Typical Past Investigations – General

Boilers and Machinery

Ball Mill Cracking

APTECH was hired by an electric utility company to assist with litigation involving the failure of coal grinding equipment in a 1200 MW coal-fired power plant. This equipment was one of eight cylinder-shaped "ball tube" mills used to pulverize raw coal into a fine powder. The failures consisted of cracking in the outer casing. Our work included an extensive review of the mill's operating history, metallurgical testing, and computerized stress analyses. These investigations revealed that high cycle fatigue (from variable loading) was the failure mode, and that the basic design of the mill was inadequate for the intended service. We provided expert testimony to this effect in the subsequent trial.

Black Liquor Boiler Tube Failures

A major paper and pulp mill experienced degradation of steam tubes in a black liquor recovery boiler. The paper mill's insurance carrier retained APTECH to determine if the cause of the tube degradation was due to inadequate boiler design or to plant operations. Our investigation included a site visit, during which time we reviewed plant operations and the recovery boiler design. We also investigated current boiler operating practices and compared these to the design conditions. Recommendations were made to mitigate the degradation.

Diesel Engine Piston Failure

An insurance company whose insured owned a large Navy submarine-type Diesel engine retained APTECH to evaluate the failure of the engine. The diesel engine had suffered mechanical breakdown that consisted of piston and bearing damage. APTECH established the failure mechanism and the cause of failure.

Gas Turbine Blade Damage

APTECH has worked on about 300 projects, claims, and cases related to gas turbine failures. In this particular instance, we were hired by an electric utility company to find the source of serious mechanical problems occurring in a 16 MW "Jupiter" gas turbine. The problems included damage to the blades and shrouds, failure-to-start, and performance degradation. We found that overheating, sulfidation, oxidation, and erosion were damaging the blades and shrouds. Many of these damage mechanisms were traced to the water injection system used to reduce emissions of NOX. We traced the startup problems to faults in the control system. These findings proved that the failures would be covered under the OEM's warranty. This compelled the OEM to supply new sets of blades and a new control system to the utility.

Generator Rotor Retaining Ring Tooth-Top Cracking

APTECH was employed by an insurance company to provide a third-party opinion regarding cracks in a power plant generator rotor. There were cracks in the rotor tooth tops and indications in the retaining rings. Field metallography, nondestructive examination, engineering report review, and interviews of plant personnel formed the basis of APTECH's conclusions. We presented expert opinions regarding the cause and structural significance of the NDE indications and cracking.

Generator Rotor Retaining Ring Cracking

During a planned outage, nondestructive testing revealed cracks in the retaining rings of a generator rotor. Aptech was hired by the electric utility company to determine the cause of the cracks. We performed metallurgical tests and a stress analysis. We found that stress corrosion cracking caused the problem. We made run/repair/replace recommendations to the client.

Generator Stator Failure and Melting

A catastrophic a failure occurred in the stator of a Westinghouse generator at a large power plant on the East Coast. APTECH was asked by counsel for the power company to perform an independent engineering investigation of the cause of this failure. APTECH wrote an inspection and test protocol. We carried it out with the assistance plant personnel, other generator consultants, and a team from the OEM.

These inspections focused on the "through-bolts." These bolts are used to hold the stator's laminations together. We found that three of the through-bolts were melted. Both ends of the bolts had arced over to the grounded steel end plates.

Six of the generator's intact through-bolts were removed to inspect and test them. Epoxy/fiberglass bushing and washer assemblies on the ends of each bolt were intended to insulate the generator's end plates from the steel washers behind the nuts. We found that all of the epoxy/fiberglass bushings on the ends of all of the bolts had separated from their washers.

Our opinion was that tightening the nuts by a re-winding contractor created an excessive bending stress on the joint between the epoxy/fiberglass bushing and washer. This caused them to break apart at the joint. This separation exposed a portion of the inside faces of the steel washers, which are at the generator's induced voltage, to the generator end plates, which are grounded. A short circuit eventually occurred and high temperature electrical arcs were created on the ends of the bolts, producing the flow of molten metal. This failure would have been avoided if the bushing assemblies had been designed such that torquing the nuts would not have caused them to break apart.

Hydroelectric Turbine Roller Bearing Failure

A paper mill in the eastern United States had been experiencing repetitive failures of a 2.5-foot diameter roller bearing in their radial Kaplan hydroturbine. On a recent occasion, the turbine's performance indicated that the bearing had again failed. In response, the plant dismantled the turbine and prepared to repair the bearing. The plant's insurance carrier retained APTECH to find the cause of the repetitive failures and to determine if the latest proposed repairs were justified. From our site inspection, records review, and follow-up engineering analyses, we concluded that the bearing housing was improperly anchored to the foundation. This created a magnitude of axial stress that the roller bearing was not designed to withstand, which eventually led to the numerous failures. Our visual examination and metallurgical analysis of the bearing revealed that it had not yet failed on this particular occasion. Recommendations were made to preclude further failures.

