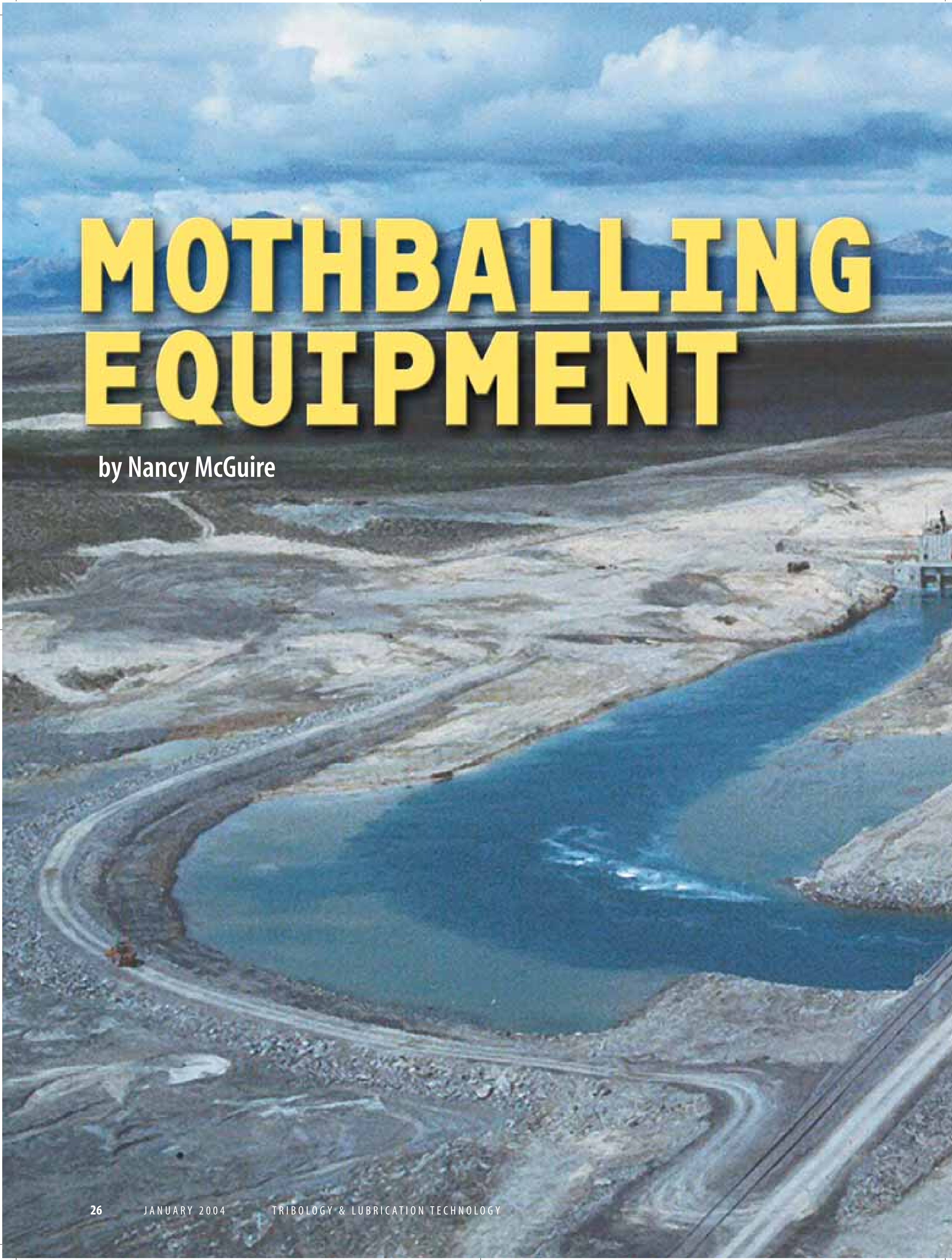
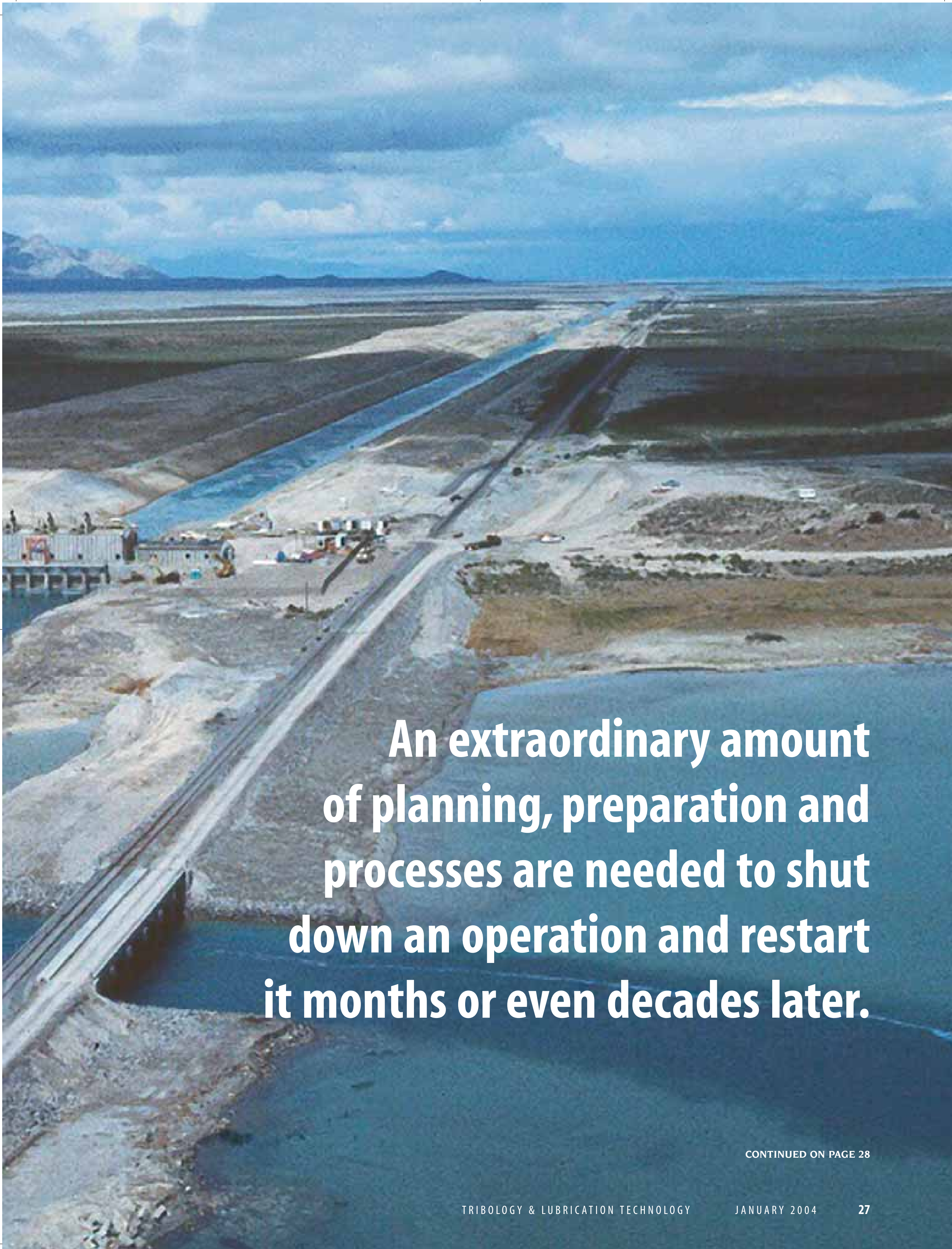


