

WILLIAM R. BROZ, P.E., MBA, LEED AP®
PRINCIPAL

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Mr. Broz is a Principal in ESI's Mechanics Practice. He has over 45 years of strong, diverse engineering and business experience including mechanical building system and industrial facility design, mechanical system failure analysis, construction claims, patent litigation, and economic analysis. A seasoned expert witness, Mr. Broz has given oral evidence on more than 40 occasions, in forums including U.S. state and federal court, U.S. domestic arbitration, and international arbitration. Matters have encompassed a broad spectrum of case types including design standard-of-care, construction defect, class action tort litigation, patent disputes, and property/casualty matters.

Mr. Broz has particular expertise in power and process piping design and served for more than 10 years on the Design Task Group of the ASME Power Piping Committee (B31.1). He has designed high-temperature and pressure piping systems for power plants and process facilities and is highly experienced in pipe stress analysis.

Mr. Broz previously served as an operations manager for the Construction Claims Consulting Group of ARCADIS. He has spearheaded claims analyses for a wide variety of projects, with issues ranging from schedule delay and loss of productivity to evaluation and pricing of direct-cost change orders. Mr. Broz is especially well versed in the analysis of complex design and construction contracts, on such varied issues as obligations of parties, delay and disruption, and sustainable design and construction.

Economic analyses performed by Mr. Broz have included net present value and return on investment for energy conservation projects, new capital programs, and major engineering system modifications.

An early adopter of the Leadership in Energy and Environmental Design (LEED) rating system, Mr. Broz has designed LEED projects for new construction up to the Gold award level.

Areas of Specialization

Heating, Ventilation and Air Conditioning (HVAC)
Variable Air Volume (VAV) systems
Variable Refrigerant Flow (VRF) systems
Underfloor displacement ventilation
Central chilled water and heating hot water plants
Data centers, including dual-refrigerant systems
Zone pressurization
Balance-by-design exhaust systems
Legionella investigations
Plumbing
Product listing and regulatory consulting
Lift station design

Domestic water systems
Vent systems
Fire protection design
Wet pipe, dry pipe, and preaction systems
Carbon dioxide suppression systems
FM 200 suppression systems
High-rise standpipe systems
Power and process piping
Process design
Pipe stress analysis
Clean-in-place systems for food processing
Force and gravity drain systems

February 2024

Education

M.B.A., Economics, Seattle University, WA, 1995
Naval Prototype Training Unit, Idaho Falls, ID, 1979
Naval Nuclear Power School, Orlando, FL, 1978
B.S. Engineering, University of Washington, WA, 1978

Licensed Professional Engineer (P.E.)

State of California	License No. 33491
State of Washington	License No. 23134
State of Alaska	License No. AELM8310
State of Massachusetts	License No. 37588
State of Colorado	License No. PE.0050944
State of Oklahoma	License No. PE 26698

Certifications

LEED 2.0 Accredited Professional®, U.S. Green Building Council

Professional Affiliations/Honors

ASME International (formerly the American Society of Mechanical Engineers)

Member
Member, Committee on Power Piping (B31.1) 1993-2009

American Society of Heating, Refrigeration and Air Conditioning Engineers

Member

National Society of Professional Engineers

Member

American Bar Association

Associate Member
Forum on Construction Law

California Arbitration (CalArb)

Member

Positions Held

Engineering Systems Inc., Irvine California

Principal, 2023 – Present
Senior Managing Consultant, 2020 – 2022

Exponent, Inc., Los Angeles, California

Senior Managing Engineer, 2012 – 2020

ARCADIS, Los Angeles, California

California Operations Manager, Claims Consulting, 2009 – 2012
Associate Vice President, 2010 – 2012

CTG Forensics, Inc., Irvine, California

Vice President and General Manager, 2006 – 2009

McGowan Broz Engineers, Inc., Bellevue, Washington

Vice President and Manager of Mechanical Engineering, 1993 – 2005

Publications/Presentations

Publications

Broz WR. Earthquakes: risks, preparation, aftermath. American Bar Association, 2019.

Broz WR, Rochwarg LA. Sustainable Design and Building. In: More sticks and bricks. Chapter 7. Barrett L et al (eds). ABA Book Publishing, Chicago, IL, 2018.

Broz WR, Hollobaugh L. The LEEDing criteria. In: Green building and the construction lawyer: a practical guide to transactional and litigation issues. Chapter 4. Montez CD, Gentilcore EB, Devries MJ, Beutler MA, Steedman TL (eds). ABA Book Publishing, Chicago, IL, 2014.

Broz WR. Forensic engineering investigation of a fuel oil pipeline failure. National Academy of Forensic Engineers Journal, Vol. XXIX No. 1, June 2012.

Broz WR, Pyke C. Green building and risk management. Constructive Technologies Group, Inc., 2007.