Nuclear Power Plant Intergranular Stress Corrosion Cracking

In this project, APTECH performed a detailed evaluation of the propensity for intergranular stress corrosion cracking (IGSCC) of Inconel 600 components in nuclear power plants (Boiling Water Reactors). These particular components, the thermal sleeve and safe end, had shown significant cracking at other plants prior to start-up. Plant management decided to remove and replace the components prior to start-up. APTECH performed an historical

document review to establish the necessity for such action, and evaluated the likelihood of IGSCC in existing and alternate materials. APTECH also provided deposition and trial testimony for this project.

Penstock Failure at a Pumped Storage Hydroelectric Plant

A 30-foot diameter penstock failed catastrophically during "water-up" of the Helms Creek pumped storage hydroelectric plant in California. APTECH was hired by the supplier of the penstock to find the cause of the failure. The issues that APTECH investigated related to weld quality and workmanship, structural significance of welding defects, and the reliability of inspection techniques to locate critical flaws. Issues of material properties and fracture toughness, in particular, were evaluated. A structure integrity reconstruction of the accident was performed. This reconstruction of the existing conditions at the time of the accident led to the conclusion that significant additional stresses were imposed on the system by the foundation settlement. APTECH provided expert testimony to this effect in the subsequent trial.

Power Plant Cycling and Derating Analysis

APTECH engineers have performed many projects to quantify the effect of cyclical operation and derating on the lifetime and reliability of electric power plants. A typical project begins with a detailed review of the plant's operating and outage records, followed by an on-site engineering examination of the plant to establish its current condition. This information is factored into a proprietary statistical analysis process that determines the economic impact of cycling operation and derating. Our results are used by the client to judge whether cycling or derating are feasible or if other power generation alternatives should be considered. For more information click here to reach our Power Generation Services website.

Power Plant Damage Due to Collapse of Underground Cooling Pipes

A major renovation of the pollution control equipment at a coal-fired power plant was midway through completion. Numerous pieces of heavy construction equipment were on-site, including pile drivers. A massive land cave-in suddenly occurred at the plant site, involving a several thousand square-foot area to a depth of up to 15 feet. Substantial damage occurred to existing and new plant structures and equipment. The cave-in was caused by the collapse of two 22-foot diameter underground cooling water pipes running from the plant to a nearby lake. APTECH conducted a detailed investigation of the power plant design and operation to determine their role in the accident. All plant operating logs just prior to the accident were reviewed in detail to determine if a cooling-water system upset occurred and caused the pipe collapse.

Steam Turbine Blade Damage

APTECH has worked on about 400 projects, claims, and cases related to steam turbine failures. This is a typical case. At the request of an insurance company, a midwestern law firm retained APTECH to investigate the catastrophic failure of a power plant's steam turbine. We performed on-site failure investigations, failure analysis, and attended meetings at the turbine manufacturer's factory. We determined that all components in the intermediate pressure turbine rotor, including the blades, nozzles, and stationary diaphragms, had been damaged or destroyed. We obtained proposals for replacement components. With our assistance, this failure was successfully adjusted to the client's satisfaction.

Steam Turbine Catastrophic Failure

At the request of an insurance company, a midwestern law firm retained APTECH to investigate the catastrophic

failure of a power plant's steam turbine. APTECH performed on-site failure investigations, failure analysis, and attended meetings at the turbine manufacturer's factory. We determined that all components in the intermediate-pressure turbine, including the blades, nozzles, and stationary diaphragms, had been damaged or destroyed. APTECH obtained proposals for replacement components. With APTECH's assistance, this loss was successfully adjusted to the client's satisfaction. This matter is typical of the many steam turbine investigations that APTECH has done over the years.

Suitability-for-Service Evaluation of Seam Welded Heating Boilers

In this project, APTECH provided ASME Boiler and Pressure Vessel code interpretation on the acceptance of lap joints for Section IV heating boilers. Although ASME Section IV specifies a butt weld design, the authorized inspector assigned to review the vendor design approved a lap joint. As a result, a technical dispute had developed between the manufacturer and the National Board of Inspectors over the code certification of approximately 8,000 boilers currently installed. APTECH assisted the manufacturer in resolving the technical issues by verifying that the structural integrity of the lap joint design was adequate and by obtaining code approval for a code case regarding alternate rules for lap joint fabrication. Passage of the code case effectively allowed the existing 8,000 heating boilers to maintain code certification.

Alaska Oil Pipeline Collapse

During construction of the support structure for a segment of the Alaska pipeline, part of the structure fell over and caused considerable damage to a crane. Also, the job was delayed for a considerable time. APTECH engineers visited the site and documented the accident sequence. The cause of the collapse was determined, and remedial measures were suggested to the client to prevent future recurrences.

