Inc., January 1999.

Belanger J, Buehler C, Reza A. Investigation of the October 1997 polysilicon CVD exhaust line explosion at Integrated Device Technology, San Jose, California. Exponent Failure Analysis Associates, August 1998.

Buehler C, Goodman M. A microbiological assessment of E-pod indoor environment at Walnut Grove Elementary School. Exponent, Inc., April 1998.

Whitehouse G, Petersen J, Buehler C, Picard B. Supplemental report to the analysis of overtime and productivity for the reconstruction project at NIPSCO's Bailly Generating Station. Failure Analysis Associates, July 1992.

Whitehouse G, Petersen J, Buehler C, Picard B. Analysis of overtime and productivity for the reconstruction project at NIPSCO's Bailly Generating Station. Failure Analysis Associates, January 1992.

Invited Presentations

Dee SJ, Buehler CS, Ogle RA, Reding N, Zanganeh N. Catastrophic Explosion Investigation and the Dogma of Process Safety, 19th Global Congress on Process Safety, Houston, Texas, March 15, 2023.

Stern M, Orella M, Wechsung A, Buehler C. Low carbon and stable electricity – what pairs best with renewable electricity: CCS, batteries, or hydrogen? Topical Conference on Emerging Technologies in Clean Energy, American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 11, 2022.

Morse TL, Stern M, Watson H, Buehler C, Kytömaa HK. Experimental evaluation of electrostatic discharge in multi-phase hydrocarbon flows. 18th Global Congress on Process Safety, American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 11, 2022.

Wechsung A, Buehler C. What did I actually buy—guarantees of origin for hydrogen? American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 12, 2022.

Stern M, James J, Morrison AM, Wechsung A, Buehler C. Carbonomics: introduction to carbon pricing, regulations, and frameworks. American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 12, 2022.

Stern M, James J, Morrison AM, Wechsung A, Buehler C. Life cycle assessments: corporate value or potential risk lies in the details. American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 12, 2022.

Sulmonetti T, Buehler C, Dee S, Wechsung A, Wikramanayake E. Transitioning from one explosive fuel to the next – safety considerations in the emerging hydrogen economy, American Institute of Chemical Engineers Spring Meeting & 17th Global Congress on Process Safety, April 2021.

Buehler CS. Panel discussion: The decarbonization pathway: separating fact from fantasy, and reality from reverie. Lloyd’s List Future Fuels Forum, Houston, TX, September 25, 2019.

Buehler CS, Myers TJ, Kytömaa HK. Using data analytics to improve process safety, 12th Global Congress on Process Safety, American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 11, 2016.

Buehler C, Ogle R, Haussmann G. Flash fire from a fractionator overflow. 2014 Mary Kay O'Connor Process Safety Center International Symposium, College Station, TX, October 28, 2014.

Buehler C, Gunaseelan P. Changing US crude oil imports are driving refinery upgrades, creating opportunities. 2009 COQA Meeting, Houston, TX, October 22, 2009.

Gunaseelan P, Buehler C, Chan WR. In profile: Carbon dioxide emissions from U.S. petroleum refining. 2009 AWMA Annual Conference & Exhibition, Detroit, MI, June 19, 2009.

Gunaseelan P, Buehler C. U.S. crude oil imports—Recent trends and their impact on refining. 2009 NPRA National Meeting, San Antonio, TX, March 24, 2009.

Buehler CS. The need for SNG production in the US. Advanced Gasification Systems 2008, Houston, TX, November 6, 2008.

Buehler CS. SNG could prevent a US natural gas supply shortfall. Designing & Operating Coal-Based Substitute Natural Gas (SNG) Plants, Houston, TX, April 10, 2008.

Buehler CS. Insights on failure analysis. Department of Chemical & Biomolecular Engineering Graduate Student Association, Rice University, Houston, TX, February 26, 2008.

Buehler CS. Meeting Canadian hydrogen demand through gasification. Canadian Hydrogen Association Workshop: Hydrogen Defense Against Climate Change, Gatineau, Québec, October 24, 2007.