Broz WR. Ethics and the expert witness — when to hang up the phone. Construction Claims Advisor, WPL Publications, February 2007.

Broz WR, Loitz D, de Steiguer A. Siphon quenches drought. Civil Engineering, American Society of Civil Engineers, August 1990.

Presentations

- Broz WR.** Mechanical Systems. ABA Forum on Construction Law Regional Session, “Sticks and Bricks,” San Francisco, CA, November 3, 2023
- Broz WR.** Mechanical Systems. ABA Forum on Construction Law Regional Session, “Sticks and Bricks,” New York, NY, September 2, 2019.
- Broz WR, Cydzik K, Wireman D.** Dealing with natural disasters – here comes the flood (of legal issues). Presented at the 2019 Annual Program of the ABA Forum on Construction Law, April 25 – 27, 2019, Hollywood, FL.
- Brown E, **Broz WR.** Demonstrative evidence in arbitration. Panel Presentation, American Bar Association Forum on Construction Law, Washington, DC, April 2017.
- Broz WR.** Forensic engineering investigation of a fuel oil pipeline failure. National Academy of Forensic Engineers, Las Vegas, NV, July 2011.
- Broz WR, Jackson B, Rochwarg LA.** There’s something green in my mediation. Panel Presentation, American Arbitration Association Construction Conference, Santa Monica, CA, April 2011.
- Broz WR, Lo Baugh L, Pyke C, Reisinger D.** Risk management for sustainable development in a changing world. Panel Presentation, Greenbuild, U.S. Green Building Council, Chicago, IL, November 2007.
- Broz WR, Cathcart RJ, Jackson B.** Building green: Risks if you do, risks if you don’t. Panel Presentation, Construction Superconference, San Francisco, CA, December 2007.
- Broz WR, Cathcart RJ, Jackson B.** Green BIM — A key tool for successful green building projects. Panel Presentation, Construction Superconference, San Francisco, CA, December 2008
- Lorman Educational Services: Co-presenter of professional development seminar, “How construction documents cause or prevent design liability in California.” Various locations in Southern California, 2006-2009.
- Moderator, Sustainable Design Panel. Presented at joint meeting between the American Council of Engineering Companies – Washington, and the Consulting Engineers and Land Surveyors of California. With Vertner A, Curtis C, Zinner J. Kauai, HI, April 2002.
- Continuing legal education to numerous law firms in California and Nevada, and the Orange County Bar Association. Topics included: “Ethics and the Expert Witness,” “Expert Witnesses – Effective Partnership with Counsel & Ethical Issues,” “CSI (Construction Scene Investigation): How Technical Investigations Crack the Case,” and “Risk Management Considerations for Green Buildings.”

Broz WR, Landauer E, Relph J. Mark 41 Vertical Launching System — Investigation of foundation bolt failures. Presented at the Annual U. S. Navy Reserve Engineering Duty Officer Technical Training Meeting, Newport Beach, CA, March 1996.

Broz WR, McGowan K. Keeping current with sustainable design. Presented to various architectural firms, engineering companies and project owners in the greater Seattle area, 2001-2004.

Project Experience

Investigations

Systems – HVAC, Plumbing, Fire Protection

Investigating design and operation of sewer distribution system and lift station following gross structural failure of blade-type flood gate.

Analysis of fuel and lube oil system design and operation for diesel engine generators used as prime power for local electric utility. Analysis is part of a fire cause-and-origin investigation.

Investigating alleged design and construction defects for steam prime power plant serving a university campus. Issues include defects in field welds, pipe support design, expansion joint installation, and third-party material certifications.

Led multidisciplinary team investigating technical basis for proposed class action certification, in litigation involving pinhole leaks in copper domestic water piping. Investigation entailed analysis of municipal water treatment methods and historical trends; survey of literature on accelerated corrosion of copper pipe; review of previous inspections of pipe removed from customers' premises; metallurgical examination of pipe specimens including borescopic examination, CT scanning, visual microscopy, and scanning electron microscopy/energy dispersive spectroscopy; and statistical analysis of reported failures. Prepared declaration in support of class certification hearing.

Led multidisciplinary team (mechanical engineering, microbiology, pathology, epidemiology) in investigation of *Legionella pneumophila* outbreak at a manufacturing facility. Conducted site inspections, obtained water and swab samples, and identified sources of bacterial propagation. Facilitated client liaison with the CDC and local health authorities.

Investigation of alleged design coordination errors for new high-rise continuity-of-care residential facility. Issues include evidence of physical interference from building information model.

Investigation of mechanical engineering issues, in a landlord-tenant dispute around alleged noise ordinance violations from industrial equipment. Testified at deposition.