Ammonia-Based Evaporator in Cold Storage Warehouse

The owners of a large cold storage warehouse alleged that the ammonia-based evaporators in the ceiling-mounted refrigeration units were not performing up to the manufacturer's original specifications. The equipment manufacturer's insurance company retained APTECH to evaluate the performance of this equipment. APTECH prepared a test plan, and then installed thermal measurement instrumentation on one of the ceiling-mounted evaporators. Consultants hired by the plant closely monitored all of our test activities, which took place in a -10°F environment. The test data indicated that there were inadequacies in the plant's overall system design and operating procedures, rather problems with the evaporator.

Catalyst Poisoning in Thermal Oxidation Unit

A manufacturer used conventional high-temperature thermal incineration to destroy volatile hydrocarbon emissions and then recovered thermal energy in a waste heat boiler. To save fuel, they installed a new catalytic oxidation unit (between the incinerator and boiler) that would combust volatile hydrocarbons at lower temperatures. The catalyst never functioned properly because there was no temperature rise across the bed and the operation failed source emissions tests. APTECH was asked to investigate the claims. The results of catalyst testing showed that the catalyst was severely poisoned (surface area of about 0.1 m2/gm) and had a negligible pore volume. APTECH used ESCA (Electron Spectroscopy for Chemical Analysis) to determine the surface composition of the catalyst; the results clearly showed the presence of silicon dioxide. It is well known that noble metal oxidation catalysts are poisoned by heavy metals (e.g., phosphorous, silicon) because they tend to adhere to active catalyst sites. APTECH prepared a report of its findings.

Cyclone Separator Failure in a Mining Operation

A hot-gas cyclone separator used in a mining operation overheated and failed. The separator, installed downstream of a fluidized bed furnace, was operating in a 1300°F environment. APTECH was retained by the mine's insurance company to find the root cause of the failure. A site inspection revealed that the outlet (four-foot diameter) of the separator had deformed so much that it was almost completely closed. We found that this outlet had been fabricated with carbon steel, which was unable to withstand the system's operating temperature.

Insulation Panel Failure

The thin aluminum facing on polystyrene insulation panels in a mushroom-growing plant partially delaminated. The delaminization voids filled with water that condensed on the surfaces of the insulation panels due to the high humidity environment maintained in the plant. It was alleged that the water trapped in the delaminization voids became a source of nematodes that would subsequently leak out of the panels, contaminate the compost, and cause a drastic reduction in mushroom yield. APTECH inspected the panels and performed a heat transfer analysis of

the compost tunnel and a modification of the original design of this tunnel.

Mercury in Natural Gas from Offshore Gas Field

APTECH was asked to develop and prepare the technical case for the owner of an onshore gas conditioning plant that received natural gas containing high levels of mercury from an adjacent offshore gas platform. Mercury is detrimental to the aluminum heat exchangers used in cryogenic separations in the plant. At issue was the performance of a column used to dry natural gas, using triethylene glycol (or TEG), as the dehydrating agent. We measured the mercury content of streams entering and leaving the TEG column. We designed a series of bench-scale experiments at full line pressure to develop a database. Several analytical instruments were used to simultaneously measure the concentration of mercury in vapor streams. Additional experiments were conducted to measure the equilibrium concentration of mercury in common light hydrocarbon gases. We prepared several reports of our findings.

Oil and Chemical Company Environmental Litigation

A major oil and chemical company sued its insurance companies to recover the cost of environmental compliance in the dozens of states in which it operated. APTECH was retained as part of a team tasked with investigating the validity of the company's claims, totaling over $1 billion. APTECH prepared time lines of critical events at the initial sites to demonstrate the progression of knowledge concerning oil and chemical leaks and spills. We also provided litigation support and topical reports as requested.

Overheating and Failure of Ore Drying Equipment
A fired heater used to generate hot gas for drying ore in a mining operation overheated and was destroyed. The insurance company retained APTECH to find the root cause of the failure. We performed an inspection and engineering analysis of the heater. We then obtained metal and refractory samples and analyzed them in our laboratory. Finally, we reviewed the operation logbooks and interviewed plant personnel. During this incident, the refractory failed completely and the metal shell buckled and melted.

Piping Freeze Damage in a Paper Mill

APTECH was hired by an insurance company to investigate a claim by a paper mill for equipment damage and loss of production. The investigation included records review (operation, production, and shift logs), personnel interviews, and equipment inspection. We found that the damage occurred during a five-day period of unusually cold weather. Water inside a support for a critical chemical piping system had frozen, and its resulting expansion had bent and broken the piping above. The absence of this chemical forced the paper machine to slow or shut down, which led to the freeze-up of other components. Our findings were summarized in a time-line format showing the sequence of events that caused the damage and loss of production.

Refinery Airborne Chemicals Release

A refiner in California continued to operate a pressurized refinery column after a leak in the column was discovered by its personnel. As part of an insurance coverage dispute, APTECH was retained to provide expert knowledge concerning refinery hydrocracker design, operating and maintenance practices. APTECH was asked to address the question of whether or not local refinery personnel expected or intended that the leak would migrate or progress offsite. APTECH reviewed the case documentation, conducted a site visit, wrote reports and provided litigation support.

