EXECUTIVE SUMMARY

Celebrating more than 30 years in business, Hughes Associates is a global leader offering engineering and consulting services for fire protection on and life safety, code compliance, hazard analysis and risk management, research and testing and physical security. Hughes’ experts are committed to providing the most cost-effective, sustainable, and appropriate solutions that meet our client’s needs.

Founded in 1980, Hughes is headquartered in Baltimore, Maryland with over 35 offices worldwide. On-site laboratory and testing facilities in Baltimore compliment our traditional consulting, engineering and forensic services. Hughes offers customers a unique combination of research capabilities and global application expertise.

ENGINEERS. CONSULTANTS. SCIENTISTS.
Our staff consists of a renowned group of 180 engineers, scientists, and computer programmers, as well as investigators and other specialists, who are among the best in the field of fire protection engineering and code consulting services. Our engineers serve on numerous National Fire Protection Association (NFPA) committees (multiple with Chairman positions) including the Life Safety Code, Fire Alarm and Signaling Code.

PETROLEUM / PETROCHEMICAL INDUSTRY
From the outset, Hughes has supported many facets of the petroleum and petrochemical industries and has provided considerable project experience, ranging from research to assessing the risk for multi-location, multi-product manufacturing facilities.
SERVICES OFFERED

FIRE PROTECTION ENGINEERING

Hughes advocates a cohesive design philosophy from concept to project execution that results in a feasible, practical, goal-oriented fire protection design. Our services cover the full range of facility and project life cycles, including:

- Conceptual planning
- Preparation of bid packages and specifications
- Detailed designs, including calculations
- Review of bids, preliminary design packages
- Field review of installed systems
- Functional and acceptance testing

CODES & STANDARDS

As members of committees and regulatory bodies, Hughes’ engineers become involved with code issues long before they reach committee. We serve on key committees of interest to the petroleum and petrochemical industries, such as NFPA 11, NFPA 30, NFPA 52/57, NFPA 58, or NFPA 72. This participation gives us unique insight into the codes and allows us to provide pragmatic and cost-effective assistance to our clients.

Our personnel are experienced in developing guidelines and standards which become corporate documents for many clients. Hughes personnel have prepared numerous corporate policies, procedures, and engineering guides for clients or as employees of various petroleum and petrochemical companies.

RESEARCH & TESTING

Hughes has a staff of engineering and scientific personnel capable of designing, instrumenting, and conducting tests. This research analyzes not only fire growth and effects, but also the effectiveness of fire protection systems. We conduct small-scale testing in our Baltimore laboratory and larger testing at 3rd party test sites.
SOFTWARE AND MODELING

Hughes has a full suite of software products to analyze and solve clients' problems. As we are neither a commercial software development company nor are we affiliated with any software vendors, we do not force-fit a problem to specific software. We select the best model available to solve the problem at hand in a cost effective manner.

Software and modeling we have available, or with which we have project experience includes:

- **Release scenario models** – includes mass release calculations, vapor generation models, pool spread models.
- **Vapor dispersion models** – from simple Gaussian dispersion models to more complex heavy gas models (e.g., DEGADIS, HEGADIS).
- **Heat radiation models** – for jet fires, spill fires, BLEVEs.
- **Overpressure models** – from unconfined vapor cloud explosions, using simple TNT equivalency modeling or more complex models, such as the Baker-Strelow model.
- **Fire Growth and Spread** – For building fires, the FAST (Engineering Tools for Estimating Fire Growth and Smoke Transport) suite of models from the National Institute of Standards and Technology.
- **Building Life Safety** – Hughes developed the Computerized Fire Safety Evaluation System (CFSES) for analyzing life safety features of various building configurations for office/business occupancies.
- **Process Hazard Analysis** – For documenting process hazard analysis studies, Hughes uses PHAWorks®

Where commercially available models are unavailable, our scientists and engineers develop in-house models for the problem at hand!
INCIDENT INVESTIGATIONS & EXPERT WITNESS

Hughes engineers and scientists support client’s investigations and litigation with their knowledge of the following:

- Reconstruction of Fire Incidents
- Engineering Analyses
- Testing
- Compliance with Codes and Standards

We have built a reputation for technically superior analysis, professional integrity, and presentation of information in a logical and scientifically credible manner.