Root-cause investigation of failed press fittings for hydronic piping in a high-rise office building. Issues include press fitting installation and system pressure excursions due to isolation of dual-temperature piping from existing expansion tanks.

Investigation of invalidity issues for patent disclosing an air/CO2 distribution system for indoor agriculture. Produced expert reports on claim construction, and on patent invalidity issues in an *inter partes* petition to the US Patent and Trademark Office. Testified at depositions addressing claim construction and *inter partes* declaration.

Investigating design of a private wastewater lift station serving a residential development. Focus is on responsibility for non-compliance of wet well pumps with contract documents, and on conduct of subsequent troubleshooting when the system failed to perform as designed.

Investigated design of grease exhaust system for commercial cooking line at a food processing facility, following a fire that resulted in total economic loss of building and equipment. Main issues were compliance of exhaust fan and ductwork with contract documents and governing codes. and identification of mechanical engineer of record in light of conflicting claims.

Investigated the basis of design and major HVAC equipment sizing for a power plant expansion under an EPCM contract. Focus was on allegedly prescriptive contract documents for a design-build project, and under sizing of heating, cooling and air distribution systems. Testified at arbitral hearing.

Led multidiscipline architectural and engineering team investigating design standard-of-care issues for an indoor cannabis grow facility. Issues included coordination of fast-track design and construction process; loss of grow space; heating and cooling equipment sizing, and unreliability of central power generation system. Testified at deposition.

Led multidiscipline consultant team investigating alleged HVAC design and construction defects, window-washing system basis of design, and quantum issues for a 55-story office tower. Mechanical issues included HVAC system capacity, remediation of airflow issues, defects in raised floor system, and smoke evacuation system performance.

Led investigation of contamination in shipboard compressed-air systems. Analysis centered on potential role of post-renovation system flushing and considered both mechanical engineering and chemistry-related issues.

Investigated design standard-of-care issues for a central mechanical plant at a higher education campus, including primary-secondary hydronic systems and sequences of operation. Testified at deposition and arbitral hearing.

Root cause investigation of injury to worker from plumbing system piping under pneumatic test pressure. Analyzed timeline, work procedures, safety precautions, warnings, and design of fittings for axial restraint.

Regulatory/compliance consultation for major manufacturer of plumbing fixtures and equipment. Client had backlog of product listings (i.e., legally required registrations) with various jurisdictions, partly due to inadvertent disposal of legacy listing records. Assessed current listing status and prioritized action; developed listing approval applications to third-party certifiers along with all required backups. Performed technical assessment of an existing fan motor listing against revised third-party standard, to determine if product modifications were required. Collaborated closely with Product Engineering staff and advised

that, contrary to client's initial evaluation, the revised technical standards did not apply to the product in question, and no modifications were required.

Multiple cases involving analysis of variable refrigerant volume system design and construction, to opine on the cause of refrigerant leakage and compressor failure in OEM equipment.

Led multidiscipline team investigating causation for extra works and rectification works at a multi-billion dollar hospitality and gaming complex, for international arbitration. Analyzed extra work against local fire code, as well as internationally adopted standards such as NFPA. Analyzed relative responsibilities of the parties for execution of detailed wet pipe sprinkler system design and layout.

Investigated potable water supply system design, in connection with bacterial outbreak at wholesale cosmetics and disinfectant production facility.

Investigated allegations of design defects at new college campus in Malaysia. Systems included central chiller plant; secondary chilled water distribution; wet sprinkler systems; parking garage exhaust; natural gas distribution; and water and sewer reticulation systems. Opined on lifecycle cost considerations between hybrid chiller and variable refrigerant flow HVAC systems.

Investigated mechanical and plumbing design and construction defects at a \$350 million luxury hotel including non-compliant piping materials; temperature and humidity control performance of dedicated outdoor air handling units; acoustic performance of fan coil units; installation and waterproofing details of floor drains; excessive leakage of medium-pressure ductwork; and overheating of central mechanical room. Testified at arbitral hearing.

Investigated alleged defective design of equipment cooling and comfort HVAC systems at a visual graphics data processing facility. Analyzed equipment sizing, air distribution system design for hot aisle/cold aisle rack cooling system, and variable refrigerant flow (VRF) system for office space. Testified at deposition.

Led multidiscipline team investigating accelerated corrosion of copper domestic water pipe at an apartment complex. Corrosion mechanism (erosion-corrosion) was correlated with system construction sequence and subsequent operation, to identify root cause.

Performed condition assessment of HVAC systems in two high-rise office towers, as part of performance evaluation of lead tenant with respect to maintenance terms in lease with owner. Systems included thermal energy (ice) storage system, as well as conventional central plant heating/cooling equipment and distribution. Testified at deposition.

Special Master appointed by US District Court to investigate condition and operation of plumbing systems at two county jails (upon habeas petition).