Refinery Delayed Coker Accident

A refinery contracted with skilled concrete workers for the repair of concrete structures supporting delayed coking vessels. The refinery staff believed that repairs could be safely made while the unit was operating. If the coker had to be shut down to make these repairs, the refinery would have to reduce production to accommodate the unavailability of the unit. While the crews were working on the unit, an accidental release of superheated steam severely scalded several workers. A law firm representing these workers retained APTECH. We were asked to investigate the prudence of assigning repair crews to work on an operating unit of this type, to survey the experience of other refineries regarding safe work practices, to develop accident statistics, and to determine if any mechanical failures were involved.

Refinery Remaining Life Assessment

For a major Canadian refiner, APTECH conducted a life assessment study for major classes of equipment, such as columns, pressure vessels, heat exchangers, fired heaters, compressors, tanks, and piping. Over 200 pieces of equipment were evaluated. The majority of this equipment had been in continuous operation for about one design lifetime. Major degradation modes evaluated included creep rupture, stress rupture, corrosion, stress corrosion cracking, high temperature hydrogen attack, wet H2S cracking, and fires and explosions. APTECH identified those pieces of equipment with limited remaining life and for which the client's current maintenance program did not make adequate provisions. Further, utilizing the results of prior risk assessments conducted for the facility, APTECH identified a list of unusually critical equipment that, upon failure, would result in a loss of production of six months or more.

Risk Management and Prevention Program

For a major supplier of magnetic media, APTECH performed a formal Risk Management and Prevention Program (RMPP) for two inorganic acids as requested by the County government. The public disclosure report documented the site location; equipment and operations history; safety, audit, and inspection procedures; emergency response plans; and actions recommended as a result of a HAZOPS study. As a part of the RMPP, APTECH also prepared process flow diagrams, conducted a seismic walkdown, prepared a HAZOP study, and prepared an off-site consequence analysis for several worst-case chemical release scenarios.

Steam Methane Reformer Catalyst Deactivation

An ammonia manufacturer asked Aptech's help in investigating the deactivation of the catalyst in a steam methane reformer. APTECH reviewed records, catalyst activity data, process flow diagrams, and strip chart recorder data rolls. Also Aptech walked the unit down and held discussions with knowledgeable personnel in management, operations, maintenance, and engineering. APTECH prepared a report recommending the installation of additional equipment items and control interlocks to prevent recurrence of the incident. The manufacturer accepted the recommendations.

Steam Turbine Damage In a Paper Mill

An electric power-generating steam turbine in a southern U.S. paper mill suffered damage during an unusual period of freezing weather. APTECH was retained to determine the cause of the damage. From our site inspection, records review, and personnel interviews, we determined that the sub-freezing temperature caused a boiler water level-control system to malfunction, which led to overfilling of the boiler. Water from the boiler eventually entered the turbine and damaged the rotor blades. After identifying this failure mode, we then reviewed the turbine

manufacturer's repair proposal.

Weld Procedure Specification Flaw Acceptance Criteria for a Pipeline

A cement-lined, brine carrying piping system was proving difficult to weld, especially the weld root pass. APTECH worked with this government client to develop a welding procedure specification (WPS) that would minimize weld root discontinuities. In parallel, we performed fracture mechanics calculations to provide the client flaw acceptance criteria that removed unneeded conservatism in the existing workmanship standards.

Infrastructure

Aircraft Engine Failure – Sioux City Crash

APTECH was hired by United Airlines to assist with the investigation of the 1989 crash of Flight 232 in Sioux City, Iowa. Other investigators, including the federal government, had determined that the catastrophic failure of an engine led to the accident. Our role was to independently calculate the failure scenario of the engine. A metallurgical examination by the National Transportation Safety Board (NTSB) of recovered engine fragments had revealed the presence of a pre-existing flaw in the original forging of the first-stage fan disk. We used this information in a series of stress, fracture mechanics, and statistical analyses to determine the size of the crack that grew from this pre-existing flaw. In our report to the client, we presented a range of crack sizes that could have existed in the disk during a previous scheduled maintenance inspection. We also determined that the manufacturing technique made it difficult to detect cracks by nondestructive examination. Our findings were incorporated into the final NTSB report on the accident.

Aqueduct collapse

A large-diameter water aqueduct pipe failed by rupturing and buckling, which caused the shutdown of a hydroelectric plant. APTECH was hired to find the root cause of the failure. Our work included an aerial survey of the aqueduct, metallurgical testing of the pipe material, fluid mechanics analysis (focusing on water hammer), and a stress analysis.

Flood Damage To Steel Supplier

A steel supplier storage yard adjacent to an estuary was subject to frequent flooding. The supplier sued the flood control agency for damages resulting from corrosion of steel materials. APTECH was hired by the agency to establish the validity of the damage claim. Our investigation included metallurgical analysis of the corrosion damage, as well as a financial analysis pertaining to the value of damaged material. Our findings, that the corrosion damage greatly exceeded that associated with a worse case flooding, indicated that the material had been subjected to other damage mechanisms, such as stagnant water corrosion due to storage conditions.

