



# Summaries of Selected Cases and Insurance Loss Investigations



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# Summaries of Selected Cases and Insurance Loss Investigations

## Introduction

Aptech Engineering Services, Inc. (APTECH), is an internationally recognized engineering consulting firm dedicated to the prediction, prevention, and analysis of failures of industrial equipment and systems. A significant portion of our consulting work is in the insurance and legal areas, for which we provide engineering analysis of major cases and losses. This document summarizes some of these cases and losses. They are organized into the following categories:

- Boilers and power plants
- Process industries
- Property loss
- Personal injury

**For more information on these and other cases and losses, please contact our Corporate Headquarters.**

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# Section I

## Boilers and Plants

### Catastrophic Failure of High Energy Power Plant Piping

A 30-inch diameter hot reheat steam pipe, operating at 1000° F and 600 psig, ruptured without warning in a fossil power plant. This accident caused numerous fatalities and major property loss. APTECH was hired by one of the defendants to investigate the failure of the pipe. APTECH performed a detailed stress analysis of the as-built line configuration and evaluated the material properties and the likelihood of creep damage under stresses sustained during normal operation. APTECH also investigated maintenance practices over an extended period at the plant prior to the failure. We concluded that the failure was caused by creep damage in local regions adjacent to the heat affected zone of the long steam weld.

### Suitability-for-Service Evaluation of Steam 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 a butt weld design is specified by ASME Section IV, a lap joint was approved by the authorized inspector assigned to review the vendor design. As a result, a technical dispute had developed between the manufacturer and the National Board of Inspectors over the code certification of approximately 8000 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 8000 heating boilers to maintain code certification.

### Intergranular Stress Corrosion Cracking in Nuclear Power Plant Reactor Components

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 (BWRs). 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.

### Hydroelectric Penstock Failure

A 30-foot diameter penstock failed catastrophically during “water-up” of a large 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 defect, 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 Generator Failure

APTECH was employed by an insurance company to provide a third-party opinion regarding generator rotor tooth top cracks and retaining ring indications. Field metallography, engineering report review, and interviews of plant personnel formed the basis of APTECH’s conclusions. We presented expert opinion regarding the cause and structural significance of the NDE indications and cracking.

## **Package Boiler Explosion**

An explosion occurred in a package boiler in a downtown office building. There were no injuries and damage was confined to the boiler and plant from the explosion. APTECH was hired to find the cause and origin and to make sure that it did not recur. First, we interviewed witnesses and examined and documented the condition of the as-found boiler. Next, we prepared a “punch-list” of recommended repairs and modifications. Finally, we gathered test data when the boiler was brought back on-line. Based on our findings, we presented four possible failure scenarios to the client, including gas supply overpressure, a fault in the flame detector system, a build-up of unburned fuel, and an overly-rich fuel/air mixture. Modifications to the boiler and its operating procedures were made to prevent a recurrence of this explosion.

## **Power Plant Cycling and Derating Analysis**

APTECH engineers have performed a number of 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 which 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.

## **Utility Boiler Explosion**

A 760 megawatt utility boiler (cyclone-fired) in the midwest suffered a severe explosion in the upper furnace. APTECH was retained by in-house counsel of the utility to investigate the cause and origin of the explosion and to quantify the extent of the damage to the boiler. The explosion occurred while test-firing western coal; the boiler was designed for midwestern or eastern coal. APTECH made recommendations for the improvement of the boiler control system and identified deficiencies in the boiler furnace enclosure design. The operator evaluated our recommendations and made the necessary upgrades and improvements.

## **Steam Turbine Failure**

At the request of an insurance company, APTECH was retained by a midwestern law firm 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 failure was successfully adjusted to the client’s satisfaction.

## **Diesel Engine Failure**

APTECH was retained by an insurance company whose client owned a large Navy submarine-type diesel 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.

## **Repetitive Failures of a Radial Hydroturbine Roller Bearing**

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. APTECH was retained by the plant’s insurance carrier 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.

## **Land Subsidence at Power Plant**

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 piledrivers. 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.

## **Tube Failures in a Paper Mill Boiler**

A major paper and pulp mill experienced degradation of steam tubes in a black liquor recovery boiler. APTECH was retained by the paper mill's insurance carrier 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.