MOTHBALLING EQUIPMENT

by Nancy McGuire



An extraordinary amount of planning, preparation and processes are needed to shut down an operation and restart it months or even decades later.

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My father owned a recreational vehicle for several years. Every autumn he would get it ready for winter storage, making sure there was enough antifreeze in the radiator and enough oil in the cranks. During the winter he would occasionally run the engine to circulate the oil and keep the battery charged. Dad kept a mental inventory of all the things he would need before he hit the road again. Come springtime, he would drive the RV around the block a few times to "drive the square corners off the tires."

Photos courtesy of www.utah.gov

Construction crews begin the excavation and dewatering process to the Great Salt Lake pumping plant, which required eight weeks of preparation time (*top*). Workers found little or no groundwater after excavating the first 20 to 30 feet of the hole, however, after 30 feet the flow increased and measured 12,000 gpm with the excavation at an elevation of 4,179 feet (*bottom*).

It's more complicated when a company decides to shut down a plant. Many companies have learned this firsthand during the past two years, as excess capacity and decreased demand have driven them to close production plants, sometimes permanently. On the other hand, if storage and maintenance costs are reasonable, and the prospects are good for an eventual business upturn (or the need for an emergency startup), plant managers may choose instead to "mothball" plants and equipment. If the company holds any hope of restarting the plant at some future date, it must plan, budget and document the shutdown and recommissioning processes, as well as plan for routine maintenance and inspections during the shutdown period.