Piping Contamination – Hospital Oxygen System

A city hospital noted the presence of contaminants in the filters in the oxygen piping leading to the incubators in the maternity ward. The hospital quickly switched over to their back-up oxygen system. APTECH was hired by an insurance company to find the source of the contamination. A field examination revealed the source to be due to a through-wall penetration caused by external corrosion in an underground copper pipe. This piping was replaced.

Propeller Shaft Coupling Failure

A propeller shaft coupling on a large oceangoing freighter failed in mid-ocean. APTECH was retained to make a determination of the root cause of the failure. APTECH engineers performed a computerized stress analysis and fracture mechanics analysis of the bolting and coupling arrangement. We concluded that the failure was due to normal wear-and-tear.

Railroad Tank Car Toxic Spill

A freight train was passing over a trestle when several cars suddenly derailed and fell into the river below. One of the cars, a tanker containing a liquid chemical, ruptured upon impact. Most of its contents leaked into the river, causing considerable damage to the downstream ecology and local tourist economy. Working for the insurance defense, APTECH's work scope included examining the damaged tank car, documenting the accident site, and critiquing the findings of other parties in the litigation. Our efforts contributed to the successful settlement of our client's involvement.

Scaffold Rigging Accident

A crane that was being used to hang a scaffold under a bridge collapsed and caused extensive damage and project delays. APTECH's investigation into this failure focused on the lifting eye that was welded to the end of the crane's boom. Destructive testing was performed on metallurgical samples in an effort to find crack initiation sites. Our findings were presented to the client in a report.

Solar Water Heater Collector Corrosion and Leaks

A solar heating system equipment manufacturer was experiencing leakage in an expanded stainless steel collector. They hired APTECH to investigate the cause of the corrosion damage. Our investigation determined that the corrosion damage was associated with oxidation contamination resulting from the welding fabrication process in combination with specific domestic water supplies that contain relatively high concentrations of chlorides. We advised the client that the stainless steel alloy should be adequate for all domestic waters, provided that the fabrication oxidation was removed prior to use.

Solar Water Heater System Corrosion and Leaks

APTECH was hired by a solar water heater manufacturer to investigate a corrosion failure problem that was allegedly due to a system design fault. The corrosion caused water leaks and insurance losses. Our work included metallurgical and corrosion engineering analysis, as well as a materials review of the entire heating system. Our conclusion was that the corrosion failure was due to incompatible materials in one of the components supplied by another company and was not associated with the overall system design.

Steel Cable Corrosion in Post-Tension Reinforced Concrete

APTECH was hired by a major homebuilder to investigate the corrosion of steel cables used in a post-tension-reinforced concrete slab design. Our investigation included the use of ground-penetrating radar and electromagnetic techniques for location of suspect cables. Soil and concrete corrosiveness were established by laboratory analysis. Our investigation concluded the there was no major corrosion problem. Recommendations were made to the builder regarding corrective actions.

Structural Steel Cracking in Wide Flange Connections

A steel fabricator/erector initially hired APTECH to determine the disposition and remediation of cracked wide flange column webs in structural steel. Following a few site visits and meetings, a remediation plan was implemented which comprised of hole drilling at the continuity plate web weld terminations (for currently fabricated columns) and use of a larger cope for new column fabrication. Subsequently, APTECH was contracted by the fabricator's legal counsel to determine the root cause(s) of the column web cracking. Using finite element modeling and mechanical property testing, APTECH's investigation showed that the most significant causes of cracking were related to: 1) a detail design that resulted in excessive restraint and constraint; 2) a detail design that required a complete penetration weld to join the continuity plate-to-column web tee joint; and 3) column

steel with highly variable and location-dependent notch toughness. APTECH's technical support and expert witness testimony lead to resolution of this issue via mediation.

Structural Steel Girders in Sony's Metreon Center

A multi-story building in San Francisco, Sony's new Metreon Center, was to be constructed on top of an existing subterranean hotel ballroom. Building construction was delayed due to differing opinions among various parties concerning remediation of the ballroom's very large, built-up, long-span steel girders. These girders came under scrutiny because they contained splice joints welded with flux-cored electrodes. APTECH used a fitness-for-service approach to confirm the fracture resistance of the existing steel work. The fracture resistance was evaluated using inspection records, design load conditions, and material properties. APTECH's evaluation showed that the existing structure had sufficient fracture resistance to support the new structure. This rigorous approach, employing sound, well-established engineering principles, led to all parties agreeing to proceed with construction of the new building.

Structural Steel Moment-Resisting Frames

The 1994 Northridge, California, earthquake occurred during the final months of erection of the structural steel frame of a hospital. The frame was welded using a high deposition rate flux-cored electrode. Following the earthquake, some of the welds in the special moment-resisting frames (SMRF) exhibited cracks. A dispute ensued which centered on the confidence in the existing, uncracked welds. APTECH was contracted by the erector to address the inspection, welding workmanship, and design issues. APTECH proposed a fitness-for-service analysis as a cost effective approach in regaining the confidence in these welds that had existed prior to the earthquake. We went on to recommend improved weld designs and procedures for the industry at large.