Investigated patent infringement issues relative to crimp-type fittings for copper piping systems. Analyzed independent claim for fitting geometry as compared to allegedly infringing exemplar.

Investigated patent validity and infringement issues relative to a variable air volume (VAV) box, a device used to control airflow in HVAC systems. Validity-related issues included prior art and obviousness infringement issues entailed both literal infringement and doctrine of equivalents. Testified at deposition.

Investigated HVAC system performance in a specialty outpatient clinic with code-required pressure differentials to protect immunocompromised patients. Performance issues included chilled water supply temperature for MRI cryogenic cooling system; inefficient sequence of operation for heating hot water system; deficient differential pressure and temperature control in sterilization suite; inefficient sequence of operation for main air handler compressors; and failure to perform required building commissioning.

Led a multidiscipline team investigating alleged design and construction defects in a luxury high-rise condominium development, housed in adaptively re-used commercial building. Issues included building envelope integrity, domestic hot water system performance, accelerated corrosion in plumbing systems and electrical code compliance.

Investigated failure of a sewer lift station serving a major health care complex. Evaluated capacity of connecting municipal sewer system; volume and composition of waste stream; specified pump features; sizing of pump and connecting force main; sizing of lift station wet well; reliability and redundancy requirements; and compliance with building code. Evaluation spanned 20-year capital program from existing facility, to final build-out including two new hospitals, medical school, and clinic buildings.

Investigated plumbing system in multi-family residence following a scalding incident. Evaluated system against plumbing code requirements, water heater manufacturer's recommendations, and American Society of Sanitary Engineers guidance. Testified at deposition.

Investigated failure of centrifugal chillers providing district cooling to a hospitality and gaming complex. Issues included cold-weather performance, and coordination of associated design and commissioning activities.

Investigated performance of air conditioning and dehumidification equipment at a natatorium, in connection with incidence of mold. Primary issue was the central air handler's ability to control negative pressure in order to prevent moisture migration from the space.

Investigated mechanical and plumbing code issues in connection with an insurance coverage claim for a World War I era building in Los Angeles. Work included research of that city's 1920s-era plumbing code.

Site inspection and mechanical and electrical systems analysis for a data center, including its power and district cooling utilities. Work supported reliability analysis of mechanical cooling under two scenarios: provided internally; and supplied from a local district cooling utility.

Investigated failure of a CPVC domestic hot water main in a high-rise building. Modeled system stresses, forces and support reactions using Bentley Auto PIPE v. 9.05.

Investigated design standard-of-care issues for a new \$44 million science building at a community college. Issues included interdisciplinary spatial coordination, mis-specification of major equipment, adherence to contractually required standards, and omissions of key building elements.

Investigated performance of HVAC systems in an airport traffic control tower at an international airport. Issues included inadequate pressurization of code-required means of egress, as well as cross-pressurization between egress zones. Modeled tower for airflows and differential pressures using the CONTAM-C zone analysis software from the National Institute of Standards and Technology.

Investigated alleged defects in HVAC system design for a high-rise hotel in downtown Denver. Primary issues included overall air balance, stack effect, infiltration, lack of building exhaust, inadequate air distribution, and life-safety issues pertaining to operation in smoke evacuation mode.

Investigated design of a Los Angeles commercial building's HVAC and plumbing systems, with respect to allegations of a Legionella outbreak. Completed multiple site investigations, including determination of building system configuration without benefit of design or as-built plans. Testified at deposition.

Testified at deposition and trial in a property dispute case between neighbors in a Los Angeles condominium building. Defendant had demolished Plaintiff's heating and air conditioning system in the course of a dispute over easement-by-necessity for common areas. Conducted site investigations and provided opinion on cost and feasibility of various re-installation options. Testified at deposition and trial.

Analyzed performance of rooftop VAV air handlers at a major non-profit headquarters in the Los Angeles area. Developed engineering criteria for functional testing to determine cooling performance and energy efficiency. Performed field work to determine actual performance and developed a report recommending remedial action.

Investigated carbon monoxide poisoning in a single-family residence in Tennessee. Determined cause of CO production from gas water heater, and concentration of CO in flue gas and in a residence following distribution through HVAC system. Testified at deposition.

Performed site investigation and analyzed performance issues for plumbing vent system in a \$400 million court and detention complex in New York City. Assessed compliance with the New York City Plumbing Code, an issue affecting public health and safety.

Investigated allegation of defective fire sprinkler design subsequent to a residential flooding incident. Examined discharged sprinkler and analyzed function against U.S. patent and associated drawings. Also investigated historical performance of fire sprinklers, including reliability and incidence of manufacturer's defects. Testified at deposition and trial.

Investigated failure of copper domestic water piping in a multi-family housing development. Potential causes investigated included water quality, chemical composition of pipe, oxygen pitting, and defective installation, including incomplete reaming of soldered joints in accordance with ASPE guidelines.