Buehler CS. Meeting Canadian hydrogen demand through gasification. Processing Canadian Oils and Coal Using Gasification, Calgary, Alberta, August 16, 2007.

McGoran B, Nunes S, Buehler C, Ross B. Role of process monitoring in a chemical plant explosion. Proceedings, 2006 International Symposium on Safety Science and Technology, Changsha, China, October 24-27, 2006.

McGoran B, Ross B, Nunes S, Buehler C, Reza A, Kemal A, Fessler J, Belanger J, Arnold D. Evaluation of a chemical plant explosion and lessons learned. Proceedings, Safety and Reliability, Annual Meeting of the Chinese Mechanical Engineering Society and 1st Annual Meeting of the Chinese Academy of Engineering, Mechanics and Transportation Engineering Division, pp. 252-257, 2006.

McGoran B, Nunes S, Buehler C, Ross B. Role of process monitoring in a chemical plant explosion. 35th Annual Loss Prevention Symposium, American Institute of Chemical Engineers Spring Meeting, Houston, TX, April 2001.

Buehler CS, Caruthers JM. Franses EI. The inverse problem of determining orientation of spheroids from Rayleigh-Debye-Gans (RDG) light scattering regime. American Institute of Chemical Engineers National Meeting, San Francisco, CA, November 1989.

Buehler CS, Caruthers JM, Franses EI. Determination of orientation distribution of nonspherical particles in the Rayleigh-Debye-Gans scattering regime. American Institute of Chemical Engineers National Meeting, Miami, FL, November 1986.

Keville KM, Franses EI, Caruthers JM, Buehler CS. Characterization of novel microspheroidal polymer particles. 60th Colloid and Surface Science Symposium, Atlanta, GA, June 1986.

Project Experience

Hazard and Operability (HAZOP) Studies

A hazard and operability (HAZOP) study is the structured and systematic examination of a planned or existing operation to identify potential hazards to personnel or equipment, or operability issues. Facilitated HAZOP studies on the sulfuric and hydrofluoric acid handling and etching processes for a new advanced glass processing facility in Jiangmen, China, and a number of systems, such as wastewater, scale inhibitor injection, the addition of seawater heaters, and membrane treatment to the water injection

system, on several floating production, storage and offloading (FPSO) vessels.

Hazard Identification (HAZID) Studies
The fundamental purpose of a hazard identification (HAZID) study is to identify, at a high level, possible hazards, safety, or environmental issues associated with a design or planned activity. Led HAZID studies on the addition of seawater heaters and a membrane treatment system to the water injection system as well as a scale inhibitor injection system for floating production, storage and offloading (FPSO) vessels.

What-If Analyses
What-If analysis is a standard methodology to identify hazards, hazardous situations, or specific event sequences that could produce undesirable consequences. This method encourages the hazard evaluation team to consider “what-if” type questions though any concerns may be raised about potential undesired events associated with a design or planned activity. Facilitated What-If analyses on various start-up, operation, and maintenance procedures with focus on the handling of concentrated sulfuric and hydrofluoric acids for a new production facility in Jiangmen, China as well as on standard offloading operations for a floating production, storage and offloading vessel (FPSO) and shuttle tanker.

High Pressure/Low Pressure Interface Review
During design and construction of a floating production, storage, and offloading (FPSO) vessel for service off the coast of Brazil, Exponent was contracted to perform a high pressure (HP)/low pressure (LP) interface review. Reviewed the piping and instrumentation diagrams to identify material specification breaks which each represented a HP/LP interface. For over two hundred interfaces, the FPSO design information was used, including design information from various package vendors, to verify whether adequate protection was provided on LP side, adequate mitigation measures were in place to prevent blockage between HP/LP interface and LP side relief facilities, LP side protection could not be isolated, and the maximum backpressure at the HP/LP interface did not exceed the maximum allowable pressure.

Explosion and Fire at a Specialty Chemicals Facility, Cresson, Texas
During the morning of March 15, 2018, employees at a specialty chemicals facility were preparing to blend sodium chlorite with water to create a 25% solution when an explosion and fire occurred. Product literature, safety data sheets, packaging labels, and plant procedures and practices were reviewed. These documents and deposition testimony were used to evaluate the actions related to the handling of sodium chlorite, including compliance with procedures, instructions, and warnings, of various plant employees leading up to the incident.