Structural Steel Weld Quality Audit

As the result of concerns expressed by the building's owner, APTECH performed a weld quality audit on the structural steel work. This project addressed two concerns: 1) the quality of the structural steel work; and 2) whether or not the quality concerns had impacted the structural integrity of the steel work. AWS-certified weld inspectors performed a sampling inspection that found, not unexpectedly, numerous deviations and nonconformance from AWS D1.1. (e.g.; cracks, linear indications, lack of fusion, cracked tack welds). APTECH then developed a generic fitness-for-service evaluation to evaluate nonconformance, which may be present in the structure but, not part of the inspection program. These evaluations were based on analyses methods to determine the likelihood of failure under the design loading conditions. While minimizing construction delays and unnecessary repairs, this inspection program and evaluation showed with a high degree of confidence that the structure had sufficient safety margins to tolerate the nonconformance during severe design basis seismic events. Counsel for the building owner also retained APTECH to facilitate the resolution of construction dispute issues. APTECH's technical support, in collaboration with experts in construction management, led to the resolution of several key issues via arbitration. APTECH also provided technical support and expert testimony for additional disputes.

Water Pipe Contamination – Black Staining

APTECH was hired by an insurance company to investigate reports of contamination in the tap water in one unit of a condominium complex. The manifestation of the problem was black stains on clothes that had been sent through the washing machine. Since this condominium unit was the only one affected in the complex, our investigation focused on the water supply line and internal plumbing. The investigation included a field examination, contaminant sampling, and chemical analysis.

Water Piping Contamination ("Blue Water")

Blue-green sediment was observed to cause widespread water contamination within numerous adjacent housing subdivisions in Northern California. This became the high-profile case known as "Blue Water." The affected homes were served by a common water distribution system and had been built at approximately the same time by a variety of contractors and plumbers. There were no instances of pipe leakage. An investigation revealed that the source of the sediment was copper corrosion products that were loosely adhered to the interior pipe surfaces. The affected copper pipe included both the service laterals connected to the water mains as well as the interior plumbing in the homes. The origin of the problems was found to be due to inadequate residual chlorine level associated with the water chemistry. The sediment disappeared as soon as the water district increased the residual chlorine level.

Water Piping Corrosion and Leaks – Copper Piping

A condominium complex suffered extensive failures in a copper pipe plumbing system. The installer of the water distribution system was among a number of parties that were implicated in the copper piping failures. The installer retained APTECH to determine the cause of the failures. Our analysis indicated that the corrosion damage was not related to the distribution piping and was associated with water chemistry and/or the copper piping materials.

Water Piping Corrosion and Leaks – Steel Piping

A major hospital experienced accelerated corrosion damage in the carbon steel piping of a recirculating hot water heating system. APTECH was retained to determine if the cause of failure was due to pipe manufacturing defects. Our analysis consisted of nondestructive inspection, metallurgical examination of corroded piping, and water chemistry analysis. We suggested that the existing water treatment/corrosion control methods be modified to include on-line corrosion rate monitoring.

Water Piping Corrosion and Leaks – Underground Copper Piping

A large condominium project experienced extensive leakage in an underground hot water piping system, which interconnected a complex of buildings. The piping was 2-inch diameter copper with external insulation that had been poured in place. The leak locations were observed to be at elbows or transitions with fittings. A metallurgical failure analysis indicated that the failures were due to erosion-corrosion damage on the internal pipe surfaces. It is likely that the piping system was operated above the design temperature and flow rate conditions for several years prior to the failures. The operating parameters were reset to the design requirements and the piping system was replaced.

Water Piping Corrosion and Leaks – Under-Slab Copper Piping

Random leakage failures of under slab piping were observed to have occurred in a large subdivision. A single contractor built the subdivision and the same plumbing contractor had installed the plumbing. The homes were a post-tensioned slab-on-grade design with under-slab copper piping. The subdivision was located in a previous area that was a ranch. Our review indicated that the leakage was due to corrosion that initiated on the exterior surfaces of the hot water piping. The cold water piping was unaffected. Chemical analysis of the soil-sand backfill adjacent to the piping revealed the presence of ammonia. A review of aerial photographs indicated that the affected homes were located in the livestock feeding area of the prior ranch. Since ammonium hydroxide is a strong copper corrosive agent, it was believed to be the source of the pipe leakage. The leaking under-slab plumbing was isolated and replaced with above-slab piping.

Water Tank Corrosion and Leaks Due to Defective Exterior Coating

A domestic water distributor experienced premature corrosion damage on several carbon steel water storage tanks. APTECH was hired by the company to conduct an independent review of the tank corrosion protection system. Our review consisted of examining the design specification and tank inspection results. We concluded that the original coating material, which was specified by the designer, was inadequate. We recommended alternative coating methods and materials.