PROCESS SAFETY MANAGEMENT

Hughes personnel have assisted many clients with developing and implementing process safety management (PSM) programs that meet or exceed applicable regulatory or company requirements.

Our staff has conducted hundreds of process hazard analysis (PHA) studies and numerous audits of PSM programs. We are prepared to assist our clients in any aspect of their PSM program including:

- Development of Program Elements
- Process Hazard Analysis
- Consequence Analysis
- Release Scenario Development
- Discharge Modeling
- Vapor Cloud Generation and Dispersion
- Toxic Impact
- Blast and Radiant Heat Impact
- Frequency Calculations
- Audits
- Process Safety Management System Audits
- Risk Management Program Audits
- Levels of Protection Analysis (LOPA)
- Safety Integrity Levels (SIL) Analysis
RISK CONTROL MANAGEMENT

Hughes’ approach to risk control management differs from traditional risk services. Our engineers assess hazards probability and model hazards consequences. We profile and rank risks are profiled and ranked in terms relevant to our customers’ organizations. We establish the cost/benefit relationship of various risk-mitigation strategies through risk-treatment modeling. Our risk control/loss prevention activities include:

- Loss Prevention Reviews
- Petrochemical Risk Analysis
- Business Continuity Reviews and Planning
- Underwriting Reports
- Plan Review

TRAINING

Hughes personnel have developed and conducted numerous training courses covering a wide range of fire protection and process safety topics, which include:

Training Formats

- Traditional training and/or
- Web-based training

Training Course Topics: Basic of Hydrocarbon Fire Protection Principles

- Emergency preparedness drills
- Fire brigade training
- Fire department operations and response
- Fire protection equipment inspection and maintenance
- Fire protection systems design
- Life safety
- Loss prevention and safety training
- Loss Prevention in the Petroleum Industry
- Process hazard analysis leadership
- Process Safety Management overview
SECURITY

Security Vulnerability Analysis (SVA)
Hughes is one of only a few consulting companies certified by the American Institute of Chemical Engineers (AIChE) for conducting security vulnerability analyses (SVA) in accordance with the CCPS methodology and criteria.

Security & Hazards Mitigation Alliance
As a member of the Security and Hazards Mitigation Alliance, we provide state-of-the-art solutions to any security issue from bioterrorism to industrial theft.

SURVEYS

Hughes personnel conduct independent surveys of facilities to assess the level of hazards, evaluate the adequacy of installed fire protection systems, etc. Typical surveys include:

- Drainage
- Emergency response plans
- Emergency shut down
- Fire protection equipment locations
- Fire protection of cable trays with critical functions
- Fire water system supply and distribution
- Flare and relief header design basis
- Needed fire flows
- Oily water sewer design
- Plant and battery isolation valves
- Plant and equipment spacing
- Plant fire protection requirements vs. Industry and international standards
- Pressure relief valve design and installation
- Fire protection of ESD valve operators and power and instrumentation cables

ENVIRONMENTAL

Hughes’ environmental group offers innovative solutions to environmental challenges, focusing on pollution prevention and abatement techniques. Our primary concern is providing the most cost-effective solution that minimizes effects on client operations while achieving the desired objectives.
FACILITIES SERVED

REFINERIES

Our refinery experience has included project design, fire protection system analysis, process safety management program implementation, process hazards analysis, audits, training, and technical support to refinery staff. Our projects have involved nearly every type of refinery process unit including:

- Alkylation units, both sulfuric acid and hydrofluoric acid
- Amine regeneration units
- Benzene, toluene, xylene (BTX) units
- Coker units
- Crude units
- Dimersol units
- Fluid catalytic cracking units
- Hydrocracker units
- Hydrogen units
- Hydrotreating units
- Merox units
- Reformers

CHEMICAL/PETROCHEMICAL PLANTS

Hughes has provided fire protection and process safety support to a number of basic and specialty chemical plants. This has included developing and implementing process safety programs, conducting process hazard analysis, audits, and training.
TERMINALS & TANK FARMS
Hughes has conducted numerous projects involving pipeline, tank farm, terminals, and loading and unloading operations. These projects have ranged from evaluating facility siting, conducting fire consequence analyses, and compliance reviews to industry and regulatory codes, and new facility design projects.