Contamination of Acetone Cargo
During the first quarter of 2016, acetone carried in a tank barge from Houston was offloaded into a storage tank at a terminal in Channahon, Illinois. Two days later, a customer rejected a tank trailer load of acetone from the storage tank for failure to meet the specification. Subsequent sampling from the storage tank revealed the acetone was degrading. Barge design and cleaning documentation, marine surveyor reports, analysis reports for acetone samples collected throughout the process, and deposition transcripts were reviewed and additional testing was performed to demonstrate the degradation mechanism. This information was used to determine the cause of acetone degradation.

Flash Fire at a Natural Gas Processing Facility, Corpus Christi, Texas
On March 11, 2014, a flash fire occurred within the inlet filter separator vessel at a natural gas processing facility. Four workers, who were changing the filter elements, of a contractor were injured. Plant documentation, including the safe work permits, and depositions were reviewed, the plant manager and operator who escorted the contractors were interviewed, and the site was inspected. This information was used to evaluate whether the contract workers were aware of the hazards and complied with plant practices and procedures.

Refinery Crude Unit Fire, Richmond, California
On August 6, 2012, a leak was discovered by an operator in an 8-inch diameter carbon steel pipe carrying light gas oil in the 4 Crude Unit (4CU) at the Chevron U.S.A. Inc. Refinery in Richmond, California. A hydrocarbon release from this pipe resulted in the formation of a white cloud and a

subsequent fire. Dr. Buehler was a member of the incident Investigation Team, reviewed the circumstances associated with the incident and the inspection history for the subject pipeline and other pipelines in similar service. He also directed several technical analyses to support the investigation, including calculation of the structural and pressure minimum wall thicknesses of the subject section of piping, evaluation of impact due to potential external forces applied to the failed section of pipe, determination of the fire origin and cause, estimation of the initial flow rate through the piping rupture, and flammability assessment of the white cloud. The Investigation Team concluded that the carbon steel pipe in the 4CU failed due to thinning caused by sulfidation corrosion in a component that had low silicon content. The silicon content of the failed component was ten times lower than the adjacent component where corrosion was monitored.

Alleged Inadequate Maintenance at Petro-Chemical Complex, Baytown, Texas

Plaintiffs alleged that inadequate maintenance over an eight-year period led to repeated equipment failures resulting in excessive atmospheric emissions at a large petro-chemical complex in Baytown, Texas. The overall design, operation and mechanical integrity practices for the facility were reviewed and compared with recognized and generally accepted good engineering practices. Further, the specific circumstances associated with over 200 reported emissions events were reviewed and evaluated with respect to the root cause. In 139 of the reported events, the circumstances were compared with the affirmative defense criteria in the Texas Administrative Code.

Natural Gas Well Site Explosion and Fire, Doddridge County, West Virginia

During the cleanup of liquid on the ground at a natural gas well site in Doddridge County, West Virginia on August 28, 2010, an explosion and fire injured three workers during flowback operations after the well had been hydraulically fractured. Conducted an origin and cause investigation that included inspection of incident and exemplar equipment; reviewed operating records, equipment specifications, eyewitness statements, and deposition testimony; and evaluated potential sources of fuel and ignition.

Refinery Loading Rack Explosion and Fire, San Antonio, Texas

An explosion and fire occurred during filling of a tank trailer at the loading rack of a refinery in San Antonio, Texas on May 5, 2010. Conducted an origin and cause investigation that included a post-fire inspection of the incident site; reviewed operating records, eyewitness statements, equipment specifications, and deposition testimony; and evaluated potential sources of fuel and ignition.