Water Piping Manufacturing Defects – Steel Piping

The galvanized steel piping throughout a condominium plumbing system had experienced premature failure. APTECH was hired by the condominium association to perform a failure analysis for the purpose of establishing the root cause. Our analysis revealed that the failures were due to pipe manufacturing practices.

Water Piping Material Defects – Cold Water

The galvanized steel piping systems in over 500 homes had to be replaced by the builder after they developed extensive leaks. APTECH was hired to find the root cause of the piping failures. A field examination revealed internal corrosive attack only on the cold water piping. The pattern of the corrosion was randomly distributed throughout the development. Water chemistry tests were performed and the quality of the pipe was found to be sub-standard. We obtained lengths of the corroded piping and found that numerous different manufacturers had supplied it. Recommendations were made to the client for a systematic materials test program to pinpoint the source of the problem and identify the responsible parties.

Water Piping Material and Manufacturing Defects – Steel Piping

A 250-unit apartment complex experienced widespread leaks in the hot and cold water piping systems. The reports written by previous experts hired by the builder were inconclusive as to the cause of the failures in this galvanized steel piping. APTECH was hired to take over the investigation. We found extensive internal corrosion during a field examination, and that the failures occurred predominantly in the hot water piping. The root cause of the problem was identified as poor quality of welds and galvanized coatings. We also reviewed the other experts' reports and outlined the needs for additional data to supplement this previous work.

Water Treatment Plant Collapse

A water treatment plant in Southern California used a parallel arrangement of three "boat clarifiers" to separate sludge from the effluent. They are so-named because they are shaped like the hull of a boat. The clarifiers were suspended in side-by-side oval-shaped "oxidation ditches." During normal operation, the water level in the clarifiers is the same as that in the surrounding ditches. One day in June 1997, a contractor was flow-testing the clarifiers after the ditch had been drained. The boat clarifier's support structure suddenly collapsed. APTECH was hired by the insurance adjuster to find the cause of this incident.

Our initial examination and interviews clearly indicated that the collapse occurred as water was collecting in the "bow" of the clarifier while there was no water in the surrounding ditch. The operation manual contained warnings regarding the need to maintain equal water levels in the boat clarifier and its ditch. We analyzed the support structure and found, indeed, that it cannot support the clarifier without the buoyancy provided by water in the ditch. We also found metallurgical flaws in the welds in the support beams, which made the clarifier even more susceptible to collapse.

We concluded that the contractor had improperly left a piping valve open during the flow testing. This accident could have been avoided if the plant designers had placed a check valves in the clarifiers' outlet piping. This would have prevented backflow from any of the boat clarifiers while they were being filled with water.

Aircraft Collision

A light aircraft was destroyed in a mid-air collision with a jet trainer. The insurance carrier of the light airplane retained APTECH to reconstruct the accident. We obtained the remnants of the airplane and reassembled them in our laboratory. Measurements of the metal deformation, followed by stress and fracture mechanics analyses, enabled us to identify an impact point on the fuselage of the light plane.

Asbestos Exposure Litigation

APTECH was hired by defense attorneys for a building products company to act as consultants and expert witnesses for asbestos exposure litigation. This case concerned an individual who claimed health damage due to alleged exposure to the manufacturer's asbestos- containing products. For our first task, we created a computer database of all of the defense's documents and evidence. This allowed us to easily search for key information as the case proceeded. Next, we wrote a protocol for scientifically sampling and analyzing both the company's products and the specific material to which the plaintiff was known to be exposed. Using this protocol, we obtained the samples and analyzed their chemical and physical characteristics. These tests revealed that the company's product had unique chemical constituents that were not found in the plaintiff's material. The analyses also showed that the company's manufacturing process had the side effect of reducing the toxicity of the asbestos fibers. Our findings were presented during depositions and a subsequent trial in Superior Court. We made extensive use of visual aids and graphics to make the data understandable.

Concrete Mixer Truck Accident

A construction worker was injured while loading bags of dry mix into a truck-mounted concrete mixer. His arm was caught in the pinch point between the charging hopper and the barrel's internal mixing blades. The workers' compensation insurance company asked APTECH to investigate the accident. APTECH's investigation included an assessment of effectiveness of mechanical guards, warning signs, and operator safety training programs.

Electrical Shock on a Main Service Panel

An electrician was knocked down and badly burned when the 2000-amp electrical chassis he was modifying short-circuited. The workers' compensation insurance company hired APTECH to investigate the accident. APTECH's findings indicated that the three-phase bus bars had been bridged by a loose metal component, and that the panel had not been de-energized before the work commenced.

Electric Switchgear Accident

An electrician was knocked down and badly burned when the 2000-amp electrical chassis he was modifying short-circuited. The worker's compensation insurance company hired APTECH to investigate the accident. Our findings indicated that the three-phase bus bars had been bridged by a loose metal component, and that the panel had not been de-energized before the work commenced.