Investigated alleged defective construction in the water, waste, and vent systems at a private residence. Directed lab analysis for accelerated crevice corrosion at joints in the copper piping. Testified at deposition.

Led investigative team on a case involving defective electrical engineering design at a correctional facility in the Phoenix area. Analysis focused on quantitative approach to professional standard of care. This

document-intensive case entailed searching over 2 million documents in an online depository using a sophisticated search engine. The team worked through the ambiguous and missing documentation chain to establish relations between RFIs, change-order requests, and change orders. Responsibility for changes and monetary impacts were established and presented in an expert report.

Investigated microscopic tubesheet leakage in new firetube boilers providing hydronic heating at a Massachusetts correctional facility. Supervised field work, including boiler hydrotest and tube removal. Led root cause investigation, including contracted metallurgical lab analysis.

Analysis of domestic water pipe alleged to have failed due to inadequate insulation and subsequent freezing of contents. Provided engineering assessment relative to client's summary judgment motion.

Power and Process Systems

Investigated asphyxiation incident in a food processing plant, focusing on LN2 piping integrity, ventilation supply and exhaust system design, automatic controls, and sequence of operation. Provided engineering oversight for pneumatic testing of LN2 system.

Analysis of design defects in a \$400+ million cosmetics factory, implicated in cross-connection of industrial waste process fluids with FDA-grade water used in production.

Consulting expert on \$380 million design and construction defect claim at an integrated petrochemical processing facility. Analyzed root causes of corrosion documented in over 150 separate piping systems including storage, inspection, hydrostatic testing, draining, drying, and pre-commissioning. Also investigated a range of other defects including pipe support design, spatial clashes between piping systems, defective materials, misalignment of pipe and connecting equipment, and improper system test pressures.

Investigated alternative methods of repair for failed polymer piping at a microelectronics wafer manufacturing facility. Specialty polymers were utilized for sulfuric acid, hydrofluoric acid and mixed acid waste piping. Alternatives were local fusion butt welding repairs versus whole-piping header replacement. Developed independent construction cost estimates. Testified at deposition.

Investigated contamination incident at a condiment processing plant. Contamination was from clean-in-place (CIP) fluid that inadvertently mixed with product due to unauthorized modifications to CIP valve manifold piping, and to coding errors in process management software.

Investigated contamination at a second condiment plant. CIP fluid was introduced into a storage tank serving a condiment kettle line, due to an infrequent and improperly managed CIP operation.

Investigation pursuant to international commercial dispute tried in international arbitration: analysis of engineering contract documents for a steam pasteurizer system installed at an almond processing facility. Process and instrumentation diagrams (P&IDs) contained errors and omissions that resulted in delay and disruption of system installation.

Led multidiscipline engineering team investigating failure of oily water line at a major bulk fuel logistics facility. Investigation included site inspection, analysis of design plans, lab analysis of failed specimen, and written report. Failure modes were microbially induced corrosion and oxygen pitting; root causes were residual sulfur present in product handled by the facility, as well as system configuration and operations that fostered growth of sulfur reducing bacteria. Client's proactive implementation of the team's recommendations led to it receiving a top environmental sustainability award from the federal government.

Analyzed design of subgrade steam and condensate system serving a new hospital, following steam line failure upon introduction of live steam. Investigation focused on support scheme design for systems utilizing both expansion joints and expansion loops. Evaluated design for compliance with restraint requirements set forth by the Expansion Joint Manufacturers Association and the American Society of Mechanical Engineers.

Determined root cause of spill from a 10-inch subgrade petroleum line. Used Auto PIPE(Bentley Systems) pipe stress analysis software to determine that a leaking flanged joint had exceeded Code stress limits, under the criterion of equivalent pressure. As a first-responder, supervised the re-preservation, corrosion prevention, and restoration of line to full service. Subsequently designed an upgrade to the pipeline to ensure future integrity, which was implemented successfully. Results published in the Journal of the National Academy of Forensic Engineers.

Analyzed engineer-procure-construct (EPC) for a large cogeneration facility in southeast Alaska, with respect to limitations on Defendant's right to direct Plaintiff's work. Provided technical opinion on appropriateness of design basis stipulated by Defendant for Plaintiff's pipe stress analysis work. Testified at deposition.

Analyzed claims regarding improper equipment sizing and inappropriate system design criteria at a municipal water pumping station and transmission line. Testified at deposition and trial.

Investigated pipe support loadings for the major hydronic systems (up to 30 inches diameter) at a \$1 billion microelectronics wafer fabrication plant. Retained as an independent following the discovery of a major error in the sizing of supplemental framing for the piping support. Project tasks included review of load combination methods as well as loading for each individual support. Several missing or improper supports were identified, as well as inappropriate load combinations.