A short search through the business pages turns up one example after another of companies mothballing facilities while they ride out the recession. FMC idles a hydrogen peroxide plant in Spring Hill, West Virginia (1). Honeywell shutters a naproxen plant in the Bahamas (2). Ameripol Synpol's styrene butadiene plant (3), Corning's fiber optic cable plant (4), and the list goes on.

Temporary shutdowns aren't all bad news. Agricultural industries, which rely on seasonal influxes of raw materials, routinely shut down processing plants for several months each year. For these companies, mothballing a plant is business as usual, and the procedures are well practiced and tested over years of use. Individual components such as gearboxes also can be mothballed for use as critical backups, remaining in storage for several years before being called into action on a moment's notice. During lengthy construction projects, equipment installed in the early stages of the project should be mothballed to keep it from corroding while the rest of the plant is being completed.

GETTING READY

A successful restart after a hiatus depends to a large extent on thorough preparations during the shutdown phase. The extent of preparations depends on several factors, according to Bob Smith of Oil Solutions N.Q. (Mt. Louisa, Queensland, Australia). The expected duration of the shutdown will determine not only the level of protection but also whether intermediate maintenance is needed.

If an immediate emergency startup is anticipated, preparation and storage arrangements will need to be configured with that end in mind. Humidity and temperature extremes will influence the types of corrosion and thermal protection needed. And the frequency and difficulty of interim maintenance procedures determines whether plant security personnel can perform these tasks or if an engineer or other trained specialist will be called in.

SALT LAKE SHUTDOWN

Putting a large operation into temporary storage requires extensive planning, careful execution and plenty of money to ensure an effective restart. The Great Salt Lake West Desert Pumping Project in Utah, a flood-control facility, operated successfully for more than two years before being mothballed. Its 1989 shutdown is especially well documented and comprises several types of procedures similar to those needed to mothball a large manufacturing plant (5).

The pumping facility was built to counteract a 20-foot rise in the water level of the Great Salt Lake between 1963 and 1987. The lake had expanded to cover an area almost the size of Delaware and Rhode Island combined, causing an estimated $240 million in damages to highways, wildlife habitat and public and private property.

In 1986, the Utah Division of Water Resources, Utah Department of Natural Resources, received $60 million to begin a mammoth project to pump water from the Great Salt Lake into the desert area west of the lake. Between April 1987 and June 1989, the facility removed 2.73 million acre-feet of water from the Great Salt Lake using three pumps, each removing 1,000 cubic feet of water per second.

Preparing the Pumping Project for long-term mothballing in June of 1989 required eight weeks of preparation and $200,000. The Dresser-Rand Services Division implemented the preservation steps in consultation with its suppliers. Just as important, they documented every step in detail, including where the dismantled parts were stored.

It wasn't just a matter of preparing and securing the pumping plant. Tools, systems and control devices had to be dismantled,

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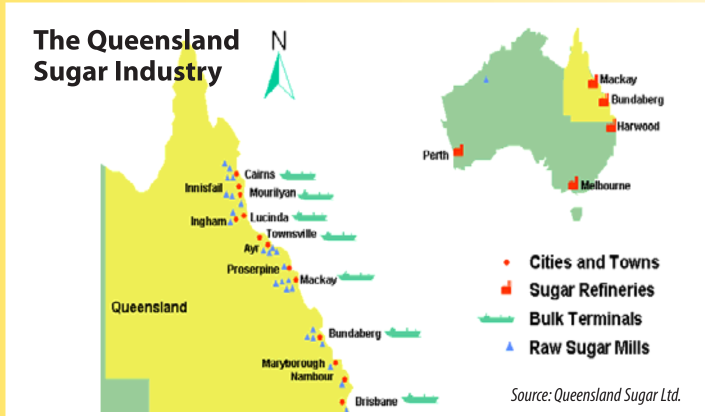
Protecting against corrosion Down Under



Source: Queensland Sugar Ltd.

Sugar mills in Queensland, Australia, routinely shut down for five to six months each year, weathering out their off season in a tropical environment. Says Bob Smith of Oil Solutions N.Q. (Mt. Louisa, Queensland), "We have had a lot of success with lanolin as a protective coating." Smith prefers lanolin (also known as wool oil) to vapor corrosion inhibitors because this waxy material protects against rust without affecting the integrity of the lubricant after startup.

"Remember that gearboxes still breathe," adds Smith, "even when they are standing, and rust will attack the uncoated surfaces." Rust-promoting moisture that would normally be expelled by temperature cycling during plant operation collects and condenses during shutdown periods. Smith vaporizes lanolin into the gearboxes under high pressure to coat all the bearings and the gear surfaces. He also keeps a store of corrosion-protected spare parts, ready for use when the plant is brought back into production. Smith states that a very small volume of lanolin will protect the equipment for years.