Food Processing Machine

A maintenance person was cleaning a nut-dicing machine. The person's hand was caught in the pinch point between two counter-rotating grinding cylinders. The worker's compensation insurance company retained APTECH to determined subrogation potential. Our investigation included site inspection, photo documentation,

plant personnel interviews, and an equipment design review.

Fumes from a Burning Rubber Gasket During Welding

An experienced welder was welding a joint in a large-diameter steel pipeline. Unbeknownst to him, the joint contained a rubber gasket. The gasket was used to seal the joint. The welder apparently was injured when he inhaled the fumes from the burning rubber gasket that was being heated by the welding process. APTECH was asked to reconstruct the incident. From the compounding recipe for the gasket, APTECH identified the likely chemical composition of the various raw materials, activators, antioxidants, pigments, accelerators and vulcanization agents used. APTECH engaged a laboratory to thermally decompose pieces of the gasket under non-oxidizing conditions and to analyze the gases evolved. Gasket heating rates were obtained from a series of transient heat transfer analyses. Using GC/MS analyses, numerous chemical species were identified, such as alkenes, alkynes, cyclic dienes, phenols, thiazoles, aromatics, ketones, alcohols, aldehydes, substituted naphthalenes, amids and amines. Several species were selected for more complex quantitative analyses. APTECH prepared a report of its findings.

Loading Dock Board Accident

The sudden release of a loading dock board injured a stevedore. APTECH performed a metallurgical evaluation, stress analysis and on-site exemplar testing (including dynamic testing) to determine the cause of the sudden release. The design, maintenance, and repair procedures of the dock board were evaluated.

Mountain Bicycle Front Fork Failure

A popular model mountain bicycle was involved in an off-road accident. APTECH determined the cause and sequence of events leading to the fracture of front fork of the subject bicycle. The contributions to the failure of corrosion, prior deformation, and riding loads were evaluated.

Paper Machine Pinch Point Injury Accident

While operating a paper machine, a plant employee's arm was caught by an in-running pinch point between two large, counter-rotating drums. The workers' compensation insurance company called in APTECH to find the root cause of the accident. The investigation focused on the procedures followed by the injured party, and recommendations were made to the plant to modify the procedure or install guarding devices.

Paper Mill Accident

While operating a machine that manufactures paper, a plant employee's arm was injured when an in-running nip point between two large, counter-rotating drums caught it. The worker's compensation insurance company asked APTECH to find the root cause of the accident. The investigation focused on the procedures followed by the injured party, and recommendations were made to the plant to modify either the machine or the procedure.

Racing Boat Steering Gear Failure

During a boat-racing event, one of the contestant boats lost control as it crossed the finish line at 190 mph. This boat then veered off course, ran ashore, and killed a spectator. APTECH performed a complete root-cause investigation of this event, including metallurgical and stress analyses of the failed steering gear and an analysis of the hydrodynamic forces on the boat hull and supercavitating rudder and propeller. APTECH also performed an extensive risk analysis of the course layout. The failure of the Woodruff key in the steering gear was explained in terms of the extreme forces that existed on the boat's rudder during deceleration after crossing the finish line.

Refinery Vessel – Poisoning and Injury

While manually cleaning out a high-pressure sour gas field separator vessel, a refinery worker was injured by inhaling noxious gases. The problem arose when an unexpectedly thick deposit of sediment was encountered on the vessel bottom. During cleanout, noxious gases adsorbed deep within the sediment layer were released when the sediment became disturbed. These gases had been deposited within or upon particles of earth and sediment at high pressures during normal vessel operation. Unfortunately, the release occurred in the immediate vicinity of workers inside of the vessel. APTECH reviewed the incident documentation and prepared an opinion concerning the origin of the noxious gases and whether or not they could be considered to be pollutants.

Therapeutic Oxygen System Fire and Injury

The gas flow from a portable therapeutic oxygen system suddenly ceased, and the patient noticed an acrid odor. The product manufacturer retained APTECH to determine the cause of the failure. The components of the system, including a valve, regulator and pressurized oxygen cylinder, were dismantled, examined, and photographed. Carbon steel and brass surfaces showed evidence of exposure to high-temperature, corrosive gases. Also, several rubber seals were missing or damaged. These findings led to the conclusion that a brief, but intense, fire had occurred inside the valve, involving the rubber seal (the fuel) and the pure, high-pressure oxygen. Possible sources of the ignition energy included a spark (frictional or static electrical) or adiabatic compression. The patient suffered temporary respiratory problems due to inhaling the gases from the fire.

Truck Tire Mounting Accident

A gas station mechanic was inflating a truck tire that he had just mounted on a wheel. The tire suddenly exploded off the detachable wheel rim, hitting the mechanic and injuring him. The insurance company for the injured party retained APTECH to investigate the accident and examine the wheel and tire. The tire, rim and wheel were the correct match, but we discovered that the wheel rim had a preexisting dent that prevented the tire bead from seating properly. We presented our findings to the client and provided expert testimony.