Construction Claims

Analyzed adherence by EPC contractor to contract requirement for completion of final project documentation, for a \$500 million+ chemical process plant. Issue tied to performance bond call representing a significant proportion of the construction cost.

Led several multidiscipline consulting teams investigating three major heads of claim and one counterclaim, as part of a multi-billion international arbitration of design and construction issues at a mine processing facility. Testified at arbitral merits hearing.

Analyzed contractor claims for a roadway improvement project at an international airport. Analyzed compensable time claim for concurrent delay and impact on critical path. Negotiated settlement of productivity loss claim based on MCAA methodology, including causation based on contemporaneous project documentation.

Analyzed contractor claims for compensable delay and loss of productivity case involving a higher education district and a general contractor. LOP claim incorporated several methodologies (measured mile, Leonard, MCAA, modified total cost). Analysis included definitions in general conditions for delay, disruption, acceleration, and loss of productivity.

Contract analysis to determine owner liability for increased labor/material cost associated with pipe supports at a wastewater treatment plant. At issue was the installing contractor's obligation to provide detailed design services for the support system, based on the specs and GCs.

Claims analyst for various disputes between a state transportation department and its general contractors. Issues analyzed included wage escalation, direct-cost change orders, and force account price adjustments.

Led consulting team for an open-order claims consulting contract between a public transportation capital program and its design-build contractor, for a \$400 million+ light rail system. Major tasks included contract analysis, risk assessment for new bid packages, and strategic consulting for claims prevention and mitigation.

Economic Analysis

Economic analysis of vacuum insulated cryogenic piping at an air separation plant. Analysis resulted in the local electric utility financing more than \$300,000 in capital improvements, representing energy savings of over 2.89 million kWh per year.

Discounted cash flow analysis for 6-MW prime power generation plant, installed at a housing development on Sakhalin Island in the Russian Far East. Analysis was undertaken to determine economic viability of exhaust heat recovery system for the plant's natural gas-fired engine generators. Performed hourly energy analysis to determine fuel consumption. Final report included sensitivity analyses for capital cost of equipment, fuel consumption, cost of fuel, and cost of capital.

Developed performance specifications and performed net discounted cash flow analysis for a PANAMAX container crane, to be used for handling explosive ordnance for the U.S. Navy and other federal agencies. The crane was planned for installation on an existing 1,800-foot-long ammunition pier at a Navy ordnance logistics facility.

Discounted cash flow analysis of a change in the primary materials of construction for a major U.S. Navy shipboard weapons system. Initial cash flows included engineering redesign, retooling, and prototyping. Operational cash flows included differential material and machining costs, weight savings, and decreased preservation expense. The analysis was done as part of a Co-operative Research and Development

Agreement (CRADA) between the Navy's program office, the in-service engineering agent, and the prime contractor.

Comprehensive energy audit for a 3.7-million-square-foot auto assembly plant. Systems analyzed included lighting, steam and condensate, compressed air, natural gas, and cooling towers. Energy conservation measures were identified totaling \$1.3 million in annual energy savings with a payback of 1.2 years.

Design and Operational Experience

Building Systems - HVAC, Plumbing, Fire Protection

Designed mechanical systems for a new 50,000-SF, \$24 million Terminal Radar Approach Control (TRACON) facility for an international airport, to accommodate airport expansion and Mechanical systems included HVAC, plumbing, fire protection, and emergency power generation. Extensive energy modeling was conducted to simulate savings from underfloor air distribution system and waterside economizer. The facility included integration of a Building Management System (BMS) to increase energy efficiency. The project was certified by the U.S. Green Building Council to the Leadership in Energy and Environmental Design (LEED) 2.0 Gold award level in 2004 and received the White House "Closing the Circle" award for outstanding federal environmental stewardship in 2005.

Mechanical engineering design of HVAC, plumbing, and fire protection systems for a new secure combined communications and 911 center located in a new concourse in an international airport. HVAC systems included a fan-powered variable air volume (VAV) system for occupied spaces, and dedicated computer room units with both chilled water and backup DX coils for equipment spaces. Fire protection included a preaction sprinkler system, as well as a zoned smoke pressurization system. Mechanical systems were designed to NFPA 1221 standards for communication facilities. Acted as design team representative to the commissioning team for testing of the smoke pressurization system.

Mechanical engineering design of a new \$21 million air traffic control tower and 18,000 SF base building at an international airport. Airside systems included fan-powered VAV, constant volume, and a raised-floor computer room. Wetside systems included heating hot water, chilled water, condensing water for cooling towers, fire protection, fuel oil for boilers and emergency generator, and domestic plumbing. An HVAC system for the 850 SF control cab provides comfort and window fog prevention in a room with 360° glass installed.