Catastrophic Rupture of a Fluorine Scrubber, South Korea

On May 3, 2010, a fluorine scrubber within a laser system catastrophically failed at a facility in South Korea. The scrubber consisted of a two-stage packed bed of activated carbon followed by soda lime. Exponent was retained to participate in a joint engineering investigation of the root cause of this incident. Reviewed the circumstances surrounding the incident, process chemistry, and relevant scientific literature. Provided input to the differential scanning calorimetry and accelerating rate calorimetry testing program. Used the literature findings and test results to develop potential reaction mechanisms that would generate sufficient heat and pressure to rupture the scrubber. This investigation also involved a literature review of alternative scrubbing media to identify potential hazards.

Explosion During Tire Repair, Splendora, Texas

During the repair of a flat tire at a tire repair facility in Splendora, Texas on August 7, 2009, the tire exploded fatally injuring the tire repair technician. An emergency tire repair and inflation product which contained a flammable propellant had been previously used in the subject tire though there were differing accounts of the quantities of the product that had been added to the tire. Further, additional gas, air and/or oxygen had been used to inflate the tire following use of the product. Reviewed the circumstances surrounding this incident and conducted an evaluation of the flammability of the gas mixture contained within the tire under a variety of potential scenarios to identify conditions that would yield a flammable mixture.

Gas Storage Facility Saltwater Tank Explosion and Fire, St. Elmo, Illinois

Led the engineering investigation of the October 28, 2009, explosion and fire that damaged a produced saltwater tank while a lug was being welded to the exterior of the tank shell at an underground natural gas

storage facility near St. Elmo, Illinois. Conducted an origin and cause investigation that included a site inspection, interviews of key personnel, review of tank operations, and flammability modeling of the tank vapor space.

Natural Gas Distribution System Maintenance Audit, California

A California gas utility company contracted Exponent to conduct a system-wide audit of regulator station and emergency valve maintenance activities in the gas transmission and distribution system during the summer of 2008. The specific audit objectives were to 1) determine whether there were any gaps in the utility's standards with respect to compliance with applicable federal and state regulations, 2) determine whether there was evidence that would indicate regulator and/or valve maintenance may have been omitted, 3) determine whether or not the individuals responsible for regulator and emergency valve maintenance work had the knowledge and ability to perform the work adequately and to the desired quality level, 4) determine if the processes being used in each location to meet the requirements are adequate and consistent, including records preparation and retention, and 5) identify opportunities for improvement in the practices for performing regulator and valve maintenance.

Supervised one of the four audit teams and visited approximately half of the gas system service locations. During the two-week audit period at each service location, Dr. Buehler interviewed maintenance personnel, reviewed selected regulator and valve maintenance records and conducted field inspections of equipment and maintenance personnel performing various procedures. At the end of each service location audit, we presented our preliminary findings to site management and maintenance personnel, followed up on outstanding issues and then issued a report.

Renewable Natural Gas Processing Facility Operational Problems, Stephenville, Texas

During the fall of 2007, the operator of a renewable natural gas processing facility retained Exponent for consulting related to various operational problems. The facility used anaerobic digestion of cattle manure and other animal wastes to produce natural gas that is compressed and treated with an aqueous amine solution for hydrogen sulfide and carbon dioxide removal and then glycol for dehydration. Reviewed historical operational information and compared three desulphurization technologies – reactive chemicals, pressure swing adsorption, and membrane – for use at this and planned future facilities. Provided recommendations to improve operations at the Stephenville facility as well as at future facilities.

Flash Fire During Construction of a New Refinery Unit, Pasadena, Texas

A flash fire occurred on November 19, 2006, during construction of a new process unit at a refinery in Pasadena, Texas. Eyewitnesses alleged the fire flashed back to a sewer in the vicinity of the fluid catalytic cracking unit (FCCU). Exponent was retained to perform an independent investigation into the circumstances surrounding the fire. Key technical issues included analysis of the FCCU operation in the days leading up to the incident, design and operation of the subject sewer system, construction activities that may have caused or contributed to the incident, and siting of a portable toilet and tool trailer that were in the vicinity of the fire.

Waste Processing Facility Fatalities, Corpus Christi, Texas

Performed an engineering investigation of a March 4, 2006 incident at a waste processing facility in Corpus Christi, Texas that resulted in the deaths of two operations personnel. The local medical examiner attributed both fatalities to hydrogen sulfide exposure. Reviewed the circumstances surrounding the incident, production and training records, and relevant chemistry literature regarding the treatment of sulfide bearing wastes. Analyzed the available process and chemical analyses data from waste samples.