## Section 2

# Process Industries

### Refinery Piping Failure and Fire

In this project APTECH evaluated the root cause of a pipe failure and ensuing fire at a refinery in Southern California. The oil/catalyst slurry at high temperature that is used for heat recovery boilers is an erosive mixture for normal carbon steel piping in refinery plants. In-plant systems are developed to monitor erosion as it occurs using various nondestructive testing techniques. In this particular incident, the FCC main column bottoms slurry piping eroded to such an extent that the flange connecting the piping to the vessel bottom failed catastrophically. The ensuing caused significant plant damage and personnel injuries. APTECH investigated the inspection procedures, the materials involved, and the process parameters that led to the accident.

### Process Heater Fire

A rupture of a fired heater piping connection containing a thermally stabilized silicone polymer fluid led to fire and extensive secondary damage to other furnace components. APTECH performed a detailed root cause evaluation of the ruptured tube and a suitability-for-service evaluation of the remaining furnace components. This evaluation involved interviews with plant personnel, field evaluation of the critical components in the furnace, review of operation and maintenance manuals and records, detailed metallurgical evaluations of select components, and engineering life assessments. A technical report and expert opinions were presented to all concerned parties.

### Refinery Maintenance Accident and Fire

A refinery piping assembly that was being dismantled by a contractor suddenly released flammable gases. The gases subsequently ignited and the contractor suffered burn injuries. APTECH was retained by the refinery's law firm to determine the cause and origin of the fire. To reconstruct the accident, we examined the site of the fire, interviewed plant personnel, inspected the plant's operating logs and safety procedures, and reviewed witnesses' statements and deposition transcripts. Key components of the piping system were examined, photographed, and pressure-tested (hydrostatistically) to document their current condition.

### Refinery Fire Caused by Ruptured Piping

A fire broke out under a coker unit in a large oil shale processing plant. Liquid hydrocarbons feeding the fire eventually caused the formation of a pool fire that spread over 20,000 ft<sup>2</sup> of the premises. The plant's pressure vessels and piping were extensively damaged due to overheating. APTECH was hired to find the cause and origin of the fire. The field inspection revealed that a slurry recycle pipe had been the first to rupture and spill its combustible contents. Metallurgical testing of the ruptured pipe showed that the wall thickness of the pipe had been greatly reduced by corrosive attack from the slurry. The rupture occurred at the thinnest part of the pipe wall.

### Failure of Oil Well Drill Casing

During a routine hydrotest of a section of high strength steel drill casing, the hydrotest plug separated from the casing causing a personal injury. APTECH performed an in-depth failure analysis of the casing pipe. This involved making detailed dimensional measurements of the thread region, strength measurements, chemical analyses, and metallurgical evaluations (of a crack in the threaded region of the pipe). APTECH provided expert opinion regarding the relative contribution of the features which caused the failure.

## **Oil Well Fire**

An oil well drilling operation was conducting a routine fracture stimulation process when a truck-mounted oil pump/storage tank caught fire. The fire spread and injured a worker, destroyed valuable drilling equipment, and eventually ignited the oil well itself. APTECH was retained by one of the defendants to determine the original ignition source. Our investigation and analysis revealed many alternative sources of ignition, including a spark from an electrical short-circuit, a frictional spark, a static electrical discharge, and flames from a diesel engine exhaust pipe.

## **Gasoline Tank Farm Explosion and Fire**

Gasoline was being delivered by a tanker truck to one of many above-ground storage vessels in a tank farm. During the delivery, an explosion of a cloud of gasoline vapors occurred near the storage vessel. Besides destroying several buildings, the explosion breached the piping system. This led to an extensive release of gasoline, which caught fire and contaminated the soil. APTECH was hired by the plant's owner to determine how the explosion caused the failure of the piping system. Our metallurgical examination and fluid mechanics calculations indicated that the gasoline vapor explosion had severely distorted a swing check valve. This event blew off a threaded plug in the body of the valve. The absence of the plug allowed the free flow of gasoline. The gasoline continued to feed the fire and contaminate the soil until the pump was shut down.

## **Fire and Explosions at a Chemical Processing Plant**

A fire of unknown origin broke out at a large chemical processing plant. The fire quickly got out of control, and eventually led to the detonation of thousands of pounds of the chemical stored at the site. The detonation demolished the plant and its shock wave caused significant property damage. APTECH was hired to investigate the accident. Our work included examining and documenting the accident site, testing subscale chemical containers, reconstructing and locating the explosion sequence, and analyzing the metallurgical condition of an underground natural gas pipeline.

## **Paper Mill Equipment Damage and Production Loss**

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.

## **Damage to a Steam Turbine in a Paper Mill**

An electric power-generating steam turbine in a southern United States paper mill suffered damage during an unusual period of freezing water. 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 the 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.