Mechanical engineering design of electronics rooms for Common Use Terminal Equipment (CUTE) and Communications Infrastructure Backbone System (CIBS) retrofit at an international airport.

Mechanical engineering design for several commercial tenant improvements in a new concourse at an international airport.

Developed measurement and verification (M&V) protocol for an \$8 billion residential and entertainment development in Las Vegas. The M&V protocol was a requirement of the LEED certification goals — all successfully met — for several of the project phases. Protocol was in accordance with IPMV criteria and entailed central plant chillers, boilers, heat recovery, and electrical.

Mechanical engineering design of natural gas piping, plumbing, compressed air, and HVAC tenant improvements in an 854,000 SF light aviation manufacturing and storage facility. Several independent tenant improvement spaces were developed within the basic building shell. The project included design of a specialized fume exhaust system for exhaust of toluene, MEK and other volatile solvents, using the balance-by-design method. This \$8 million fast-track project went from shell-and-core only to full beneficial occupancy in six months.

Mechanical engineer and principal-in-charge for retrofit of a combined wet-pipe sprinkler and standpipe system covering residential portions of an existing 14-story student residence hall. Project included detailed sprinkler head layout for architectural coordination of residential and lobby floors. Close coordination with the local Fire Department was a critical task.

Mechanical engineer and principal-in-charge for a \$2.7 million fire safety, kitchen, and energy conservation upgrade to an existing 13-level student residence hall. The fire protection system entailed a building-wide combined wet-pipe sprinkler and standpipe system. The project also included a complete catering kitchen retrofit, including new Type I exhaust hood, ductwork and exhaust fan, new freezer/cooler compressors and fan coils, and new gas and waste services. Building energy conservation measures included gravity film heat exchangers to recover heat from shower waste lines, waterless urinals, low-flow shower heads, and a new dry cooler to shift refrigeration from once-through cooling to closed-loop cooling.

Mechanical engineering design of a new 100,000 sf, \$15 million cruise ship facility. The facility consists of a pre-engineered building with stick-built tenant improvement areas within the interior. The project design included field investigations, meetings, and redesign to accommodate stakeholder requirements (including Customs Service, INS, and provisions for future airline check-in). Design elements involved HVAC, plumbing, and fire protection.

Mechanical engineering design of a new 9,620 SF public library. The project required close coordination with the architect from the selection of exposed duct material to utility routing that ensured conformance with the building profile. Aesthetic considerations required a "clean" roof surface, so exterior mechanical utilities were located to avoid public view. Mechanical systems featured exposed spiral duct work and fittings in reading rooms, and acoustic mitigation. The project won an AIA National Honor Award in 2002.

Led multidisciplinary team in design for demolition and replacement of a 665-slip marina on Puget Sound, WA, following structural failure in the wake of historic snowfalls in 1996. Systems included potable water, fire protection, wastewater, electric power, and lighting.

Principal in charge of commissioning mechanical and electrical systems for new firefighting headquarters (operational and administrative) for the City of Los Angeles. Reviewed and approved functional test procedures and field protocol for the Commissioning Agent.

Power and Process Piping

Project manager and lead mechanical engineer for design of a \$150 million (2020 dollars) kraft recovery furnace facility (firing 3.7×10^6 pounds of dry solids per day). Managerial responsibilities included primary client contact, interdisciplinary coordination, budgeting, quality assurance, project scheduling, and communications with outside organizations. Technical responsibilities included engineering for 800-psi, 175-psi, and 55 psi steam systems; piping and instrumentation diagrams for all processes; mechanical equipment and process piping layout; pipe stress analysis; forced draft and induced draft system ducting and breeching; stack design; bid specifications; and construction cost estimates.

Mechanical engineering design for replacement of existing single-wall subgrade Jet-A piping with double-walled piping at an airplane manufacturing plant. The system included interstitial leak detection and associated (400 Hz) power for five fueling positions. Containment pipe for the 8-inch carrier pipe was carbon steel, fusion-bonded, and epoxy coated. The system was designed for upgraded flow requirements for a new passenger aircraft.

Developed functional test procedures for the mechanical systems at a cogeneration facility (diesel waste heat-to-power). Systems included generators, cogen runaround loop, electric boilers, and automatic control systems. Completed and optimized sequence of operation to match field conditions.

Mechanical engineering design of a 10.5-MW, \$10 million prime power plant. The facility is located in Chukotka Province in the Russian Far East. Power generation equipment included seven (Caterpillar 3516B) diesel generators. Spool drawings were produced for all large-bore piping (heat recovery, fuel, and compressed air), which was fabricated in the United States and designed for rapid onsite assembly. HVAC and combustion air systems were designed for arctic conditions (-70° F.), including wintertime attemperation and pressure control of building exhaust. Estimated construction cost was over \$10 million.