Refinery Steam System Damage Analysis, Texas City, Texas

As Hurricane Rita approached the Houston Area in September 2005, the external provider of all steam and electric power to an area refinery initially indicated they would continue operation but later decided to shut down for evacuation and ceased steam production a few hours later. By this time, the refiner did not have the time or the ability to perform a normal cold shutdown, as these procedures typically involve steam to clean and purge the process piping and vessels within the units. Instead, the steam was shut off and the process units went into cold shutdown with hydrocarbons, chemicals, and water left in the pipes and vessels. Evaluated the cause of and extent of the damage to the refinery steam system as a

consequence of Hurricane Rita and whether the repairs made to the steam system were reasonable and prudent under the circumstances to safely restart. In addition, this effort involved evaluation of whether the refiner's plan to recommission the steam system after Hurricane Rita was reasonable and prudent and if so, was the plan implemented in a reasonable and prudent manner.

Refinery Isomerization Unit Explosion and Fire, Texas City, Texas

On March 23, 2005, an explosion and fire within the Isomerization Unit (ISOM) in a Texas City refinery resulted in 15 fatalities and over 170 injuries. The ISOM boosts the octane rating of components used in gasoline formulations. Exponent was retained on behalf of the refiner to investigate this incident. Led this investigation which included on-site inspection of damaged vessels and testing of process equipment, observation of off-site testing of selected pieces of process equipment, and review of technical drawings, process data, and eye-witness statements. It was learned that during startup of a distillation tower that separates gasoline blending components, overfilling of the tower opened pressure relief valves and allowed a large quantity of flammable liquid to flow into a knockout drum and atmospheric vent stack. The quantity of liquid overwhelmed the capacity of the knockout drum resulting in an expulsion of flammable liquid and vapor from the vent stack. Eyewitnesses reported seeing a geyser of liquid and vapor emitted from the top of the stack. A cloud of flammable vapor formed and eventually ignited.

Wastewater Treatment Plant Flash Fire, Linden, New Jersey

Investigated a localized flash fire within the attic space of a floating tank cover on a sludge storage tank at a wastewater treatment plant in Linden, New Jersey on October 15, 2004. At the time of the incident, hot work on the floating tank cover roof was in-progress as a part of an upgrade project. This work included review of the circumstances surrounding the incident, the conduct of the parties involved, and evaluation of both a new powder corrosion inhibitor coating the interior and thermal degradation of the original coal tar epoxy coating as potential fuel sources.

Refinery Excess Sulfur Dioxide Emissions, Westlake, Louisiana

On January 18, 2003, a partial power outage within the refinery shut down the pumps that supplied amine to an absorption column where amine removes hydrogen sulfide (H2S) from refinery fuel gas. During the power outage, H2S laden fuel gas combustion resulted in additional sulfur dioxide (SO2) emissions. This work involved estimation of the SO2 emission rate from each source throughout the incident and the total quantity of emissions using process data, fuel gas laboratory analysis results and design information for the equipment that burned the fuel gas. It also included analysis of the operation of the delayed cokers, hydrotreaters, and fluid catalytic cracker to assess whether operators made appropriate adjustments to reduce production of fuel gas containing high levels of H2S.

Refinery Explosion and Fire, Tuscaloosa, Alabama

On May 13, 2001, an explosion and fire occurred near a flare at a refinery in Tuscaloosa, Alabama. The incident occurred during start-up of the crude unit when the naphtha fractionator was over filled and pressure relief devices opened, allowing flammable liquid to fill the flare header and knock-out drum. Extinguishment of the flare followed by pressure relieving from another vessel caused a geyser of flammable liquid from the unlit flare. Work by a maintenance contractor allegedly caused the malfunction of a liquid level-measuring instrument on the naphtha fractionator that led to overfilling during start-up. Investigated the cause of the incident, which included analysis of process data, design documents, and eyewitness statements as well as engineering analyses of the distillation column involved and the pressure relief system including the knock-out drum.