## **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. APTECH was retained by the insurance company 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 log books and interviewed plant personnel. During this incident, the refractory failed completely and the metal shell buckled and melted.

## Failure of a Cyclone Separator 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.

## Glass Furnace Failure

During batch operation, the sidewall of a glass furnace ruptured, releasing 400 tons of hot molten glass. The molten glass flowed into the basement of the plant where it came into contact with an electrical transformer. The heat of the surrounding glass caused the transformer to rupture and release PCB-containing oil over a wide area. The plant was down for several months while repairs and PCB cleanup were accomplished. APTECH performed a complete reconstruction of the accident, tracing the sequence of events from the original furnace rupture to the moment the transformer ruptured. A detailed subscale model of the glass furnace facility was constructed to aid in visually depicting the accident scenario.

## Evaluation of Welding Quality on Seaport Cranes

APTECH evaluated the quality of welds in container cranes at a major California seaport. These cranes were subject to refurbishment and capacity expansion. During that activity, questions arose regarding the quality of initial weld fabrication. APTECH performed a site inspection and evaluation of weld attributes, such as undercut size and slag inclusions. In addition, APTECH provided expertise in the interpretation of the structural welding code and acceptance criteria for workmanship standards.

## Natural Gas Compressor Fire

A fire broke out in a gas turbine-driven natural gas compressor, causing damage to the unit and to adjacent equipment. APTECH was hired to determine the root cause of the fire and to itemize the extent of damage produced by this fire. Our evaluation involved site inspections, interviews with site personnel, field metallurgical testing (e.g., metallurgical replication, hardness measurements, etc.), reviewing the lubrication system designs and fire suppression, and a nondestructive laboratory failure investigation of a fractured lube oil line. We determined that an unnoticed oil line vibration caused fatigue at a fitting and the oil line ruptured. The oil impinging on the hot section of the gas turbine ignited and caused the fire. APTECH provided expert opinions regarding the cause of the fire, the extent of subsequent damage, and the repair cost estimates.

## Analysis of the Performance of Industrial Refrigeration Equipment

The owners of a large cold storage warehouse alleged that the system's ammonia-based evaporation units were not performing up to the manufacturer's original engineering specifications. The 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 evaporator units. All test activities, which took place in a -10° F environment, were closely monitored by consultants hired by the plant. The test data indicated inadequacies in the system design and plant operating procedures.

## Insulation Panel Failure

The thin aluminum facing on polystyrene insulation panels in a mushroom-growing plant partially delaminated. The delamination voids filled with water which 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 delamination voids became a source of nematodes which 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.

## **Asbestos Exposure Litigation**

APTECH was hired by defense attorneys for a building products company to act as consultants and expert witnesses for an 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.

## Section 3

# Property Loss

### Natural Gas Migration and Explosion in an Apartment Building

In this project, APTECH was hired by the local natural gas utility company to evaluate the origin and cause of a gas explosion in a downtown apartment building. APTECH visited the accident scene shortly after it had occurred and performed analyses to investigate the following: (1) the likelihood of a gas leak from nearby regulators; (2) the likelihood of gas migration across the road to the location of the apartment building; and (3) the significance of mechanical tool marks on gas piping and gas fittings. APTECH's analysis eliminated all of the component failure events that could reasonably be responsible for the gas explosion. It was later concluded that the root cause of this explosion was due to human intervention.

### Gas Explosion and Fire in an Industrial Building

An investigation and analysis of an explosion which occurred in the attic space of a newly constructed industrial building was performed. The physical evidence indicated that the accident resulted from ignition of an accumulation of natural gas. The gas was being purged through a new gas line being attached to a gas heating furnace. Visual examination, interviews with plant personnel, review of accident reports, leak testing of the gas piping, and evaluation of ventilation requirements were included in APTECH's evaluation of this accident.

### Mobile Home Fire

A mobile home in an isolated location caught fire during the night and one occupant was fatally injured. APTECH was brought in by the insurance company for one of the potential defendants to determine the cause and origin of the fire. The investigation included a review of fire department accident reports and photographs, interviews of knowledgeable parties, and an examination of the accident site. Potential fire causes included non-code gas piping, a malfunctioning appliance, and an improperly discarded cigarette.

### Agricultural Warehouse Fire

A fire in an agricultural chemicals warehouse destroyed the building and its contents. APTECH was retained by the building owner's law firm to find the cause and origin of the fire. Previous investigators, including the fire department, had narrowed down the source of the fire to a pickup truck that was parked inside the warehouse. We reviewed the witnesses' deposition transcripts, inspected the exemplars of the pickup truck (because the original truck had been destroyed), and examined the truck manufacturer's drawings and specifications. Our investigation indicated that an electrical wiring harness had short-circuited and ignited a nearby plastic fuel line.