EXPLORATION & PRODUCTION FACILITIES
Hughes personnel have worked on many projects at exploration and producing facilities, both onshore and offshore. We have conducted audits of facilities, worked on the design of fire water and fire protection systems for new platforms, performed failure modes and effects analyses (FMEA) of conceptual sub-sea production systems, and provided ongoing loss prevention technical support to operating facilities.

GAS PLANTS
Hughes personnel have conducted numerous projects at a number of gas plants. These gas plants have included gas-oil separation facilities, both onshore and offshore. We have carried out projects for numerous liquefied natural gas (LNG) and compressed natural gas (CNG) plants, hydrogen and methanol alternative fuel storage and refueling facilities:

- Providing ongoing fire protection support during plant construction or expansions
- Evaluating fire systems
- Calculating fire radiation in support of a facility's siting
- Conducting process hazard analyses.

HAZARDOUS CHEMICAL WAREHOUSES
Hughes has conducted evaluations of hazardous chemicals to identify compliance with local and national codes and standards. Where needed, fire tests to define the appropriate level were conducted, fire protection systems designed, fire resistive construction, venting, drainage, electrical area classification, explosion relief specified and permits obtained.
GUIDELINE FOR FIRE PROTECTION FOR CHEMICAL PROCESSING FACILITIES

Fire Protection Guidance Development
Hughes coauthored a textbook for the Center for Chemical Process Safety aimed at providing general fire protection guidance for the petrochemical industry. Hughes authored the chapter on Fire Hazard Analysis, which provides an introduction to fire protection chemistry, hazard identification, typical fires, and the impact from fires. Emphasis was placed on thermal radiation from fires, and resulting impact on equipment, structures, and personnel. Example calculations are included.

Kinder Morgan, Reno Tank Farm, Reno, NV

- **Foam System Design** (2013)
  The design of foam suppression systems is being provided for two petroleum storage tanks.

- **AFFF Suppression System Design** (2012)
  Foam suppression systems were designed for six existing floating roof fuel tanks at Kinder Morgan’s Reno fuel tank terminal. Work included construction period services.

- **Alyeska Pipeline Service Company, Anchorage, AK**
  Fire Protection Engineering Services

- **East Tank Farm** (2010)
  Services were provided to review a prior fire protection study regarding internal floating roofs on crude and ballast water tanks. A design basis was generated and recommendations were made for fire, smoke detection and alarming. The concept for fire protection piping routing was developed.

- **Valdez Tank Farm** (2009)
  Hughes participated in a risk assessment of the recommendation to install fire monitors at the tank farm.

- **Pump Station Risk Assessment** (2009)
  Hughes participated in a risk assessment of pump stations.

- **Cable Tray Risk Assessment** (2008)
  Hughes participated in a risk assessment of cable trays at PS3 and PS4.


*Fire Safety Evaluation*
Hughes reviewed existing fire protection facilities to identify significant fire protection and life safety deficiencies at 12 existing pumps stations and the Valdez Marine Terminal. Hughes personnel conducted a facility walk down to identify deviations from codes and standards. Results were used to implement a plan to correct identified deficiencies, and justify continued permit to operate.
ExxonMobil Development Co., Houston, TX  (2012)
- **Loss Prevention Support, Upper Zakum Project, Abu Dhabi**
  Hughes provided loss prevention support for the Upper Zakum Project, involving the construction of artificial islands to support production from an offshore oil field. Assistance is also being provided to resolve issues arising from a Quantitative Risk Analysis and other loss prevention issues.
- **Loss Prevention, Barzan Project, Yokohama, Japan  (2010)**
  Hughes is providing loss prevention and process hazard analysis support for the Barzan Project in Japan.
- **Loss Prevention, Banyu-Urip, Indonesia (2009)**
  Support was provided to resolve risk and loss prevention issues in preparation for the start-up of a new gas-oil separation plant (GOSP).