Alleged Self-Heating of Hazardous Cargo, Papeete, Tahiti and Off the Coast of Brazil

Fires aboard two container ships, one in October 1997 and the other in November 1998, were allegedly initiated by self-heating within containers of calcium hypochlorite, a hazardous chemical cargo. Even though the chemical was known to be thermally sensitive, it was stowed adjacent to and/or directly above heated fuel tanks. Reviewed the events surrounding both fires and assessed the propensity of the calcium hypochlorite to undergo self-accelerating decomposition under the conditions experienced during transport. This assessment included reviews of calcium hypochlorite decomposition literature and shipping history, analysis of production data for the lots transported as well as testing of individual drums and full-size shipping containers packed with calcium hypochlorite in accordance with the United Nations

Recommendations on the Transport of Dangerous Goods Manual of Tests and Criteria.

Refinery Hydrocracking Unit Explosion and Fire Damage Assessment, Martinez, California

During January 1997, a 12-inch-diameter pipe carrying reactor product ruptured in the hydrocracking complex of a refinery in Martinez, California. A mixture of hydrocarbons and hydrogen flowed from the ruptured pipe and ignited. The explosion and ensuing fire damaged property primarily in the second-stage of the hydrocracking unit, with some additional damage to the first-stage and the hydrogen plant.

After the incident, the refiner repaired the hydrocracker complex and filed a claim with its insurance carriers for both property damage and business interruption. The insurers disagreed with a number of the claimed items. Exponent was retained to provide an independent analysis of each of the property damage issues. Directed the technical analyses, including estimation of the depressurization rate and flows through the system during depressurization and mechanical integrity assessments for a heat exchanger shell and the internal trays within all of the first and second stage reactors. The results of these analyses were then used to evaluate the repair schedule.

Sulfur Recovery Unit Upset Cases, Chalmette, Louisiana

Failures of various refinery components and systems resulted in the inadvertent shutdown of the sulfur recovery unit (SRU) at a New Orleans area refinery on four separate occasions, two in 1996 and two in 1998. While the SRU was shut down, all of the acid gas feed that it normally processed was diverted to the flare, resulting in increased emissions of sulfur dioxide. Each of these projects involved estimations for emission rates and the total quantity of emissions as well as the destruction efficiency of the flare. These tasks required the analysis of process data and review of laboratory analysis results, the design details of the flare, and scientific literature on flare combustion testing.

Refinery Hydrotreating Unit Explosion and Fire, Los Angeles, California

On November 11, 1996, an explosion and fire occurred in a hydrotreating unit of Los Angeles area refinery. The failure of an elbow in piping associated with an air cooler allowed a release of flammable hydrogen and hydrocarbons that resulted in an explosion and fire. However, the explosion and resulting fire caused additional piping ruptures, which then emitted additional hydrocarbons to the fire. Quantified and characterized the hydrocarbons released through the various ruptures. Process data prior to and during the incident, process design mass balances, and mechanical drawings for all the vessels in the unit were used to estimate the emissions over the course of the incident. These estimates were incorporated into the incident report submitted to various regulatory agencies.

Fertilizer Plant Detonations, Port Neal, Iowa

On December 13, 1994, two massive detonations at a Port Neal, Iowa fertilizer plant killed four and injured eighteen plant workers. The first detonation originated in a neutralizer vessel, where ammonium nitrate was produced from the exothermic reaction of nitric acid with gaseous ammonia. The resultant ammonium nitrate solution flowed from the neutralizer into a rundown tank, the origin of the second detonation. This investigation included analysis of the events surrounding the incident, research into ammonium nitrate properties and decomposition mechanisms, and analysis of the chemical process using all available information, such as DCS data, sample analyses, and operator log entries. These analyses revealed the ammonium nitrate had become sensitized from the addition of excess nitric acid and chlorides. Furthermore, plant employees had injected superheated steam directly into the neutralizer vessel. The high temperature steam initiated the exothermic decomposition of the sensitized ammonium nitrate eventually leading to runaway decomposition and detonation.