Corrosion inhibition is a must, especially in humid climates or for machinery exposed to the weather. Contact inhibitors are liquids that are applied directly to machine surfaces, sometimes in the form of a spray.

Volatile corrosion inhibitors (VCI) penetrate to all accessible surfaces, but the equipment must be sealed in a casing or a plastic wrap enclosure or breathable foam capsule in order to apply the vapor. The VCI is volatilized into the system, providing a self-replenishing protective coating that can be faster to apply and more economical than spray coatings (6). VCIs can be powders, applied as a fog or a volatile liquid or oil additive, or gradually released from treated papers or capsules.

The type of chemicals in contact with the equipment plays a vital role in the choice of corrosion inhibitors. Chlorinated compounds can react violently and exothermically with hydrocarbon-based materials. If the equipment will be exposed to heat, including welding, or if it is in a confined space, amine nitrile and carboxylate-based corrosion inhibitors should be avoided. These compounds are flammable and sometimes explosive when exposed to heat (6). <<

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preserved and stored. Three large engines and pumps remained intact on-site so that the pumping plant could be restarted in the event of a flood. The circuitry for the control panels was removed and stored in the plant. Open ports of the pneumatic safety shutdown and end devices were plugged, and the pneumatic circuitry of the engine and control panel are maintained under a slight positive pressure charge of nitrogen gas to prevent the entry of dust and salt from the ambient air. The panel was covered with plastic to prevent dust contamination, and volatile corrosion inhibitor (VCI) paper was placed inside the engine-mounted wiring junction box. (See "Protecting Against Corrosion Down Under.")

During normal operations, engines generate heat, air circulates and fluids flow. This all comes to a halt during a shutdown period. Dust and moisture accumulate, planting the seeds of corrosion. Lubricating fluids obey the force of gravity, pooling in the lowest accessible parts of the system and leaving the upper parts dry. The Utah group knew this, and safeguards against dust and corrosion constituted a large part of the shutdown and maintenance plan. They used a series of procedures to protect the crankcases, valve trains and accessory drive components of the engines.

A three-phase rust inhibitor was added to the oil in each engine during the last 30 to 60 minutes of operation before shutdown. After the engines cooled, a solvent-based rust inhibitor was sprayed on all engine internal components and into the power cylinders, and VCI capsules were placed in various locations inside each engine. Hydraulic lifters were removed, dipped in protective oil, bagged and tagged for location and placed in the rocker arm area of the cylinder heads. The push rod tubes, valve-stem lubricator reservoir, pumps and tubing were filled with protective oil. The crankcase breather piping and the electric motors for the valve stem lubricator and auxiliary oil pump were wrapped in plastic to prevent dust contamination.

The distributing tubes of the grease system were disconnected from the measuring valves and capped, as were the inlet ports on the valve blocks. The main grease supply lines were disconnected at the unit's reversing valve. The electric motor was wrapped in paper and plastic, the reversing valve and grease pump were purged of grease and sealed, and the pump drive gearbox was filled with protective oil. The grease reservoir and bulk grease transfer pump were cleaned and sealed, the bulk grease pump motor lubricator was filled with protective oil, and the microprocessor circuitry was removed and stored in a controlled environment. VCI paper was placed inside the circuit boxes.

Any facility that handles corrosive substances must be cleaned thoroughly in advance of prolonged storage. At the Utah facility, the water piping was flushed with fresh water, and brine pump rotating elements and casings were removed, flushed with fresh water, and stored inside the engine room. The brine pump motors were removed and stored.

The Utah team didn't forget the systems that took care of the plant personnel. After removing and storing the pump and motor for the building's potable water system, the storage tank and the indoor pressurized water tank and hypochlorinator were drained, disconnected, sealed and filled with nitrogen gas. All water pipes were drained and blown out with compressed air. The wastewater system was sealed, and the septic tank was pumped. The HVAC system, safety and emergency lighting systems,

Photos courtesy of www.utah.gov

One of the three engines used to keep the pumping plant intact had to be hauled to its final position on trucks, which ran on a system of rails and hydraulic tracks to help support the weight of the engines (*top*), plus skids (165,000 lbs.) by steel beams located at the top of the jacks (*bottom*).

control room electrical enclosures, doors, windows and ventilating grilles were sealed as well. Tools and other equipment were either boxed for storage in the building or removed to other storage areas.