BP Whiting Refinery, Whiting, IN  (2012)
*Fire Safety Consulting Services*
Hughes provided a detailed on-site survey of the all new steel construction and Refractory QA expertise was supplied for coker furnaces as part of the Whiting Refinery Modernization Project.

BP Exploration (Alaska), Inc., Anchorage, AK  (2011)
*SFRM Analysis*
A site visit was conducted to observe in-place spray-applied fire-resistive material for deficiencies. A remediation plan was developed to determine what structural steel needed to be protected, how best to remediate, and what type of materials should be used.

BP Exploration (Alaska), Inc., Anchorage, AK  (2007)
*Clean Agent Consulting*
Consulting is being provided to BP Exploration for clean agent system use. Tasks include:
- **Clean agent training preparation** – Preparation of a power point presentation to BPXA. Covering the basics of clean agent system protection and the specifics of their applications.
- **FM200 as Direct Halon Replacement Study** - Development of a white paper on the ability to use FM200 as a direct drop in replacement for Halon 1301 in total flood systems.
- **FE-13 Leakage Calculations**
- **Halon 1301 system review**

BP Production America, Houston, Texas (2003-2006); (2006-2009)
*Master Contract*
Hughes has provided fire safety consulting services an open-contract basis for BP worldwide fire protection, safety and environmental design and consulting services. Three projects conducted include...
establishing the correct concentration of fire protection gaseous extinguishing agent to protect a specific chemical compound; analyzing the fire risk of operation of a triplex pump/combustible engine for pumping methanol into the piping system, and developing a white paper on relative value of using HSSD detection vs. ionization and photoelectric detection.

**Saudi Aramco, Dammam, Saudi Arabia (2010)**

*Training Course Development & Presentation*

Five-day training courses on fixed fire systems design and fire alarm system design were developed and presented three times during 2011.

**Strategic Petroleum Reserve Sites**

- **Fire Protection Program Evaluation (2013)**
  Hughes is conducting an assessment of the SPR Fire Protection Program for Program Administration, Emergency Response, and Facility Fire Protection.

- **Hydrant Flow Testing (2011)**
  Hughes performed hydrant flow testing at all Strategic Petroleum sites in Louisiana and Texas.

- **Update of Baseline Needs Assessment (2009)**
  Hughes is providing an update of a Baseline Needs Assessment that it developed in 2007, to ensure compliance with Department of Energy Orders. Work also includes development assistance for emergency planning based on a vulnerability analysis, and providing solutions based on engineered systems, programmatic changes, or modifications to approaches on staffing.

- **Halon Fire Suppression System Evaluation (2001)**
  Hughes provided all necessary services to evaluate the control room halon fire suppression systems at Strategic Petroleum Reserve Sites (SPR) for compliance with accepted industry fire protection requirements and the applicable standards. The Bayou Choctaw, Big Hill, Bryan Mound and West Hackberry sites were analyzed and an assessment was made of fire prevention and protection program documentation; engineered drawings, operational requirements, and implementation of those requirements. Hughes made a determination of whether the SPR meets the Improved Risk/Highly Protection Risk (IR/HPR) level of protection. Recommendations were made for modifications and elimination of redundant systems.


*Fire Protection Systems Design Concepts Review*

Using NFPA and industry codes and standards, Hughes reviewed the proposed fire protection design for the planned construction of a petrochemical/hydrocarbon jetty to service up to two large tanker vessels in Haiphong Harbor. Work included the development of the needed fire flow, the appropriate length of time that water will be needed at the fire flow to determine the fire water tank size, and then the development of the fire pumps type and size, foam system and water tank requirements, the water tank and tank supply system, the gas and/or fire detection, fire water system reliability, and location of monitors, hydrants and hose reels appropriate for the project.
Enbridge Pipelines, Inc., Edmonton, Alberta, Canada  (2008)

tank Full Surface Fire Study
Hughes developed radiant heat exposure distances from the full surface storage tank fires to prevent damage to tanks.