### Elevator Fire

A three-alarm fire broke out in a 14-story, senior citizen apartment building. The fire caused several fatalities and significant property damage. The source of the fire was traced to one of the passenger elevators. APTECH was hired by the attorney for one of the defendants, the elevator maintenance company, to find the cause and origin of the fire. The plaintiff's expert witness had developed a seemingly logical theory that involved the lubricant tubing (installed by the defendant) having acted like a fuse to spread the fire from the machine room, through the walls, and into the elevator shaft (hoistway). Experiments designed and conducted by APTECH cast doubt on this theory. We demonstrated that a flame attached to the tubing would have been extinguished by the wall's insulation batting before it passed through to the hoistway.

### **Failure of Water Piping in an Apartment**

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 predominately 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 expert's reports and outlined the needs for additional data to supplement this previous work.

### **Failure of Water Piping in a Tract Development**

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 evaluated. We obtained lengths of the corroded piping and found that it had been supplied by numerous different manufacturers. Recommendations were made to the client for a systematic materials test program to pinpoint the source of the problem and identify the responsible parties.

### **Contamination of Water in a Condominium**

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.

### **Contamination of Hospital Oxygen Piping**

A city hospital noticed the presence of contaminants in the filters in the oxygen piping leading to the incubators in the maternity ward. The hospital quickly switched 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.

### **Steel Tendon Corrosion**

APTECH was hired by a major home builder 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 tendons. Soil and concrete corrosiveness were established by laboratory analysis. Our investigation concluded that there was no major corrosion problem. Recommendations were made to the builder regarding corrective actions.

### **Water Tank Corrosion**

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.

### **Degradation of Condominium Plumbing System**

The galvanized 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.

### **Recirculating Hot Water Piping System**

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.

### **Solar Water Heater System Failure**

APTECH was hired by a solar water heater manufacturer to investigate a corrosion failure problem that was allegedly due to a system design fault. Our work included metallurgical and corrosion engineering analysis, as well as 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.

### **Flood Damage to Steel Supplier**

A steel supplier yard adjacent to an estuary was subject to frequent flooding. The supplier sued the agency responsible for flood control 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.

### **Condominium Copper Plumbing Failures**

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. APTECH was retained by the installer 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.

### **Leakage in Stainless Steel Solar Collectors**

A solar heating system equipment manufacturer was experiencing leakage in an expanded stainless steel collector. They hired APTECH to investigate 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.

### **Propeller Shaft Failure**

A shaft coupling on a large oceangoing freighter failed in mid-ocean. APTECH was retained to make an unbiased 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.

## Section 4

# Personal Injury

### Loading Dock Accident

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

### Mountain Bicycle Accident

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 the front fork of the subject bicycle. The contributions to the failure of corrosion, prior deformation, and riding loads were evaluated.

### Electrical Shock Accident in a Nodular Electric Power System

An electrical contractor was injured while he was installing electrical cables for a modular office system. He was subjected to a high-voltage shock while making what turned out to be an incorrect connection. The workers' compensation insurance company asked APTECH to investigate the accident. We found that the connection being made should not have been energized, and that the equipment design, installation procedures, and lack of warning signs all contributed.

### Truck Tire Mounting Accident

A service station employee was injured when the truck tire he had just mounted on a wheel exploded during inflation. APTECH's investigation of this accident included nondestructive testing of the tire to look for pre-existing flaws, confirming that the wheel and its lock ring were matched correctly, and reconstructing the sequence of events leading to the injury.

### Paper Mill Accident

While operating a machine that manufactures paper, a plant employee's arm was injured when it was caught by an in-running nip point between two large, counter-rotating drums. APTECH was called in by the workers' compensation insurance company 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.

### Electric Switchgear Accident

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.

### 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 between the charging hopper and the barrel's internal mixing blades. The worker's 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.

## **Racing Boat Accident**

During a dragboat 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.

## **Aircraft Collision**

A light aircraft was destroyed in a mid-air collision with a jet trainer. APTECH was retained by the insurance carrier of the light airplane 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 in the fuselage of the light plane.

## **Portable Oxygen System Fire**

The gas flow from a portable therapeutic oxygen system suddenly ceased, and an acrid odor was noticed by the patient. APTECH was retained by the product manufacturer 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.