IN THE MEANTIME

If a plant is shut down for an extended period of time it won't do to simply walk away and leave it until time to start up again. The Utah project required extensive preservation procedures, including monthly inspections by qualified individuals and periodic internal inspections of preserved equipment. The mixture of engine oil and rust inhibitor that had been put in during shutdown remained in the engine oil sump and piping, and a pneumatic auxiliary oil pump equipped with a small air compressor was operated periodically to recirculate this mixture through the gear reducer. The natural gas fuel supply remained connected to the engine room and was used to power a small generator.

Vapor-phase inhibitors should be replaced periodically, especially for extended shutdown periods or if the machinery is very expensive. If the equipment is to be started up periodically to relieve stress on the components, the lubrication will need to be maintained, and any corrosion inhibitors in the system must not degrade the lubricants. For short-term storage, the oil can be drained, and a volatile wax or other corrosion inhibitor can be used to coat the internal surfaces. When the machinery is started up again, the wax mixes with the oil and is flushed out when the next oil change is performed.

STARTING OVER AGAIN

If the lubricating oil has been left in the system during shutdown, and especially if the machinery has not been restarted since then, it will be necessary to perform a comprehensive sampling of all the lubricants in the system. Oil degrades and loses its effectiveness with time, temperature changes and humidity. Ambient heating and cooling causes air exchange in any enclosure that is not sealed from the atmosphere. Atmospheric moisture can condense on inner surfaces and collect between these surfaces and the lubricating oil, decreasing the oil's lubricating ability, according to Bob Smith. Any water that has collected in the machinery must be removed before the plant is recommissioned.

Disposing of the old oils and greases when bringing a large plant back online can present a significant disposal problem. Any plans for recommissioning a plant must include the resources necessary to ensure compliance with federal, state and local regulations. Food processing and pharmaceutical manufacturing equipment must

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DID YOU KNOW?

Great Salt Lake West Desert Pumping Project

Operating Facts:
Volume pumped, April 10, 1987, to June 30, 1989: 2.73 million acre-feet

Pumping Rate:
One pump: 450,000 gpm (1,000 cfs)
Two pumps: 900,000 gpm (2,000 cfs)
Three pumps: 1,350,000 gpm (3,000 cfs)

Pumps:
Type: Ingersoll-Rand vertical axis mixed flow
Impeller: 3 blades, 119 in.dia., 12,000 lbs.
Shaft: 10.7 in.dia., 45.5 ft. long, 18,750 lbs.

Engines:
Dimensions: 27 ft. 11 in. long, 11 ft. 10 in. wide, 17 ft. 10 in. high, 16-cylinder 3,500 hp rating, 16.25 in. bore, 18 in. stroke
Operating speed: 330 rpm
Weight: engine and skid – 162,800 lbs.

Pumping Plant:
Dimensions: 110 ft. long, 55 ft. wide, 85 ft. high
Engine deck elevation: 4,230 feet
Sump bottom elevation: 4,175 feet
Construction: Steel and reinforced concrete (13,000 cu. yds. of reinforced concrete)

Source: www.utah.gov

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If the Great Salt Lake West Desert Pumping Project is restarted, the procedure will take between eight and 12 weeks.

meet government cleanliness standards before they can be put back into service.

After a prolonged shutdown, chances are that at least a few of the most experienced operators have retired or moved to other employment, taking their knowledge with them. This need not be an insurmountable problem if a complete set of instruction manuals and documentation has been stored in an accessible location, perhaps on an internal company web site.

Murphy's Law dictates that many of the spare parts needed to restart an operation are now obsolete and available only on e-Bay. Retrofitting the system with new parts is one option, but if the plant must be up and running quickly, a stock of spare parts, stored at the time of the shutdown with corrosion protection and full documentation on the specifications, are vital for a successful restart.

If the Great Salt Lake West Desert Pumping Project is restarted, the procedure will take between eight and 12 weeks. Many pieces of equipment must be partially or completely dismantled and inspected to ensure that corrosion or obsolescence haven't rendered them unusable.

In some cases, it might be more efficient to replace 1980s-vintage components such as the control electronics with current technology. Reactivating the pumping plant would require contracting with a qualified mechanical services company for start-up services. When the pumping plant was mothballed in 1989, the estimated cost of reactivating it was $250,000 to $300,000, compared to the annual operating budget of about $2 million. It would be inefficient to start it up unless it could continue in operation for at least a year. Nevertheless, the state of Utah appropriates funding each year to keep this facility at the ready (7).

Whether the plan is to store an RV in the backyard for the winter, shut down a sugar mill in a humid climate for half of every year or keep a giant desert saltwater pumping facility at the ready for over a decade, careful planning and preparation pay off when the time comes to start the engines again. **<<**

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