Project manager for design of a 6-MW prime power generation plant for a housing development on Sakhalin Island in the Russian Far East. This design-build project included mechanical, electrical, controls, and acoustical engineering services for the power plant building and site electrical distribution. The plant is designed to operate full time, independent of the existing municipal electric grid.

Design review and consulting services for a new hydrant fueling system at the international airport in Kazakhstan. Quality assurance work included review of all process and instrumentation diagrams (P&IDs), piping layouts, plot plans, storage tank plans, instrumentation drawings, construction specifications, and calculations for the fuel system. Consulting services included recommendations for equipment selection, and review of material requisitions for adequacy under design wintertime conditions (-40 °C) and conformance to design intent. System completed successful startup in April 2005 with the refueling of a commercial jetliner.

Supervised mechanical engineering design and served as engineer of record for subgrade hydrant aircraft fueling system at a new concourse at an international airport.

Mechanical design of one mile of new 24-inch, above-grade JP-4 pipeline at a petroleum oil and liquids (POL) marine loading and storage facility. Design included pressure relief, pipe support and thermal

stress mitigation. The optimum method of construction phasing was determined to minimize the impact of construction on site operations.

Mechanical engineering design for 1-million-gallon fuel oil tank and associated transfer system located at a marine fueling terminal in southeast Alaska. Project included both above- and below-grade piping design. Specifications included transfer pumps, tank heaters, piping, insulation, and control sequence of operation for fuel transfer.

Mechanical engineering design for \$5 million upgrade to the existing emergency power generating system at an international airport. The upgrade included two new (1,500 kW) engine generators, supplementing two existing (600 kW) generators. Design challenges included an extremely limited and congested existing space envelope, and CO₂ fire suppression system. The upgraded subsystems included cooling and combustion air, fuel oil supply and return, primary and secondary cooling water, and diesel exhaust.

Evaluated condition of deteriorated under-pier fuel oil line, for marine fuel dispensing facility at a seaport's primary container facility. Conducted non-destructive examination of existing pipeline and performed quantitative risk analysis of status quo and rebuilding options.

Performed piping flexibility and stress analyses for the heating water, heat recovery water, secondary cooling water, and tertiary cooling water systems at an electronic wafer fabrication facility. The pipe systems were ANSI Class 150, with sizes ranging from 2½ to 10 inches and materials that included type 304L stainless steel and polypropylene-lined carbon steel. After pipe loading and seismic forces transmitted to the existing building structures were determined, designs for individual pipe supports and redesigns of the affected building support framing were provided. Services also included general mechanical and structural onsite engineering.

Stress analysis of hydronic piping systems at a microelectronics wafer fabrication plant, using Auto PIPE v. 4.7. Each piping run was secured to two separate structures subject to differential seismic drift. Following the analysis, the required pipe support types and locations were established.

Stress analysis for a new process line within the existing chemical reactor at an oil refinery. The line carries naphtha and hydrogen gas at 300 psig and 650 °F. Analysis included code stresses, as well as reactions at the reactor nozzle inlet.

Project manager and stress analyst for relocation of subgrade 24-inch steam and 8-inch condensate return lines in a municipal district heating/cooling system. Deliverables included complete mechanical and structural drawings, analysis of pipe stresses and forces, design of pipe supports and anchors, and design of manholes and encasements.

Designed two booster pump stations for a municipal water district. Each pump station included four booster pumps capable of producing a combined nominal flow of 5,000 gallons. Due to varying pump station head requirements, motor sizes of 90 and 250 hp were required.

Mechanical engineering design of a 400-ton/day old, corrugated container (OCC) recycling plant. Black Clawson hydropulper, cyclones, reverse cleaners, and Lehman-slotted pressure screens were specified.

Design elements included piping design, flow rate analysis, equipment selection, bid administration, and pipe stress analysis. The project won the American Consulting Engineers Council Grand Award for Special Projects in 1991.

Project manager for construction of a 24-inch diameter, 1,800-foot-long, high-density polyethylene overland siphon. Project included site investigation, ascertaining feasibility, completion of mechanical calculations, specification of pipeline material and fabrication method, development of the bill of material, and execution of the design drawings required by the contractor and government agencies. The siphon was constructed in two weeks, at a remote work site and under extreme conditions. Supplying 20 million gallons per day, the line exceeded the design flow rate, averted a mill shutdown, and prevented the layoff of 600 employees by replenishing the mill's primary watershed. The project was featured in the August 1990 issue of Civil Engineering magazine.

Supervised the operation, testing, and maintenance of a shipboard nuclear propulsion plant, including all primary (nuclear) and secondary mechanical systems and equipment. Qualified by the Naval Sea Systems Command as Engineer Officer of a nuclear-powered ship.