Willich Chile S.A., Santiago, Chile  (2008)

Manual Development
Hughes provided assistance to Willich Chile to develop a guidance manual for ENAP for the application of passive fire proofing (PFP) for refineries.

Magellan Midstream, Tulsa, OK  (2006-2012)

Fire Protection Engineering Services
Consulting services have been provided for Magellan facilities since 2006. This work has included:

- Fire suppression system evaluation, truck loading racks, Sioux Falls
- New foam system protection design, Dallas & East Houston Terminals
- Fire investigation, tank fire
- Ethanol canopy, East Houston
- Code evaluation, tank expansion, Marrero, LA
- Foam water sprinkler system design, truck load rack, Dallas

ConocoPhillips Terminal, Mount Pleasant, TX  (2008)

Fire Protection Engineering Services
Under a Master Services Agreement, fire protection consulting services were provided for ConocoPhillips facilities, including fire protection system upgrade designs for loading racks, and the design and specification of a deluge system for the Los Angeles Refinery.

Chevron Corporation Facilities, San Ramon, CA  (2008-2010)

Fire Protection Engineering Services
Under a Master Service Agreement, Hughes personnel have provided consulting services for the upgrade of existing 50,000 – 285,000 bpd refineries, petrochemical plants, producing operations and marketing terminals, research laboratories, and other facilities. Fire protection consulting has included code reviews, equipment spacing and layout, emergency shutdown, isolation, fire water supply and distribution, drainage, oily water sewer design, pressure relief valve and flare design, deluge and sprinkler systems, foam water systems, monitors and hydrants, emergency response, mass notification systems, gas and fire detection, fire proofing of critical instrumentation and cables, fire proofing of column skirts and supports, and development of business continuity plans per corporate objectives.
DoD Fuel Tank Storage Facility, Craney Island, VA  (2008)

**Fire Alarm System Design**
Hughes provided the design for a fire alarm system for a fuel tank storage facility at Craney Island.

**Borger Refinery, Borger, TX  (2007)**

**Deluge Systems Design**
Hughes assisted client in extending deluge water spray coverage to two vessels at the Borger Refinery. The scope of work included performing detailed design of systems, including piping, supports, and hydraulics. Construction-ready documentation was prepared for the installation.

**Sunoco Engineering Services, Philadelphia, PA  (2002-2008)**

**Fire Protection Engineering Services**
Consulting services have been provided to Sunoco since 2002. Work has included:

- Process Hazard Analysis updates, using PHAWorks:
- Corporate Fire Protection & Prevention guidelines
- Training course development and presentation
- Facility expansion projects

**Amerada Hess Corporation, Port Reading, NJ  (2003-2008)**

**Process Hazard Analysis & Facility Siting Revalidations**
Hughes assisted the client in revalidating the process hazard analyses of a wet gas scrubber and of a steam boiler system. Assistance was also supplied to update a facility siting study of the refinery.


**Engineering Review**
Hughes performed an engineering review of Marioff Hi-fog water mist systems at the Alpine drilling and crude processing site operated by Phillips Petroleum on Alaska’s North Slope. Work involved site visits, systems inspection, engineering documentation review, tubing workmanship review, conducting flow tests to confirm hydraulic performance of a high pressure pumping system, review electrical interfaces, and prepare a technical report.


**Engineering Review**
Hughes provided an engineering review of the Water Mist fire protection systems in the primary turbine hall at BP’s Endicott site and in two compressor/pump modules at the Milne Point site. Work included advising in selection of appropriate systems, obtaining approvals, preparation of construction specifications, review of bids, review of construction plans and calculations, attending commissioning to conduct and evaluate final performance testing, and preparation of a final report.
Maxum Petroleum, Richmond, CA  (2012)
*High-Piled Storage & Hazardous Materials Analysis/Permit Submittal*
Hughes is performing a code review of high-piled storage and storage of hazardous materials and preparing drawings for submission to the local AHJ to obtain applicable permits.

Port of Long Beach Container Terminal Facility, Long Beach, CA  (2007)
*Code Consulting Services*
Hughes provided code consulting services for an above-ground diesel and gasoline tank installation at a Port of Long Beach Container Terminal Facility.